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F. R. C.	FRANK RICHARDSON CANA, F.R.G.S. Staff, *Encyclopædia Britannica*, 1903–11 and 1914–5; Staff of *The Times*, London, since 1916. Author of *South Africa from the Great Trek to the Union; The Great War in Europe; The Peace Settlement.*	**Egypt** (*in part*); **Eritrea** (*in part*).
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G. D. D.	G. D. Dunkerley, B.Sc., A.R.C.S. Secretary, Incorporated Association of Assistant Masters. Joint-Author, *The Assistant Master*. Joint Editor, *The Journal of Education*.	**Educational Associations** (*in part*).
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H. Bn.	Harry Bateman. Professor of Mathematics, Theoretical Physics and Aeronautics, California Institute of Technology, Pasadena, California.	**Elasticity.**
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H. C.	Hugh Chisholm, M.A. Editor of the 11th and 12th Editions of the *Encyclopædia Britannica*. *See* biographical article: Chisholm, Hugh.	**Edward VII.** (*in part*).
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H. Fi.	Herman Finer, D.Sc. Lecturer in Public Administration, London School of Economics. Author of *Foreign Governments at Work; The Case Against Proportional Representation;* etc.	**Electoral Systems.**

H. H. L. B.	HUGH HALE LEIGH BELLOT, M.A., D.C.L. Late Associé de l'Institut de Droit International; Hon. Secretary, International Law Association and Grotius Society, Formerly Acting Professor of Constitutional Law, University of London; Secretary, Breaches of the Law of War Committee. Author of *Commerce in War; The Pharmacy Acts; Permanent Court of International Justice;* etc.	**Embargo; Exterritoriality.**
H. Je.	HILARY JENKINSON, M.A., F.S.A. F. W. Maitland Lecturer in the University of Cambridge and Reader in Diplomatic and English Archives in the University of London. Assistant Keeper of the Public Records.	**Exchequer** (*in part*).
H. J. F.	HERBERT JOHN FLEURE, D.SC. Professor of Geography and Anthropology, University College of Wales, Aberystwyth. Hon. Secretary, Geographical Association; Hon. Editor of *The Geographical Teacher.* Author of *Human Geography in Western Europe;* etc. Editor of the Geography section, 14th Edition, *Encyclopædia Britannica.*	**Europe** (*in part*).
H. J. T. E.	H. J. T. ELLINGHAM, A.R.C.S., B.SC., A.M.I.CHEM.E. Imperial College of Science and Technology, South Kensington.	**Electrochemistry.**
H. Kl.	HEINRICH KLÜVER, PH.D. Research Psychologist, Behavior Research Fund Institute for Juvenile Research, Chicago, Ill. Author of *An Experimental Study of the Eidetic Type; Genetic Psychology Monograph.*	**Eidetic Images.**
H. L. T.	HENRY LETHEBY TIDY, M.A., F.R.C.P., M.D. Assistant Physician to St. Thomas' Hospital, London. Formerly Demonstrator of Clinical Pathology to the London Hospital. Author of *Synopsis of Medicine.*	**Encephalitis Lethargica.**
H. L. W.	H. L. WESTOVER, B.S.A. Senior Agronomist in charge of alfalfa, turf grass and silage investigations, Department of Agriculture, Washington.	**Ensilage** (*in part*).
H. M. J. L.	H. M. J. LOEWE. University Lecturer in Rabbinic Hebrew, Oxford University.	**Essenes.**
H. Q.	HUGH QUIGLEY, M.A. Chief Economist, The British Electrical and Allied Manufacturers' Association.	**Electrical Power, National and Regional Schemes** (*in part*).
H. R. H.	HARRY REGINALD HOLLAND HALL, M.A., D.LITT., F.B.A., F.S.A. Keeper of Egyptian and Assyrian Antiquities in the British Museum.	**Egypt** (*in part*).
H. Si.	HENRY SIDGWICK, LL.D. Knightbridge Professor of Moral Philosophy, Cambridge University, 1883–1900. Author of *Outlines of the History of Ethics; Lectures on the Ethics. See* the biographical article: SIDGWICK, HENRY.	**Ethics, History of** (*in part*).
H. van D.	HENRY VAN DYKE, D.D., LL.D. Professor of English Literature, 1900–23, Princeton University, New Jersey. Author of *The Poetry of Tennyson; The Ruling Passion; The Spirit of America.*	**Emerson.**
H. W. G. C.	LIEUT.-COLONEL HENRY W. G. COLE, C.S.I., C.V.O., O.B.E. Director, Exhibitions and Fairs Division, Department of Overseas Trade; British Commissioner-General at Rio de Janeiro Exhibition, 1922, and Paris International Exhibition, 1925. Chairman, Committee for Government Participation at Wembley Exhibition, 1924–5.	**Exhibition and Trade Fair.**
I. A.	ISRAEL ABRAHAMS, M.A. Formerly Reader in Talmudic and Rabbinic Literature in the University of Cambridge. Author of *A Short History of Jewish Literature; Jewish Life in the Middle Ages; Judaism;* etc.	**Einhorn, David.**
I. F. D. M.	IAN F. D. MORROW, PH.D. Formerly Senior Moderator of Trinity College, Dublin.	**Eulenburg-Hertefeld, Philip Zu.**
I. S. M.	I. S. MACADAM, O.B.E., A.M.I.MECH.E. Ex-President and Secretary of the National Union of Students.	**Educational Associations** (*in part*).
J. A. F.	SIR JOHN AMBROSE FLEMING, M.A., D.SC., F.R.S. University Professor of Electrical Engineering in the University of London, 1910, and Professor in University College, 1885–1926. Fellow of University College, London. Formerly Fellow of St. John's College, Cambridge. Vice President, Institution of Electrical Engineers. Author of *The Principles of Electric Wave Telegraphy and Telephony; Electrons, Electric Waves and Wireless Telephony;* etc.	**Electrical Machine** (*in part*); **Electricity Supply: Technical Aspects** (*in part*).
J. A. Si.	JUDITH ANN SILBURN. Journalist and Domestic Science Consultant. Diplomée of Domestic Science, M.I.H. Formerly Trade Investigator, Ministry of Labour.	**Egg Cookery.**
J. A. St.	J. A. STRAHAN, LL.D. Barrister-at-Law. Emeritus Professor of Jurisprudence, University of Belfast. Reader in Equity, Inns of Court, London. Author of *The Bench and Bar of England;* etc.	**Equity; Executors and Administrators** (*in part*).
J. A. Th.	JOHN ARTHUR THOMSON, M.A., LL.D. Regius Professor of Natural History in the University of Aberdeen; Gifford Lecturer, St. Andrews, 1915; Terry Lecturer, Yale University, 1924. Author of *The Study of Animal Life; Outlines of Zoology; Heredity; Darwinism and Human Life; What Is Man?; Concerning Evolution.* Joint Author (with Professor Geddes) of *Evolution; Sex; Biology.*	**Education in Animals; Evolutionary Ethics.**
J. B.	JOHN BROWNLEE, D.SC., M.D., D.P.H. Director of Statistics, National Institute for Medical Research, London.	**Epidemiology** (*in part*).

J. Bar.	JOSEPH BARCROFT, C.B.E., M.A., B.Sc., M.D., F.R.S. Fellow and Lecturer, King's College, Cambridge. Professor of Physiology, Cambridge University. Fullerian Professor of Physiology, Royal Institution, 1923-6. Editor of the Physiology section, 14th Edition, *Encyclopædia Britannica.*	**Excretion.**
J. B. Pr.	JOHN BOYNTON PRIESTLEY, M.A. Author and Journalist.	**English Literature** (*in part*).
J. C. Sq.	JOHN COLLINGS SQUIRE, M.A. Editor of *The London Mercury.* Chairman of the English Association. Chairman of the Architecture Club, 1922-8. Author of *Tricks of the Trade; Essays on Poetry; Grub Street Nights; The Comic Muse;* etc.	**English Literature** (*in part*).
J. D. M. S.	J. D. MAIN SMITH, PH.D., B.Sc., A.I.C. Chief Works Chemist, late Research Assistant to the Professor of Chemistry, University of Birmingham. Late Assistant Examiner in Chemistry, University of London. Author of *Chemistry and Atomic Structure;* etc.	**Elements, Chemical.**
J. F. C. F.	COLONEL JOHN FREDERICK CHARLES FULLER, C.B.E., D.S.O. Military Assistant to the Chief of the Imperial General Staff. Chief General Staff Officer, Tank Corps, 1917-8. Formerly Chief Instructor, Camberley. Author of *Tanks in the Great War; The Reformation of War;* etc.	**Engines of War.**
J. F. S.	J. F. STENNING, M.A., C.B., C.B.E. Warden of Wadham College, and University Lecturer in Aramaic, Oxford.	**Exodus, Book of.**
J. G. B-C.	J. G. BEEBE-CENTER, A.B., PH.D. Professor of Psychology, Harvard University.	**Elements, Conscious.**
J. Gi.	J. GINSBERG. Associate, Department of Mathematics, Teachers College, Columbia University, New York. Professor of Mathematics, Yeshiva College, New York.	**Euler Numbers.**
J. G. R.	JOHN GEORGE ROBERTSON, M.A., PH.D. Professor of German Language and Literature, University of London. Author of *The Literature of Germany; Schiller After a Century;* etc.	**Eulenspiegel, Till.**
J. H. Ro.	JOHN HOLLAND ROSE, M.A., LITT.D. Vere-Harmsworth Professor of Naval History, Cambridge University. Reader in Modern History, Cambridge, 1911-9. Author of *The Development of the European Nations, 1870-1900.* Co-Editor of the *Cambridge History of the British Empire.*	**English History** (*in part*).
J. H. Rs.	JAMES HARDY ROPES, D.D. Professor of Divinity and Dexter Lecturer on Bible Literature, Harvard University. Formerly Bussey Professor of New Testament Criticism and Interpretation.	**Ephesians, Epistles to the.**
J. H. Van A.	J. H. VAN ALSTYNE. Otis Elevator Company, New York.	**Elevators.**
J. J. Be.	JOHN J. BERNET. President of the Erie Railroad Company, New York.	**Erie Railroad Company.**
J. J. Th.	SIR JOSEPH (JOHN) THOMSON, O.M., D.Sc., F.R.S. Master of Trinity College, Cambridge. Cavendish Professor of Experimental Physics, Cambridge, 1884-1918. Nobel Prize for Physics, 1906. Author of *Conduction of Electricity Through Gases;* etc.	**Electricity, Conduction of** (*in part*); **Electric Waves.**
J. La.	SIR JOSEPH LARMOR, M.A., D.Sc., LL.D., F.R.S. Fellow of St. John's College, Cambridge. Lucasian Professor of Mathematics in Cambridge University. Secretary of the Royal Society. Professor of Natural Philosophy, Queen's College, Galway, and in the Queen's University of Ireland, 1880-5. Author of *Ether and Matter* and various memoirs on Mathematics and Physics.	**Energy** (*in part*).
J. L. G.	JAMES LOUIS GARVIN LITT.D. Editor-in-Chief of the *Encyclopædia Britannica.* Editor of *The Observer* (London). Author of *The Economic Foundations of Peace;* etc.	**English Speaking World.**
J. L. My.	J. L. MYRES, O.B.E., M.A., D.Sc. Wykeham Professor of Ancient History, and Fellow and Librarian of New College, Oxford.	**Euboea.**
J. M. C.	JOHN MARTIN CREED, B.A., B.D. Ely Professor of Divinity in the University of Cambridge.	**Eucharist** (*in part*).
J. M. La.	J. M. LANDIS, A.B., LL.B. Professor of Legislation, Harvard Law School.	**Ejectment** (*in part*); **Executors and Administrators** (*in part*).
J. M. Ma.	JOHN MATTHEWS MANLY, A.M., PH.D. Professor and Head of the Department of English in the University of Chicago. Managing Editor of *Modern Philology.* Author of *The Language of Chaucer's Legend of Good Women;* etc. Editor of *Specimens of the Pre-Shakespearean Drama; English Prose, 1137-1890; English Poetry, 1170-1892;* etc.	**English Literature** (*in part*).
J. M. Mag.	JOHN M. MAGUIRE, A.B., LL.B. Professor of Law, Harvard Law School. Author of *The Lance of Justice, a Semi-Centennial History of the Legal Aid Society.* Editor of *Cases on Evidence.*	**Evidence** (*in part*).
J. N. P.	JOHN NORMAN PRING, M.B.E., D.Sc. Head of Physical Chemistry Branch, Research Department in Royal Arsenal, Woolwich. Formerly John Hastings Professor in Physics and Reader in Electro-Chemistry, Victoria University, Manchester. Author of *The Electric Furnace* and a number of textbooks and publications of original research in scientific journals.	**Electricity, Conduction of** (*in part*); **Electrolysis** (*in part*); **Electro-plating; Electro-typing.**
J. R. Ro.	SIR JAMES RENNELL RODD, G.C.B., G.C.M.G., G.C.V.O., M.P. Secretary of Legation, Cairo, 1894-1901; Councillor of Embassy at Rome, 1901-4; H. M. Ambassador to the Court of Italy, 1908-19. Accompanied Lord Milner's Mission to Egypt, 1920; British Delegate to League of Nations, 1921 and 1923.	**Egypt** (*in part*).

J. S. Be.	REV. J. S. BEZZANT, M.A. Lecturer on Theology, Exeter College, Oxford.	**England, Church of.**
J. S. H.	JULIAN SORELL HUXLEY, M.A. Hon. Lecturer, King's College, London. Fullerian Professor of Physiology in the Royal Institution. Author of *Essays of a Biologist;* etc. Editor of the Biology and Zoology section, 14th Edition, *Encyclopædia Britannica.*	**Evolution, Organic** (*in part*).
J. S. S.	JOHN STUART SCRIMGEOUR, O.B.E. of the Middle Temple, Barrister-at-Law.	**Entertainments Duty.**
J. T. B.	JOHN T. BOWEN, B.S. Senior Electrical Engineer, United States Department of Agriculture, Washington. Author of *Dairy Engineering.*	**Electrical Power in Agriculture.**
J. W. B.	J. W. BUCKLEY, M.Sc. Research Department, Metropolitan Vickers Electric Co., Ltd., Manchester.	**Electric Furnaces.**
K. M. A.	DUCHESS OF ATHOLL, D.B.E., D.C.L., LL.D., M.P. Parliamentary Secretary, Board of Education, London.	**Elementary Education** (*in part*).
L. C. M.	SIR LEO CHIOZZA MONEY, F.R.STAT.S., F.R.G.S., F.Z.S. Author and Journalist. Member of the War Trade Advisory Committee, 1915–8. Parliamentary Secretary to the Ministry of Shipping, 1916–8. Chairman of the Tonnage Priority Committee, 1917–8. Editor of the Economics, Engineering and Industries section, 14th Edition, *Encyclopædia Britannica.*	**Electrical Power, National and Regional Schemes** (*in part*); **Exports** (*in part*).
L. D. S.	LAURENCE DUDLEY STAMP, B.A., D.Sc., F.G.S., M.I.P.T. Sir Ernest Cassel Reader in Economic Geography in the University of London. Author of *An Introduction to Stratigraphy.*	**Eocene.**
L. F. B.	L. F. BARKER. Emeritus Professor of Medicine, Johns Hopkins University, Baltimore.	**Endocrinology** (*in part*).
L. H. D. B.	L. H. DUDLEY BUXTON, M.A. Reader in Physical Anthropology in the University of Oxford. Author of *Peoples of Asia.*	**Euphrates.**
L. J. C.	L. J. COMRIE, M.A., PH.D., F.R.G.S. Deputy Superintendent of H.M. Nautical Almanack Office, Royal Naval College, Greenwich.	**Ephemeris.**
L. J. S.	L. J. SPENCER, M.A., SC.D., F.G.S., F.C.S., F.R.S. Keeper of Mineralogy, British Museum (Natural History). Editor of *The Mineralogical Magazine.*	**Epidote.**
L. O. H.	LELAND OSSIAN HOWARD, PH.D., M.D., LL.D., SC.D. Principal Entomologist, United States Department of Agriculture, Bureau of Entomology since 1878. Author of *Mosquitoes, How They Live; The Insect Book.*	**European Corn Borer.**
L. P.	LOUISE POUND, A.M., PH.D. Professor of English Literature, University of Nebraska, Lincoln, Nebraska.	**English Language** (*in part*).
L. T. H.	L. T. HOGBEN. Professor of Zoology, University of Cape Town, South Africa.	**Endocrinology** (*in part*).
M. Bo.	MORITZ JULIUS BONN. Professor of Economics at the School of Commerce, Berlin. Author of *Die Englische Kolonisation in Irland; Amerika als Feind.*	**Erzberger, Matthias.**
M. C. B.	MILES C. BURKITT, M.A., F.S.A. Lecturer for the Board of Archaeological and Anthropological Studies, Cambridge University. Author of *Prehistory.*	**Eoliths.**
Me.	RT. HON. JAMES SCORGIE MESTON, 1ST BARON MESTON, K.C.S.I., LL.D. Chancellor of Aberdeen University, 1928. Secretary to Finance Department, Government of India, 1906–12. Lieut.-Governor, United Provinces of Agra and Oudh, 1912–7.	**Egypt** (*in part*).
M. Gr.	MAJOR GREENWOOD, F.R.C.P., F.R.S. Professor of Epidemiology and Vital Statistics, London School of Hygiene and Tropical Medicine, University of London. Formerly Medical Officer, Ministry of Health.	**Epidemiology** (*in part*).
M. H. L.	MISS M. H. LONGHURST. Assistant, Department of Architecture and Sculpture, Victoria and Albert Museum, South Kensington.	**Effigies.**
M. H. M.	MABEL H. MILLS, M.A. Editor of *The Pipe Roll for 1295; Surrey Record Society;* and author of articles on the Exchequer in *The English Historical Review* and *The Transactions of the Royal Historical Society.*	**Exchequer** (*in part*).
M. Pa.	REV. MARK PATTISON, LL.D. Rector of Lincoln College, Oxford, 1861–84. Author of *Isaac Casaubon;* etc. *See* biographical article: PATTISON, MARK.	**Erasmus, Desiderius** (*in part*).
M. R. J.	MONTAGUE R. JAMES, LITT.D., F.S.A., F.B.A. Provost of Eton since 1918; Trustee of the British Museum. Author of *Eton and King's, 1875–1925.*	**Eton.**
M. S. S.	MATTHEW SCOTT SLOAN, M.S. President and Director of The New York Edison Company, New York. Lecturer in Engineering, Union College, Schenectady, N.Y.	**Electricity Supply: Commercial Aspects.**
N. D. R.	N. DWIGHT RAND. Hercules Powder Company, Wilmington, Del. Author of *Nitrocellulose; High Explosives and Blasting Supplies, and Detonators; Pyroxylin Coated Fabrics.*	**Explosives** (*in part*).
N. E. C.	NORMAN E. CRUMP. Statistical Correspondent to the *Financial Times*, London. Member of the Council of the Royal Statistical Society. Joint Author of *Clare's A. B. C. of the Foreign Exchanges.*	**Exchange, Foreign.**

N. G. G.	NICHOLAS G. GEDYE, O.B.E., B.SC., M.INST.C.E. Consulting Civil Engineer. Formerly Chief Engineer, Tyne Improvement Commission. Served B. E. F. (Lt.-Col.). Acting Director, Civil Engineer-in-Chief's Department, Admiralty. Chief Civil Engineer for Docks, Harbours and Inland Waterways, Ministry of Transport.	**Embankment.**
O. C. A.	OSWALD C. ALLEN., C.B.E. Principal Clerk, Ministry of Labour, London. Barrister-at-Law, Middle Temple.	**Employment Exchange** (*in part*).
O. E.	OLIVER ELTON, M.A., HON.D.LITT., F.B.A. Lecturer on English Literature, Owens College, Manchester, 1890–1900. King Alfred Professor of English Literature, University of Liverpool, 1900–25. Emeritus Professor, 1926. Author of *Survey of English Literature, 1730–1928.*	**English Literature** (*in part*).
O. G. S.	ORRIN G. SHERMAN. Policy Holders' Service Bureau, Metropolitan Life Insurance Company, New York.	**Employee Representation; Employee Stock Ownership; Employment Exchange** (*in part*).
O. J. L.	SIR OLIVER LODGE, D.SC., LL.D., F.R.S. Principal of the University of Birmingham, 1900–19; Romanes Lecturer at Oxford, 1903; President of the British Association, 1913–4. Author of *Ether and Reality; Evolution and Creation; Energy.*	**Ether.**
P. A.	PERCY ALDEN, M.A., M.P. Chairman of the British Institute of Social Service; Bursar of the Sir Richard Stapley Educational Trust; Warden of Mansfield House Settlement, 1891–1901; Commissioner to Board of Agriculture for Cultivation of Lands. Author of *Housing; Democratic England;* etc.	**Elberfeld Poor Relief System.**
P. B. B.	P. B. BALLARD. Divisional Inspector, London County Council.	**Examinations** (*in part*).
P. B. I.	P. B. INGHAM. Director of the London School of Dalcroze Eurhythmics.	**Eurhythmics.**
P. G. B.	PETER GORDON BROWN, M.A., F.I.A. Assistant Actuary, Government Actuary's Department, London.	**Expectation of Life.**
P. La.	PHILIP LAKE, M.A., F.G.S. Lecturer in Physical and Regional Geography in the University of Cambridge. Formerly of the Geological Survey of India. Author of *Monograph in British Cambrian Trilobites.* Translator and Editor of *Kayser's Comparative Geology.*	**Europe** (*in part*).
P. L. A.	PHILIP L. ALGER, M.S. Assistant Engineer, A. C. Engineering Department, General Electric Company, New York. Non-Resident Instructor, Massachusetts Institute of Technology.	**Electric Generator.**
R. A. M.	ROBERT ANDREWS MILLIKAN, PH.D., LL.D., SC.D. Chairman of the Executive Council of the California Institute of Technology and Director of the Norman Bridge Laboratory of the Institute. Professor of Physics, University of Chicago, 1910–21. Vice-Chairman, National Research Council, 1916. Recipient of Edison Medal, 1922; Nobel Prize in Physics, 1923; Faraday Medal, 1924; etc.	**Electron.**
R. B. M.	R. BORLASE MATTHEWS, A.M.INST.C.E., F.R.A.S. Editor of the Journal *Electro-Farming.*	**Electrical Power in Agriculture** (*in part*).
R. C. Ga.	R. C. GALE, F.I.C. Assistant Professor of Chemistry, Artillery College, Woolwich.	**Explosives** (*in part*).
R. G. H.	RALPH GEORGE HAWTREY. Assistant Secretary to the Treasury, London. Author of *Currency and Credit;* etc.	**Exchequer** (*in part*).
R. Ha.	SIR ROBERT A. HADFIELD, D.SC., M.INST.C.E., M.I.M.E., F.R.S. Chairman and Managing Director of Hadfields, Ltd.; Director of Sheffield Gas, Mond Nickel and other companies; Member of Arbi. Panel, Senate and Court of Governors of Sheffield University. Inventor of Manganese and Silicon Steel. Author of *Metallurgy and Its Influence on Modern Progress,* and numerous papers for scientific and technical societies.	**Engineering Education** (*in part*).
R. H. Ch.	REV. ROBERT HENRY CHARLES, M.A., D.D., LITT.D., F.B.A. Archdeacon of Westminster; formerly Grinfield Lecturer and Lecturer in Biblical Studies, Oxford. Professor of Biblical Greek at Trinity College, Dublin, 1898–1906.	**Enoch, Book of** (*in part*).
R. H. Gr.	R. H. GRETTON., M.A. Lecturer in Modern History, University of Oxford.	**English History** (*in part*).
R. H. R.	SIR HENRY REW, K.C.B. Board of Agriculture and Fisheries, 1898; Assistant Secretary, 1906–18; President, Royal Statistical Society, 1920–2. Secretary to the Ministry of Food, 1916–7; Chairman, Inter-Departmental Committee on Unemployment Insurance in Agriculture, 1925–6. Author of *A Primer of Agricultural Economics;* etc.	**Eggs** (*in part*).
R. H. Ra.	ROBERT HERON RASTALL, SC.D., F.G.S. University Lecturer in Economic Geology; Fellow of Christ's College, Cambridge. Member of Council of the Geological Society, 1915, and Mineralogical Society, 1918. Attached to War Office, 1915–9. Author of *Geology of the Metalliferous Deposits.* Editor of the Geology section, 14th Edition, *Encyclopædia Britannica.*	**Esker.**
R. J. G.	REGINALD JOHN GLADSTONE, F.R.S.E., M.D., F.R.C.S., L.R.C.P. Reader in Embryology and Lecturer on Anatomy, University of London. Author of numerous articles in the *Journal of Anatomy* and other scientific publications.	**Embryo** (*in part*).

R. N. B.	ROBERT NISBET BAIN. Assistant Librarian, British Museum, 1883–1909. Author of *Scandinavia—The Political History of Denmark, Norway and Sweden, 1513–1900; The First Romanovs, 1613–1725; Slavonic Europe—The Political History of Poland and Russia from 1469 to 1796;* etc.	**Esternazy of Galantha** (*in part*); **Eudoxia Lopukhina.**
R. Pi.	RUDOLF PINTNER, M.A., PH.D. Professor of Education, Teachers College, Columbia University, New York. Author of *A Scale of Performance Tests; The Mental Survey; Intelligence Testing.*	**Examinations** (*in part*).
R. R. Sl.	ROBERT R. SLOCUM, B.S. Chief Marketing Specialist, Bureau of Agricultural Economics, United States Department of Agriculture, Washington. Author of *The Mating and Breeding of Poultry; Turkey Raising; Ducks and Geese.*	**Eggs** (*in part*).
R. S. P.	REGINALD STUART POOLE. English Archaeologist and Orientalist. Late Keeper of the Department of Coins and Medals, British Museum.	**Egypt** (*in part*).
R. U. S.	R. U. SAYCE, M.A. Lecturer in Material Culture and Physical Anthropology, University of Cambridge. Formerly Lecturer in Geology and Geography, Natal University College, Pietermaritzburg, Natal.	**Ermelo.**
R. W.	RICHARD WILLIAMS.	**Eisteddfod.**
S. G. T.	STEPHEN GEORGE TALLENTS, C.B., C.B.E. Secretary to the Empire Marketing Board.	**Empire Marketing Board.**
S. L. Ph.	SYDNEY L. PHIPSON, M.A. Late Barrister-at-Law, Inner Temple. Author of *The Law of Evidence.*	**Evidence** (*in part*).
S. P. S.	SAMUEL P. SPRENG, D.D. Bishop, Evangelical Church, Naperville, Ill. Author of *Life of Bishop John Seybert; Rays of Light on the Highway to Success.*	**Evangelical Church.**
T. F. H.	TALBOT F. HAMLIN, B.A., B.ARCH. Instructor in the History of Architecture, Columbia University, New York. Chairman, City Plan Committee of the Merchants' Association, New York. Author of *The Enjoyment of Architecture; The American Spirit in Architecture.*	**Erechtheum.**
T. F. T.	THOMAS FREDERICK TOUT, M.A., LITT.D. Hon. Professor, Manchester University; formerly Professor of History (1890–1925). Author of *The Place of the Reign of Edward II. in English History; Edward the First;* etc.	**Edward I.; Edward II.; Edward III.; Edward, The Black Prince.**
T. H. R.	THEODORE H. ROBINSON, M.A., D.D. Professor of Semitic Languages, University College of South Wales and Monmouthshire.	**Exodus, The.**
T. K. C.	REV. THOMAS KELLY CHEYNE, D.LITT., D.D. Oriel Professor of the Interpretation of the Scripture, Oxford University, and Canon of Rochester, 1885–1908. Author of *The Prophecies of Isaiah; The Reconciliation of Races and Religions;* etc. *See* biographical article: CHEYNE, THOMAS KELLY.	**Esther** (*in part*).
T. L. H.	SIR THOMAS LITTLE HEATH, K.C.B., K.C.V.O., HON.D.SC., F.R.S. Assistant Secretary to the Treasury, 1907–13. Hon. Fellow of Trinity College, Cambridge. Author of *The Thirteen Books of Euclid's Elements; A History of Greek Mathematics;* etc.	**Euclid.**
T. S.	THOMAS SECCOMBE, M.A. Late Lecturer in History, East London and Birkbeck Colleges, University of London. Stanhope Prizeman, Oxford, 1887. Assistant Editor of *Dictionary of National Biography,* 1891–1901. Author of *The Age of Johnson;* etc.	**English Literature** (*in part*).
T. S. A.	THOMAS SEWALL ADAMS, A.B., PH.D. Professor of Political Economy, Yale University. Author of *Taxation in Maryland; Outlines of Economics.*	**Excess Profits Duty or Tax** (*in part*).
V. G. C.	V. GORDON CHILDE, B.LITT., F.R.A.I., F.S.A. Professor of Prehistoric Archaeology, Edinburgh. Author of *The Dawn of European Civilization; The Aryans;* etc.	**Europe** (*in part*).
V. S.	VILHJALMUR STEFANSSON, A.M., LL.D. Arctic Explorer; Commander of the Canadian Arctic Expedition under the auspices of the American Museum of Natural History and the Geological Survey of Canada, 1908–12; and of several other expeditions to Arctic Regions. Author of *My Life with the Eskimo; The Friendly Arctic; The Folklore of the Eskimos;* etc.	**Eskimos.**
W. A. P.	W. ALISON PHILLIPS, M.A. Lecky Professor of Modern History, Dublin University. Contributor to *Cambridge Modern History;* etc.	**Esquire; Excellency.**
W. B. R. K.	W. B. R. KING, M.A., F.G.S. Sedgwick Museum, Cambridge.	**England** (*in part*).
W. B. Sm.	W. B. SMITH, A.M., PH.D. Emeritus Professor, Tulane University, formerly Professor of Mathematics and Philosophy, University of Missouri.	**Ellipse.**
W. C. T.	W. CAVE THOMAS. Author of *Symmetrical Education; Mural or Monumental Decoration; Revised Theory of Light.*	**Encaustic Painting.**

W. D. M.	WILLIAM DILLER MATTHEW, M.A., PH.D., F.R.S. Professor of Palaeontology; Director, Museum of Palaeontology, University of California, Berkeley, Calif. Author of various scientific treatises and magazine articles on fossil vertebrates.	**Equidae.**
W. E. Co.	RT. REV. WILLIAM EDWARD COLLINS, D.D. Formerly Professor of Ecclesiastical History, King's College, London, and Lecturer, St. John's and Selwyn Colleges, Cambridge. Author of *The Beginnings of English Christianity.*	**Establishment** (*in part*).
W. E. E.	W. ELMER EKBLAW, M.A. Clark University, Worcester, Mass. Assistant Editor, *Economic Geography.* Special field of research, agricultural geography and arctic geography.	**Everglades.**
W. F. G. S.	W. F. G. SWANN, M.A., D.SC. Director of Bartol Research Foundation, Philadelphia.	**Electricity, Atmospheric.**
W. F. R.	WILLIAM F. RASCHE, B.SC., M.A., PH.D. Director of Personnel, General Motors Truck Corporation, Pontiac, Michigan. Formerly Professor of Education, University of Pittsburgh.	**Education and Industry** (*in part*).
W. Gar.	W. GARNETT, HON.D.C.L. Educational Adviser to the London County Council, 1904–15. Formerly Fellow and Lecturer of St. John's College, Cambridge. First demonstrator of physics in the Cavendish Laboratory, Cambridge, under Professor James Clerk Maxwell.	**Energy** (*in part*).
W. G. C.	W. G. COWLES, LL.B. Vice-President, Travelers Insurance Company, Hartford, Conn. Author of many pamphlets on insurance subjects.	**Engineering Insurance** (*in part*).
W. H. C.	W. H. COATES, LL.B. Secretary of Nobel Industries, Ltd., London.	**Estate Duties; Excess Profits Duty or Tax** (*in part*).
W. H. Cl.	SIR WILLIAM HENRY CLARK, K.C.S.I., C.M.G., M.A. High Commissioner in Canada for H.M. Government in Great Britain; Comptroller-General, Commercial Intelligence Department, Board of Trade, 1916–7; Comptroller-General of Department of Overseas Trade, 1917–28.	**Export Credits.**
W. J. Do.	W. J. DONALD, A.B., PH.D. Managing Director, American Management Association, New York. Author of *Canadian Iron and Steel Industry* and numerous articles for the *Journal of Political Economy.*	**Employees, Training of.**
W. M. Ca.	WILLIAM M. CARPENTER, C.E. Research Statistician, National Electric Light Association, New York. Author of *Electric Light and Power, Its Facts and Figures.*	**Electrical Power, National and Regional Schemes** (*in part*); **Electricity Supply: Technical Aspects** (*in part*).
W. M. M.	WILLIAM M. MARSTON, A.B., LL.B., PH.D. Lecturer in Psychology, Columbia University and New York University. Author of *Emotions of Normal People; Psychology.*	**Emotions, Analysis of.**
W. O. E. O.	REV. W. O. E. OESTERLEY, M.A., D.D. Professor, Hebrew and Old Testament Exegesis, King's College, London University. Author of *The Books of the Apocrypha: Their Origin, Contents and Teaching.*	**Enoch, Book of** (*in part*).
W. P. P.	W. P. PYCRAFT. Assistant Keeper in charge of Osteological collections, Museum of Natural History, South Kensington. Author of *History of Birds; The Courtship of Animals.*	**Egg.**
W. R. D.	WARREN R. DAWSON, F.R.S.E., F.S.A. Author of numerous articles on Egyptology and the History of Medicine.	**Embalming.**
W. R. Ho.	W. R. EATON HODGKINSON, C.B.E., PH.D., F.R.S.E. Formerly Professor of Chemistry and Metallurgy, Artillery College, Woolwich. Part Author of Valentine-Hodgkinson's *Practical Chemistry;* etc.	**Explosives** (*in part*).
W. S. G-B.	W. S. GRAFF-BAKER, B.SC., A.C.G.I., M.INST.T. Assistant Mechanical Engineer, London Underground Railway.	**Escalators.**
W. T.	WALTER JOHN TURRELL, M.D., B.CH. Consulting Physician, Oxford County Asylum. Electro-Therapeutic Physician, Radcliffe Infirmary, Oxford. Author of *The Principles of Electro-Therapy.*	**Electrotherapy.**
W. Th.	WILLIAM THALBITZER. Professor of Eskimo Language and Literature, University of Copenhagen.	**Eskimo Language.**
W. T. S.	WILLIAM T. SHANAHAN, M.D. Medical Superintendent of Craig Colony, Sonyea, New York.	**Epilepsy.**
W. Wal.	WILLIAM WALLACE. Fellow and Librarian (1871) of Merton College, Oxford. Late Whyte's Professor of Moral Philosophy. Author of *The Logic of Hegel; Life of Arthur Schopenhauer;* etc. *See* biographical article: WALLACE, WILLIAM.	**Empedocles** (*in part*).
W. Wi.	WILLIAM WILSON, PH.D., D.SC., F.R.S. Hildred Carlile Professor of Physics, University of London. Chairman of the Institute of Electrical Engineers. Contributor of papers to the *Philosophical Magazine, Proceedings of Royal Society* and *Physical Society* on Photoelectricity, Thermionics, Quantum Theory, Theory of Relativity, etc.	**Electrification of Industry** (*in part*).

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EDUCATION AND INDUSTRY TO EXTRACT

EDUCATION AND INDUSTRY. The problem of the relations of the school to industry and commerce is only part of the wider question of vocational training (*q.v.*), namely that of co-ordinating the preparation for livelihood (specialized training) with the existing preparation for life (general education), and deciding how much or how little of the former should be given in the schools. The wide-spread neglect of the problem till recent times seems all the more surprising, considering the practical bent that has always distinguished the English genius. The neglect is mainly due to two reasons, both historical.

The first is the comparative eclipse of the idea of vocational training in the university sphere, an eclipse which lasted from the Renaissance till the closing years of the 19th century. In the middle ages the university was predominantly professional, and vocational, its principal object being to turn out doctors in theology, law or medicine; the Latin and later the Greek authors studied were mainly regarded as providing the raw material for the technical equipment of the future graduate whatever his faculty. The Renaissance gave a great impetus to the gospel of the value of learning for its own sake, while in this country the increasing resort of the aristocracy to the university that dates from the same period tended to overshadow and obscure the more strictly professional character of its work by the new ideal of its being the finishing school of the scholar and the gentleman. Yet in the case of the latter this seemingly general education was in a very real sense vocational, since the culture of the day and the power to handle his fellows (mancraft) acquired at the university were the indispensable stock in trade of a member of the ruling classes. On the other hand the ordinary mediaeval school, apart from certain monastic and a few other schools, was either preparatory to the university or gave a general education, all technical training in the then existing arts and crafts being provided outside the school by a very complete system of apprenticeship (*q.v.*).

It was just this very system of apprenticeship which explains in its turn the absence until recently of the vocational idea from the purview of education below the university. In fact it was only with the gradual decay of apprenticeship since the beginning of the 19th century, and the increased demand for more scientific training for the higher walks of industry towards the close of the same century that the question came to the fore and efforts were made by the technical Education Acts of 1889 and 1891 and still more by the Education Act of 1902 to deal with the problem on a national scale (*see* Technical Education). Today it is realized that it is no longer a problem of technical education pure and simple, to be dealt with as a separate department, but a much wider one of bringing national education in all its stages, primary, secondary and university, into closer touch with commerce and industry without injuring the general education they provide.

GREAT BRITAIN

The main headings under which the relations between the school and industry may be considered both as regards the present conditions and future developments are as follows:—(1) The contact between the two as at present furnished by official or other machinery for placing out the products of the school in industry and commerce. (2) The contact already set up by means of trade and technical schools and colleges. (3) The contact at present existing in establishments of general education.

On many of these points the report of the committee on education and industry (first part 1927, second part 1928) throws valuable light. For certain reasons however, the committee ruled out of consideration what may be called the counting house side of commerce as well as the university's share in the problem.

Official Machinery.—The first attempts to create official machinery for the placing out of pupils dates from the establishment in 1909 of labour exchanges, subsequently known as employment exchanges, some of which contained not only juvenile departments but also juvenile advisory committees. Various legislative modifications have since taken place, including the introduction of the Board of Education, and today the work is either carried on by the Ministry of Labour through its local offices, normally assisted by a juvenile advisory committee, or else by local education authorities, where they have decided to undertake it through juvenile employment committees. These local authorities comprised in 1926 11 county councils, 56 county boroughs, 26 boroughs and 21 urban councils, the number of areas for which they were responsible being 166, while the Ministry of Labour looked after 191; in one or two cases the areas are divided between them. The work of the two types of committee are largely alike. Advice and information is furnished to boys and girls while still at school, through school conferences or individual interviews. In both cases particulars are collected from head-teachers on the character, ability and physical capacity of

pupils on the leaving list. Other features of the work include the interviewing of applicants, the keeping in touch with employers in respect to vacancies, etc., the putting forward of juveniles for vacancies, the keeping in touch with those who have got jobs, generally known as "after care."

Every juvenile employment committee contains a member of the local education committee and normally representative employers, workers, voluntary social workers and teachers and those of the Ministry of Labour when they exist are organized on similar lines. The amount of after care work by the committees is of considerable value and volume. The number of situations found in 1926 by the Ministry of Labour and the local authorities committees amounted to the impressive number of 224,645, yet these figures only represent about 20% of the pupils leaving school during the year. In addition a large number of posts are found by individual elementary headmasters and headmistresses, specially by those of central schools, and the headmasters and headmistresses of secondary schools generally make a point of keeping in touch with employers. Those in or around London have also joint agencies for placing out boys and girls. Broadly speaking, a pupil completing the course in a secondary school has little difficulty in securing a job. In trade schools and technical institutes the finished products are readily absorbed by the business world. In the universities again appointment boards have been established. There is among certain big trading companies a growing demand for men of a university type, especially for posts abroad, where qualities of character and grit are often a paramount consideration. Increasing numbers of scientific and technically trained graduates such as chemists, engineers, biologists, statisticians and the like are being taken on by the bigger firms in this country, though the intake is still far below that of Germany. This tendency is likely to be further fostered by the growing amalgamations and federations in industry, while still more recently the value of the university student (man or woman) has been appreciated by the larger stores where manners and ability to manage large masses of employees are recognized as a business asset. Mention may also be made of the experiments conducted by the Institute of Industrial Psychology whose tests promise to be of great assistance in the sorting out of pupils and the prevention of industrial misfits.

Co-operation of Education and Commerce.—For the direct contact already established with trade and commerce through trade schools, including those run by certain big firms, day and evening continuation schools, technical institutions and schools of art and agricultural institutes, *see* the appropriate articles on the subject. Reference should also be made to the juvenile unemployment-centres which are run as a sort of "ambulance" classes for juveniles temporarily out of work. There is need however of these being made permanent and some kind of compulsion appears to be necessary. One is the suggestion of the establishment of working certificates (in use in the United States) which however is fraught with certain difficulties. The whole question is bound up however with the gap which at present exists in public supervision owing to pupils leaving the elementary school at 14 and the scheme of national insurance only starting at the age of 16. The remedy probably lies in some form of prolongation of the existing school-age, though, unless extended beyond 16, this would still fail to affect the older juveniles. Most authorities on education would prefer to raise the compulsory age of school attendance to 15, following the lines of the Hadow scheme, others pin their faith to day continuation schools from 14 to 16 with a possible extension to 18. With the growing improved conditions in workshops, the institution of trade boards, and the introduction of welfare workers, the latter policy may in the long run become for the rank and file the more popular of the two because it combines earning and learning, bringing the school and the workshop into daily contact. At present a good deal of the commercial and technical (including artistic) equipment of the elementary or secondary ex-pupil is provided in the evening by the Junior and Senior Commercial Education and the Junior technical and Senior technical Institutes (*see* COMMERCIAL EDUCATION). Probably in no country in the world is there more evening work, ranging as it does from simpler courses in the movements of commerce and technology to preparation for the higher walk of commerce and industry and including university work and even postgraduate research. But the whole is run on a voluntary basis and the leakage especially in the lower grades is, owing to various causes, considerable. It also leads to a good deal of overpressure owing to the long hours of business of many of the students, while in rural districts the problem is further complicated by the difficulties of travelling.

As regards contact with the elementary school, criticism from the business world of the latter has certainly decreased. Taking the elementary school as it is, the only improvements that appear feasible appear to lie in the provision of more handicraft and domestic work and in some cases a closer relation of the school instruction to the pupils' environment in industrial or rural districts (*see* RURAL EDUCATION), with visits to factories and places of business by the children still at school, if not by the formation of school-leaving classes, which seem to present a great many difficulties. But with the elementary school as at present constituted it is hard to see how the contact can be made closer. The central school with its technical and commercial bias seems to have established a very substantial contact with the business world. The secondary school, as pointed out elsewhere, incidentally gives in the English, Arithmetic, Geography and other subjects that it teaches a good deal of the technical equipment the pupil will require in commerce and to some extent in industry. Only 28·5 of its boys and only 7·1 of its girls enter industrial occupations, of whom only a fraction take up rural occupation as against 65·8 of the boys and 63·9 of the girls who select professional, commercial or clerical callings. From the point of view of industry it is clear that a widening of the present form of the school certificate would be desirable in the way of allowing the practical subjects, handicraft, art, domestic science, etc., more weight by permitting two of these instead of one to count towards the five necessary for a pass (*see* also EXAMINATIONS). There must be among the 34–40% who fail in the examination, not counting the 60% who do not take it all, many who would thus be able to qualify. Among the pupils over 16 it is interesting to note that there is a growing tendency to enter trade and technical schools and this should increase in the future. Again, as indicated above, the universities are sending an ever larger number into commerce and industry.

Conclusion.—(a) On the industrial side: in spite of much progress in the past, a vast amount still remains to be done. While the value of the school has steadily risen in the opinion of the more enlightened members of the business world, an enormous number of industrialists and traders are still largely uninformed of the work of the school. To organize them with a view to making them better acquainted with its work is an immense task. The departmental committee points out one serious difficulty—industry is mainly organized nationally, trade and commerce mainly locally and education locally. A step forward has however been taken. Their suggestion that a national advisory council for juvenile employment to consider the questions arising out of the first part of the report was adopted by the Ministry of Labour in Feb. 1928. The committee also formulated other suggestions for promoting closer co-operation between the two parties and inaugurating local enquiries, with a view ultimately to national action, and in this connection they recommended the Board of Education should establish a small special body representative of the view of employers, workers, local education authorities and teachers to undertake national negotiations the object of which should be to inform trade and industry of the educational system; to assist trade and industry in the formulation of their views, and to consider with educational authorities how far these views can be met. This committee was later appointed by the Board.

There is however one point with which the committees, intentionally or not, did not deal and that is the colossal cost of providing adequate technical training for all the various groups of industry and commerce throughout the country;—great as has been the advance of technical education in the past, there are obviously a large majority of business callings which are only

imperfectly if at all catered for under the existing provision of technical education. Possibly the cost can only be satisfactorily met if all the main trades and industries of the country organize themselves both on the side of employers and of trade unions to make some definite financial contribution to the national exchequer in return for the benefits received by their own particular industry.

(b) On the school side: among the schools themselves much may be expected as the Hadow scheme is gradually put in operation. An extra year added to school life would allow some sort of commercial or technical bias being given in the last year or two of the course, similar to that so successfully introduced in both central schools when first founded. An extension of the day continuation schools on vocational lines would also be helpful. The problem is a vast one yet in spite of its vastness nothing seems more certain than that the school and the industrial world are closer together than they have ever been before and that the existing gaps are likely to diminish with even greater rapidity in the near future. (C. Br.)

THE UNITED STATES

A study of the educational literature of the last half century reveals that the evolution of American education is rapidly tending toward a proper balance of the cultural and vocational objectives over which there has been so much strife in past decades between the proponents of general and practical education. Progressive leaders in the general education field now insist upon adequate provision for the practical education of all persons seeking occupational preparation, and the ablest vocational educators with equal emphasis insist that all persons seeking vocational preparation should first secure the most thorough fundamental general training which the capacities and resources of the trainees will permit. This balance is being accepted with a full recognition of the principle that educational adjustments must be made to fit individual needs to the extent that these do not conflict with society's interest in that general education which is essential for the common good of all citizens.

Occupational statistics for the United States indicate clearly that population is shifting from rural to urban centres and that the number of workers in industrial occupations is greatly increasing. This new economic development has brought with it a vigorous demand for industrial education. This demand is being met by both public and private agencies and is resulting in the industrial enlightenment of the general population along two lines, (1) consumption and (2) production.

Education for consumption is largely supported financially through the advertising campaigns of manufacturers who make products of commercial value which satisfy popular wants. In the best elementary and some secondary schools, however, school children are now being taught in carefully prepared lessons the true value of products offered the public to satisfy the desire for food, clothing, shelter, recreation, transportation and other necessaries. This early education in the grades also serves to introduce children to certain general aspects of industrial life and is further strengthened in later grades by handwork courses which develop muscular skill. Interest is also stimulated in the study of occupations through formal courses in the junior high school years and in the practical work of try-out laboratory courses which provide experiences typical and representative of community occupations to adolescents who, in many cases, are seeking early induction into industrial occupations. The steady discharge of juveniles 14 years of age and older from the schools into industry, whether caused by necessity or lack of interest in school work, has led to the further provision for a public guidance and placement service in many American cities, in order that working children may make better occupational adjustments than would be possible for them were they to seek work unassisted. In such communities continuation schools (*q.v.*) usually exist to give young workers 14 to 16, 17 or 18 years of age (as the State laws may require) further vocational and civic training on a part-time "learning while earning" programme, which calls for four to eight hours attendance weekly at these schools. This schooling aims to make economic and civic adjustment more satisfactory and certain than is possible when such children drift about in juvenile jobs without any educational guidance whatever.

Great variety characterizes training for productive efficiency. Public senior, technical and co-operative high as well as continuation schools give both trade preparatory and trade extension courses in their day and evening classes for the more well defined trades of industry. While public secondary schools for both part and full time pupils have shops in which to give practical training in the more common occupations, it is, nevertheless, an accepted principle of vocational education, that the most effective practical instruction is given on the job in industry. Such practical training may embrace any practical instruction, requiring in some instances only a few days or even hours to master, as in highly and narrowly specialized operations, or as much as five years in some of the very complex all-round trades. Industry provides the short-time training in vestibule schools and the all-round trade training through apprenticeship under indenture agreements with the trainee. The public day and evening vocational schools give such trainees the necessary related theoretical training.

Private industrial initiative, however, since 1916, has greatly extended educational opportunity in industry. In the larger industrial corporations of international reputation extensive industrial training of workers and executives (*see* also EMPLOYEES, TRAINING OF) has been undertaken in the form of foreman training classes and corporate trade and engineering schools. One of these, the General Motors Corporation, has established the Institute of Technology at Flint, Mich., to which co-operative engineering students from the many units of the corporation are sent in alternate months for engineering training to supplement the practical instruction received by them in the shops of the units sending them. So great is the need for industrial education on all levels of maturity that even the units of this corporation make use of available training agencies other than their own. Thus, the Frigidaire Corporation, a General Motors unit at Dayton, O., for example, sends co-operative students not only to the institute at Flint, but also to the University of Cincinnati and Antioch college in Ohio and augments this effort further by co-operative relations with the technical high school of the city of Dayton. The Ford Motor Company and the Westinghouse Electric Manufacturing Company are other notable examples of the many other large corporations which have established training organizations to meet their own industrial needs. Industrial requirements are further satisfied by absorbing engineering and technical graduates from State and private universities, where the entire training effort is confined to the class and laboratory work at the universities. Such graduates, however, seldom find their places in industry without first serving supplementary apprenticeships following their graduation from the universities. Such apprenticeships usually run from one to two years. Students at these universities are usually recruited from the graduates of technical high schools.

Finally, it may be said that the educational opportunities in the United States have been extended and developed to that point where, through public, private and corporate schools, a flexible system now obtains which meets the nation's demand for a citizenry well grounded both in the common essentials and those specialized occupational skills or abilities which ensure economic efficiency. (W. F. R.)

EDUCATIONAL ASSOCIATIONS. Many educational and professional associations have been formed since the middle of the 19th century; these have done much to co-ordinate methods of education and to organize the teaching profession as a whole.

GREAT BRITAIN

University teachers of Great Britain are represented by two Associations: The Association of University Teachers (founded 1919) has a membership of 1,200 and publishes The University Bulletin terminally. The Association of University Women Teachers, formed in 1883, has a membership of 2,640, its main objects being to promote the cause of education and to further the professional interests of women teachers.

In the sphere of secondary education, there are five important associations: The Head Masters' Conference (founded 1869); membership (171) is restricted to head masters of public schools and is revised periodically, regard being had to the measure of independence enjoyed by the school's governing body and the head master, and to the number of resident undergraduates at Oxford and Cambridge who have been educated at the school. The Association of Head Mistresses Incorporated (founded 1874); its membership is approximately 600 and its objects are to support and protect the status of women teachers and to safeguard professional and educational interests. The Incorporated Association of Head Masters (founded 1890), mainly represents the interests of publicly controlled secondary schools, with a membership of 800; like the Association of Head Mistresses, it has a wide influence on school administration; it issues a review terminally. The Association of Assistant Mistresses Incorporated was founded in 1884, to promote the discussion of educational questions and to improve professional status side by side with the cause of education; it has a membership of 6,800 drawn from 860 schools. The Incorporated Association of Assistant Masters was founded in 1891; its membership, confined to masters in secondary and public schools, totals over 8,000. It is organized in a central body with 71 branches. Its objects are educational and professional. It publishes a monthly journal, *The A.M.A.*, and a Year Book; it has also issued many memoranda on teaching methods.

The four major secondary associations set up a Joint Committee in 1916 under the title The Joint Committee of the Four Major Secondary Associations. This Committee, when united action is required, speaks with the authority arising from a combined membership of over 15,000 secondary school teachers.

Secondary teachers in Wales are mainly enrolled in one or other of the four major secondary associations, but there is also the Welsh County Schools Association (membership 148) for headmistresses and headmasters; this publishes *The Welsh County Schools Review*.

Two other associations connected with secondary education are The Association of Preparatory Schools, founded in 1892, with a present membership of 700, all of whom are or have been headmasters of preparatory schools, and an official organ *The Preparatory Schools Review;* and the Independent Schools Association, with a membership confined to proprietors; its official publication is *Secondary Education.*

There are three main associations connected with technical education: The Association of Teachers in Technical Institutions was founded in 1904 for the advancement of technical education and the safeguarding of professional interests. It has a membership of 1,700 and issues monthly *The Technical Journal.* The Association of Technical Institutions includes representatives from 102 technical institutes in Great Britain. The Association of Principals in Technical Institutions has 149 members. The Joint Committee of the Four Major Associations, the Association of Teachers in Technical Institutions, and the National Union of Teachers have set up a Joint Committee (Joint Six) with the object of co-ordinating the views of the constituent bodies and taking united action when desirable.

Associations on the administrative side are: The Association of Education Committees representing 260 local education authorities; it publishes a weekly journal, *Education,* and organizes annually the North of England Education Conference. The County Councils' Association and the Association of Municipal Corporations also have education committees in constant relationship with the Association of Education Committees and these bodies have considerable influence with the Board of Education. The Association of Directors and Secretaries for Education has a membership of about 220.

The more important subject associations are: The Classical Association (2,000 members), The English Association (6,500—*Bulletin*), The Geographical Association (4,400), The Historical Association (4,000 members—many local branches), The Mathematical Association (1,700 members—*Mathematical Gazette*), The Modern Language Association (1,300 members—*Modern Languages*), The Science Masters Association (1,350 members—*School Science Review*) and The National Society of Art Masters (800 members). Other subject associations are The Art Teachers' Guild, the Educational Handwork Association, the Music Teachers Association and the Secondary Schoolmasters Physical Education Association.

Bodies of a more general order include: The Association for Education in Industry and Commerce, The British Association for the Advancement of Science (17 sections including educational science), The British Science Guild, The Civic and Moral Education League, The Education Guild of Great Britain, the New Education Fellowship (2,000—*New Era*, with editions in English, French and German), The National Union of Scientific Workers, The Parents National Education Union, and the Workers Educational Association (25,000 members, over 2,000 affiliated associations and nearly 600 branches).

Most of the above associations are affiliated to the Annual Conference of Educational Associations presided over by distinguished educationists and first held in 1913. The Conference has supplied a rallying place for teachers and administrators of all categories and its comprehensive organization gives a free platform for full discussion of educational questions from all points of view. A full report of the papers and discussions is published yearly. (G. D. D.)

National Union of Teachers.—The National Union of Teachers was constituted in 1870. Its principal objects are to associate and unite the teachers of England and Wales; to provide means for co-operation and the expression of collective opinion upon matters affecting education and the teaching profession; and to secure the establishment of an efficient national system of education. In 1927 the Union achieved a record membership with a total of 125,274 of all types and grades of teachers: university professors, secondary, primary and special school teachers, and fully qualified instructors in handicraft, domestic science and other special subjects.

The controlling body of the Union is an annual conference held at Easter, of about 2,000 delegates, representing 624 local associations which, for the most part, are grouped together in 57 county associations. The executive consists of 37 members, controlling a large official and clerical staff.

The headquarters of the Union are situated at Hamilton House, Mabledon Place, London, and housed in the same building are two other bodies which are independently constituted and governed, yet are integral parts of the Union. The Teachers' Provident Society, with accumulated funds of £3,000,000, and nearly 70,000 members, offers friendly society benefits expressly designed to suit teachers; the benevolent and orphan fund raises about £50,000 annually for charitable purposes. Minor departments are the Union library, its War Aid fund, which raised £250,000 to aid ex-service men or their dependents, and the Thank-offering fund which was raised to augment the pensions of those who retired under pre-war superannuation schemes. The Sustentation or Defence fund has invested funds worth £750,000. The Union publishes its own journal: *The Schoolmaster and Woman Teacher's Chronicle.*

In recent years successful efforts have been made to establish contact and work in co-operation with teachers in other lands for educational progress and international goodwill, and the Union is affiliated both to the World Federation of Education Associations and to the International Federation of Teachers' Associations.

Working in friendly co-operation with the Union are the National Association of Head Teachers and the National Federation of Class Teachers. The first of these organizations includes a large number of head teachers of primary and central schools who are employed in the principal urban centres of the country. Similarly, the National Federation of Class Teachers includes in its membership a considerable number of assistant teachers. Both bodies hold annual conferences at which educational and professional policies are formulated generally in harmony with those proposed by the National Union of Teachers. (F. W. G.)

INTERNATIONAL CONFEDERATION OF STUDENTS

The International Confederation of Students (Confédération

Internationale des Étudiants [C.I.E.]) was founded at Strasbourg in 1919, with the triple object of creating friendship and understanding between the university students of the world, of coordinating student activities in all countries, and of studying international questions pertaining to the life of the students so as to foster the broadening of culture and the spread of learning. It is a federation of National Unions, having no direct individual membership, and carrying on its work in complete independence of party politics and sectarian religion. It possesses a membership of over a million.

There are at present 23 full members, eight free members (*i.e.*, Unions which do not represent a majority of the students of their countries, and so have a consultative voice only), one associate member and one association in collaboration. The countries affiliated are Belgium, Bulgaria, Canada, Czechoslovakia, Denmark, England and Wales, Estonia, Finland, France, Georgians abroad, Germany, Holland, Hong-Kong, Hungary, Italy, Latin Americans abroad, Latvia, Luxembourg, New Zealand, Norway, Poland, Rumania, Russian emigrants, Scotland, South Africa, Sweden, Switzerland, Turkey, Ukrainians abroad, United States of America, Uruguay, White Ruthenians abroad, Yugoslavia.

The C.I.E. is governed by a council consisting of five delegates from each National Union and meeting annually in different parts of Europe. This council elects from its members an executive, which meets six times during its two years of office. The detailed work of administration is carried on by various permanent commissions, of which the most important are the central office (Brussels), which controls the internal affairs of the Confederation; the international sports office (Paris); the director of commission office (London); and the international relations and travel office (London). This last is of the utmost importance in the policy of the C.I.E.: its object is to facilitate student travel while increasing its educational value, and it is thus concerned with all the details incident to displacement—reductions in fares and cost of passports and visas, arrangement of intercontinental tours, student hostels, the international student identity card—as well as with international centres for sport and study.

Each national union is responsible for the funds necessary to carry out its own work, and in addition subscribes annually to the confederation on a membership basis.

Publications issued by the C.I.E. include an *Annuaire* in French and English, the *Handbook of Student Travel*, and a *Handbook of Foreign Study for Students*. (I. S. M.)

UNITED STATES

Educational associations of teachers for mutual improvement and for the advancement of the profession were formed very soon after education became an established policy of the United States and a system of training instituted through the interest and vision of such leaders as Horace Mann and Henry Barnard.

The United States has no Federal system of education but does have a distinct American system. It has no governmental authority requiring standard courses of study, teacher training, management, methods or finance as in those countries where education is directed by the central Government. The American system, however, has grown up through the zeal and courage of teachers who have formed local educational associations and overstepped State boundaries to join with their co-workers in conference and in educational investigation. These associations have become clearing houses for educational procedure. Teachers have discussed methods, determined failures and successes, and catalogued educational experiences and results. They have listened to addresses from leaders of the profession and have formed investigating committees until educational methods and standards, materials, processes and attitudes have become greatly unified throughout the States and Territories of the Union.

There are four types of organization common to American teachers: (1) local (generally under the direction of the chief educational officer of the community), (2) county, (3) State and (4) national, and of these types there are general and special divisions. The general association is largely inspirational. In addition, there are those which have to do with the teaching and advancement of special subjects and are more especially technical. There is scarcely one of the 2,950 counties of the United States or one of the States and Territories which has not its organization. So important are these societies that teachers who are interested in the work they do are urged by their own desire and ambition to attend. Thus, teachers of all groups and subjects find themselves affiliating. In most cases, there are divisions, for conference purposes, into kindergarten, primary, rural, grammar and secondary schools, and special subject groups such as social studies, mathematics, language and for the promotion of special or new forms of educational activities.

The most outstanding and influential organization in the United States is The National Education Association, organized at Philadelphia, Pa., in 1857, under the title, The National Teachers' Association. It has held annual meetings since that time. The name was changed in 1870 to The National Educational Association and in 1907, by act of the U.S. Congress, the new charter was adopted designating the organization as The National Education Association of the United States. Its general purposes may be considered the objectives of all educational associations in America. "The purpose and object of the incorporation shall be to elevate the character, to advance the interests of the profession of teaching and to promote the cause of education in the United States." It includes the National Council of Education with the following departments and such others as may be created by organization or consolidation: departments of (1) superintendence, (2) normal schools, (3) elementary education, (4) higher education, (5) manual training, (6) art education, (7) kindergarten education, (8) music education, (9) secondary education, (10) business education, (11) child study, (12) physical education, (13) natural science instruction, (14) school administration, (15) library, (16) special education, (17) Indian education. The powers, duties, number and names of these departments of the National Council of Education may be changed or abolished by the corporation.

Membership in the national organization has always been voluntary and general until in 1921 the Delegate Assembly was provided. Educational organizations, State and local, may have representation according to membership in the national body. These representatives participate in the business sessions and in establishing the general policy. However, any teacher or friend of education is eligible to general membership. Under this reorganization, the association undertook to carry its influence and its support to every teacher in the United States. The membership has been extended from a possible 10,000 in 1918 to a registration of 181,000 in 1927, and the attendance is rapidly increasing. There are 1,500 life members. More than 2,500 elementary and high schools have held teachers' meetings during 1927 to consider problems of the profession. This work of the National Association is one of the monumental achievements in education in the United States. The association has been instrumental in aiding local educational administrations in promoting legislation, increasing salaries and promoting research and the general advancement of learning and culture. It has sponsored many of the most forward movements in education. Among them, it has prepared year books which represent the advanced thought on curricula making and educational procedure. Under its direction, the first World Conference on Education was called in San Francisco in 1923, which resulted in the organization of the World Federation of Education Associations which now numbers in its enrolment about 1,000,000 of the 5,000,000 teachers of the world.

In addition to the organizations mentioned, there are 99 other national organizations consisting largely of special interests. They include the American Council of Education, the American Association of Colleges and Universities and organizations for the promotion of almost every conceivable phase of educational life. In addition, there are 30 sectional organizations of New England, Southern States, and Central States. The American Federation of Teachers is a general educational organization which is a branch of the American Federation of Labor. It is a growing concern with gilds in many cities and communities throughout the United States.

The State associations are growing rapidly. Many of them publish educational journals within their States and also have 100% of the teachers engaged in education within the State enrolled and practically no State falls below 60%. In 1908, only 65,993 enrolled in State associations; in 1927, there was an enrolment of 650,368 out of a possible 900,000.

These associations stand as sponsors for the American public school as the foundation of American democracy. They believe in giving every child an opportnuity to secure all the education he is capable of receiving and in making universal education a basic principle of the free institutions of the United States.

(A. O. T.)

EDUCATION IN ANIMALS. In some birds and mammals it has been observed that the young receive parental education. This varies in its detail in different cases, for it may be little more than the supplying of a liberating stimulus or an incentive to action, while in more complicated expressions the education amounts to careful training in the way in which certain things should be done. It is advantageous in lessening the time required for learning by individual experiment, and in lessening the risks of this self-education. Moreover, there is some profitable handing-on of the gains of parental experience—a simple form of extra-organismal heritage.

To begin with simple cases, we may notice how a dabchick, with its young ones on its back, depresses itself in the stream and thus forces them to begin to learn to find their way about in the water. A grebe has been seen ducking one of its offspring, as if accustoming it to immersion. The great crested grebe often dives after fish while carrying the young ones on its back, and they soon learn their lesson. Although young birds do not require to be taught to fly, the parents may force or encourage them to make a beginning, sometimes tempting them with food. A guillemot may push its young one off the brooding-ledge on to a slope leading steeply to the sea. T. A. Coward notes that "a more usual method is for the old bird to seize the unfortunate by one wing, and, flying out with it until clear of surf and rocks, let it drop." The young bird opens its wings and flutters. It takes its first flight, diagonally down to the sea, where it also takes its first, somewhat compulsory, dive, and follows this by beginning to swim. It is waited on by its parents or by one of them, and gets some help with its meals until it is able to fend for itself. There are several similar cases well authenticated.

Some kinds of education take the form of graduated meals, as has been observed in birds of prey. From prepared pieces of flesh, to begin with, the nestlings are gradually trained to tackle more or less intact booty. L. J. Hobhouse refers to the expertness shown by some young woodpeckers in getting at the seeds of fir-cones, but he points out that the parent woodpeckers bring their young ones first the seeds themselves, then partly opened cones, and finally intact ones. "The method of preparing the family dinner is at least as much a tradition as an instinct." It is the outcome of both teaching and learning.

Among mammals the instruction is almost always on the mother's part. The carnivore often brings a living captive to the den and sets it free in presence of the young ones. This serves as a liberating stimulus to instinctive capacities, but it also affords some training. In many cases, *e.g.*, foxes and stoats, the mother takes her offspring with her on her hunting expeditions, and they gradually learn their business. The instinctive basis is, of course, present, but its exercise under maternal control may continue for months. Tregarthen describes circumstantially the detailed instruction given by the mother otter to her cubs. It includes the long alphabet of country-sounds, the fit and proper ways of diving and lying perdu, the methods of capturing different kinds of booty, and the recognized ways of eating trout, eel and frog. It may be safely said that too little attention has been given to the factor of education in developing animal behaviour. (*See* also PSYCHOLOGY, COMPARATIVE.) (J. A. TH.)

EDWARD, "THE CONFESSOR" (d. 1066), so called on account of his reputation for sanctity, king of the English, was the son of Aethelred II. (the Unready), and was born at Islip in Oxfordshire. On the recognition of Sweyn as king of England in 1013, Aethelred, with his wife and family, took refuge in Normandy, and Edward continued to reside at the Norman court until he was recalled in 1041 by Hardicanute. He appears to have been formally recognized as heir to the throne on the death of Hardicanute in 1042 though his coronation was delayed until Easter 1043. A few months later Edward, in conjunction with the three great earls of the kingdom, made a raid on the queen-mother Aelfgifu, or Emma, and compelled her to live in retirement.

In the earlier years of the reign the influence of Earl Godwine was predominant, though not unopposed. His daughter Edith or Eadgyth became Edward's queen in 1045. But the king's personal tastes inclined much more to foreigners than to Englishmen, and he fell more and more into the hands of foreign favourites. Between Godwine, representing the spirit of nationalism, and these favourites (especially Robert of Jumièges) there was war to the knife. In 1046 Magnus, king of Norway, who had succeeded Hardicanute in Denmark and claimed to succeed him in England as well, threatened an invasion, but the necessity of defending Denmark against his rival Sweyn Estrithson prevented him from carrying it into effect. In 1049, Godwine's son Sweyn, who had been outlawed for the seduction of the abbess of Leominster, returned and demanded his restoration. This was refused and Sweyn returned into exile, but not before he had murdered his young kinsman Beorn. He was, however, inlawed next year. The influence of Godwine, already shaken, received a severe blow in 1051 in the appointment of Robert of Jumièges to the archbishopric of Canterbury, and the same year saw the triumph of the foreigners for the moment complete. Edward, indignant at the resistance offered by the men of Dover to the insolence of his brother-in-law Eustace of Boulogne and his French followers, ordered Godwine to punish the town. Godwine refused. The king at the prompting of the archbishop then summoned a meeting of the witan, at which the old charge against Godwine of complicity in the murder of the Aetheling Alfred was to be revived. About the same time came news of a fresh outrage by the foreigners. Godwine gathered his forces and demanded redress, while the earls Leofric of Mercia and Siward of Northumbria hastened to the side of the king. Civil war seemed imminent, but at length the matter was referred to a meeting of the witan to be held at London. At the appointed time Godwine presented himself at Southwark, but his followers were rapidly deserting him and he fled to Flanders, while his son Harold went to Ireland. But the tale of Godwine excited universal sympathy, for he represented the cause of national independence. Encouraged by assurances from England, he sailed thither, and joining forces with Harold sailed along the south coast and up the Thames. The king would have resisted, but found no support. He allowed himself to be reconciled, and Godwine and his house were restored to their old position. The queen at the same time was brought back from the monastery of Wherwell, whither she had been despatched after her father's flight.

The foreigners had already ignominiously fled the country, and henceforth the influence of Godwine, and, after his death, of Harold, was supreme. In 1063 Harold made a great expedition into Wales, in which he crushed the power of King Gruffyd. But he was the minister of the king rather than his personal favourite. This latter position belonged to his younger brother Tostig, earl of Northumbria. In 1065 Tostig's subjects broke into revolt. They elected Morkere as their earl, then marching south demanded Tostig's banishment. Edward desired to crush the revolt by force of arms, but he was overborne and forced to submit. The election of Morkere was recognized, and Tostig went into exile. Intensely mortified at this humiliation, the king fell sick, and henceforth his health failed rapidly. He was unable to be present at the consecration of his new abbey of Westminster, the foundation of which had been the chief interest of his closing years, and on Jan. 5, 1066 he died.

The virtues of Edward were monkish rather than kingly. Always dependent on others, he ever inclined to the unworthier master. But the charm of his character for the monastic biographer, and the natural tendency to glorify the days before the Norman oppression began, combined to cast about his figure a halo

which had not attached to it in life.

BIBLIOGRAPHY.—A number of lives of Edward are brought together in a volume of the Rolls Series entitled *Lives of Edward the Confessor*, ed. Dr. H. R. Luard (1858). Of these the most valuable is the contemporary *Vita Edwardi*, which would appear from internal evidence to have been written by an unknown writer soon after the Norman Conquest—some time between 1066 and 1074. The other chief authorities for the reign are (1) the *Saxon Chronicle* (C. Plummer, Oxford, 1892–99); (2) *Florence of Worcester*, ed. B. Thorpe, English Historical Society (1848–49). Reference may also be made to J. M. Kemble, *Codex diplomaticus aevi Saxonici* (London, 1839–48). (C. S. P.)

EDWARD, "THE ELDER" (d. 924), king of the Angles and Saxons, was the second son of Alfred the Great, and with his sister Aethelflaed was educated at the court of his father. He took part in the campaigns against the Danes, especially in that of 894, and as early as 898 he signs a charter as "rex," showing that he was definitely associated with his father in the kingship. He succeeded his father in Oct. 899, but not without opposition. The Aetheling Aethelwold, son of Alfred's elder brother Aethelred, seized Wimborne and Christchurch. Edward advanced against him, and Aethelwold took refuge among the Danes in Northumbria. In 904 Aethelwold landed in Essex, and in the next year he enticed the East Anglian Danes to revolt. They ravaged all southern Mercia and returned home victorious, though Aethelwold fell in the battle of the Holme. In 905 or 906 Edward made a peace with the East Anglian and Northumbrian Danes at "Yttingaford," near Linslade in Buckinghamshire, perhaps the peace known as "the Laws of Edward and Guthrum." In 909 and 910 fresh victories were won against the invading Danes at Tettenhall and Wednesfield in Staffordshire. From 907 onwards Edward and his sister Aethelflaed, the Lady of the Mercians, were busy strengthening their hold on Mercia and Wessex. Forts were built at Lincoln (907), "Bremesbyrig" (910), "Scergeat" and Bridgenorth (912), and when in the year 911 Aethelflaed's husband Aethelred died, Edward took over from Mercia the government of London and Oxford, with the lands belonging to them, *i.e.*, probably Oxfordshire and Middlesex. Hertford was fortified in 911, Witham in 912, while Aethelflaed fortified Cherbury in Shropshire, "Weardbyrig" and Runcorn (all in 915). In 913 the Danes in Eastern Mercia gave considerable trouble, and in 914 a fresh horde of pirates, coming from Brittany, raided southern Wales, but were besieged by the English forces until they promised to leave the king's territory. The Danes failed to secure a hold in the Bristol channel and were ultimately forced to sail to Ireland. In the same year Edward fortified Buckingham and received the submission of the jarls and chief men of Bedford. In 915 he fortified Bedford, Maldon in 916, and Towcester and "Wigingamere" in 917. In 917 Edward also captured Tempsford and Colchester. An attack by the Danes on Maldon failed, and in 915 Edward went to Passenham and received the submission of the men of the "borough" of Northampton. The Danish strongholds of Huntingdon and Colchester were now restored and repaired, and Edward received the submission of the whole of the East Anglian Danes. Before midsummer of this year Edward had fortified Stamford, and on the death of his sister he received the submission of the Mercians at Tamworth. There also three kings of the North Welsh took Edward as their lord. Nottingham was now fortified; Thelwall in Cheshire (919) and Manchester soon followed; Nottingham was strengthened by a second fort; Bakewell was fortified and garrisoned, and then came the greatest triumph of Edward's reign. He was "chosen as father and lord" by the Scottish king and nation, by Raegenald, the Norwegian king of Northumbria, by Ealdred of Bamborough, and by the English, Danes or Norwegians in Northumbria, and by the Strathclyde Welsh.

With the conclusion of his wars Edward's activity ceased, and we hear no more of him until in 924 he died at Farndon in Cheshire and was buried in the "New Minster" at Winchester. He was thrice married: (1) to Ecgwyn, a lady of rank, by whom he had a son Aethelstan, who succeeded him, and a daughter Eadgyth, who married Sihtric of Northumbria in 924. This marriage was probably an irregular one. (2) To Aelflaed, by whom he had two sons—Aelfweard, who died a fortnight after his father, and Eadwine, who was drowned in 933—and six daughters, Aethelflaed and Aethelhild, nuns, and four others (*see* AETHELSTAN). (3) To Eadgifu, the mother of Kings Edmund and Edred, and of two daughters.

See the *Anglo-Saxon Chronicle* (ed. Plummer, 1892–99); Florence of Worcester (*Mon. Hist. Brit.*); William of Malmesbury, *Gesta regum* (Rolls Series); Simeon of Durham (Rolls Series); Ethelweard (*Mon. Hist. Brit.*); Birch, *Cartularium Saxonicum*, Nos. 588–635; *D.N.B.*, *s.v.* (A. M.)

EDWARD, "THE MARTYR" (*c.* 963–978), king of the English, was the son of Edgar by his first wife Aethelflaed. Edgar's second wife Aelfthryth desired to obtain the crown for her son Aethelred, but Dunstan upheld Edward's claim, and he was crowned at Kingston in 975. Edward's brief reign was marked by an anti-monastic reaction. There seems also to have been an attempt to bring the Danes into more direct dependence on the crown by the banishment of Oslac, earl of Northumbria. In ecclesiastical matters there were two parties in the kingdom, the monastic, which had its chief hold in Essex and East Anglia, and the anti-monastic, led by Aelfhere of Mercia, who expelled many of the monks whom Aethelwold had installed. Conferences were held at Kirtlington in Oxfordshire and at Calne in Wiltshire in 977 and 978, but nothing definite seems to have been decided. On March 18, 978, Edward was assassinated at Corfe castle in Dorsetshire. The crime was probably inspired by his stepmother, Aelfthryth, who was anxious to secure the succession of her son Aethelred. The body was hastily interred at Wareham and remained there till 980, when Archbishop Dunstan and Aelfhere of Mercia transferred it with great ceremony to Shaftesbury. Very shortly after his death he was popularly esteemed to be both saint and martyr.

See *Saxon Chronicle; Vita S. Oswaldi* (*Hist. of Ch. of York*, Rolls Series); *Memorials of St. Dunstan* (ed. Stubbs, Rolls Series).

EDWARD I. (1239–1307), king of England, born at Westminster on June 17 1239, was the eldest son of Henry III. and Eleanor of Provence. He was baptized Edward after Edward the Confessor, for whom Henry had special veneration, and among his godfathers was Simon de Montfort, earl of Leicester, his aunt Eleanor's husband. His political career begins when the conclusion of a treaty with Alphonso X. of Castile, by which he was to marry the Spanish king's half sister Eleanor, necessitated the conferring on him of an adequate establishment. His father granted him the duchy of Gascony, the earldom of Chester, the king's lands in Wales and much else.

The Prince.—In May 1254 Edward went to Gascony to take possession of his inheritance. He then crossed the Pyrenees, and in October was dubbed knight by Alphonso and married to Eleanor at the Cistercian convent of Las Huelgas, near Burgos. He remained in Gascony till November 1255, but his father was too jealous to allow him a free hand in its administration. After his return, the attempts of his agents to establish English laws in his Welsh possessions brought Edward into hostile relations with the Welsh. Here also his father would give him no help, and his first campaign brought him little result. Edward became extremely unpopular through his association with his Lusignan kinsfolk, his pride and violence, and the disorders of his household. In 1258 his strenuous opposition to the Provisions of Oxford further weakened his position, but, after the banishment of the foreigners, he began to take up a wiser line.

In 1259 he led the young nobles who insisted that the triumphant oligarchy should carry out the reforms to which it was pledged. For a moment it looked as if Edward and Leicester might make common cause, but Edward remained an enemy of Montfort, though he strove to infuse his father's party with a more liberal and national spirit. He was the soul of the reconstituted royalist party formed about 1263. In 1264 he took a prominent part in the fighting between the king and the barons. At the battle of Lewes his rash pursuit of the Londoners contributed to his father's defeat. Two days later Edward surrendered to Leicester as a hostage for the good behaviour of his allies. He was forced to give up his earldom of Chester to Leicester, but at Whitsuntide 1265 he escaped from his custodians, and joined the lords of the Welsh march who were still in arms. With their aid he defeated and slew Leicester at Evesham on Aug. 4, 1265.

For the rest of Henry III.'s reign Edward controlled his father's policy and appropriated enough of Leicester's ideals to make the royalist restoration no mere reaction. So peaceful became the outlook of affairs that in 1268 Edward took the cross, hoping to join the new crusade of St. Louis. Want of money delayed his departure till 1270, by which time St. Louis was dead, and a truce concluded with the infidel. Refusing to be a party to such treason to Christendom, Edward went with his personal followers to Acre, where he abode from May 1271 to August 1272. Despite his energy and valour he could do little to prop up the decaying crusading kingdom and he narrowly escaped assassination. The declining health of his father induced him to return to the West.

He learned in Sicily the death of Henry III. on Nov. 16, 1272. On Nov. 20, the day of Henry's funeral, he was recognized as king by the English barons. Edward did not hurry home. After a slow journey through Italy and France he did homage to his cousin Philip III. at Paris, on July 26, 1273. He then went to Gascony, where he stayed nearly a year. He landed at Dover on Aug. 2, 1274, and was crowned at Westminster on Aug. 18th.

Character and Administration.—Edward was 35 years old when he became king, and the rude schooling of his youth had developed his character and suggested the main lines of the policy which he was to carry out as monarch. He was a tall, well-proportioned and handsome man, extravagantly devoted to military exercises, tournaments and the rougher and more dangerous forms of hunting. He had learned to restrain the hot temper of his youth, and was proud of his love of justice and strict regard to his plighted word. His domestic life was unstained, he was devoted to his friends, and loyal to his subordinates. Without any great originality either as soldier or statesman, he was competent enough to appropriate the best ideas of the time and make them his own. His defects were a hardness of disposition which sometimes approached cruelty and a narrow and pedantic temper, which caused him to regard the letter rather than the spirit of his promises. His effectiveness and love of strong government stand in strong contrast to his father's weakness. Though he loved power, and never willingly surrendered it, he saw that to be successful he must make his policy popular. Thus he continued the system which Montfort had formed with the object of restraining the monarchy, because he saw in a close alliance with his people the best means of consolidating the power of the crown.

The first years of Edward's reign were mainly occupied by his efforts to establish a really effective administration. In carrying out this task he derived great help from his chancellor, Robert Burnell, bishop of Bath and Wells. From 1275 to 1290 nearly every year was marked by an important law. Few of these contained anything that was very new or original. They rather illustrate that policy which caused Stubbs to describe his reign as a "period of definition." Yet the results of his conservative legislation were almost revolutionary. In particular he left the impress of his policy on the land laws of England, notably by the clause *De Donis* of the Westminster statute of 1285, and the statute *Quia Emptores* of 1290. The general effect of his work was to eliminate feudalism from political life. At first he aimed at abolishing all franchises whose holders could not produce written warranty for them. This was the policy of the statute of Gloucester of 1278, but the baronial opposition was so resolute that Edward was forced to permit many immunities to remain. Though the most orthodox of churchmen, his dislike of authority not emanating from himself threatened to involve him in constant conflict with the Church, and notably with John Peckham, the Franciscan friar, who was archbishop of Canterbury from 1279 to 1292. The statute of Mortmain of 1279, which forbade the further grant of lands to ecclesiastical corporations without the royal consent, and the writ *Circumspecte Agatis* of 1285, which limited the church courts to strictly ecclesiastical business, both provoked strong clerical opposition. However, Peckham gave way to some extent, and Edward prudently acquiesced in many clerical assumptions which he disliked. He was strong enough to refuse to pay the tribute to Rome which John had promised, and his reign saw the end of that papal overlordship over England which had greatly complicated the situation under his father.

WELSH, SCOTTISH AND PARLIAMENTARY POLICIES

Wales.—Besides administration and legislation, the other great event of the first 15 years of Edward's reign was the conquest of the principality of Wales. It was part of Edward's policy of reconciliation after the battle of Evesham that in the treaty of Shrewsbury of 1267 he had fully recognized the great position which Llewelyn ab Gruffyd, prince of Wales, had gained as the ally of Simon de Montfort. However, Llewelyn's early successes had blinded the Welsh prince to the limitations of his power, and he profited by Edward's early absences from England to delay in performing his feudal obligations to the new king. Even after Edward's return Llewelyn continued to evade doing homage. At last Edward lost patience, and in 1277 invaded north Wales. He conducted his campaign like a great siege, blocking all the avenues to Snowdon, and forcing Llewelyn to surrender from lack of supplies. He thereupon reduced the Welsh prince to the position of a petty north Welsh chieftain strictly dependent on the English.

For the next five years Edward did his best to set up the English system of government in the ceded districts. The Welsh resentment of this soon gave Llewelyn another chance, and compelled Edward to devote the years 1282–83 to completing his conquest. In 1284 he issued the statute of Wales, which provided for a scheme for the future government of the principality. Edward is often called the conqueror of Wales, but in truth he only effected the conquest of Llewelyn's dominions. The march of Wales was only indirectly affected by his legislation, and remained subject to its feudal marcher lords until the 16th century.

Foreign Policy.—Though preserving nominal peace with his cousin Philip III. of France, his relations with that country were constantly strained. After Philip III.'s death in 1285, Edward crossed the Channel in 1286, to perform homage to his successor, Philip the Fair. He remained abroad till 1289, busied in attempts to improve the administration of Gascony, and making repeated and finally successful efforts to end by his mediation the still continuing struggle between the houses of Anjou and Aragon. His long absence threw the government of England into confusion, and on his return in 1289 he was compelled to dismiss most of his judges and ministers for corruption. In 1290 he expelled all Jews from England.

The affairs of Scotland furnished Edward with his chief preoccupation for the rest of his reign. After the death of Alexander III., in 1286, Scotland was governed in the name of his granddaughter Margaret, the Maid of Norway. The English king had suggested that Edward of Carnarvon, his eldest surviving son, should marry the little queen of Scots, and thus bring about the union of the two countries. However, the death of Margaret in 1290 frustrated the scheme. The Scottish throne was now disputed by many claimants, and the Scots asked Edward to arbitrate between them. Edward accepted the position, but insisted that, before he acted, the Scots should recognize him as their overlord. The claimants set the example of submission, and soon the chief Scots nobles followed. Thereupon Edward undertook the arbitration, and in 1292 adjudged the throne to John Baliol. The new king did homage to Edward, but his subjects soon began to resent the claims of jurisdiction over Scotland, which Edward declared were the natural results of his feudal supremacy. At last the Scots deprived John of nearly all his power, repudiated Edward's claims, and made an alliance with the French.

During the years of the Scottish arbitration Edward had slowly been drifting into war with France. The chronic difficulties caused by French attempts to confine Edward's power in Gascony were now accentuated by the quarrels between the sailors and merchants of the two countries. In 1293 Edward was persuaded by his brother, Edmund, earl of Lancaster, to yield up Gascony temporarily to Philip the Fair. But Philip refused to restore the duchy, and Edward, seeing that he had been tricked, declared war against France, at the very moment when the Scottish resistance gave the French a firm ally in Britain. To make matters worse, the Welsh rose in rebellion. It was therefore quite impossible for Edward to recover Gascony.

The Model Parliament.—The most critical years of Edward's

reign now began. He saw that he could only meet his difficulties by throwing himself on the support of his own subjects, and convoked, in 1295, a representative parliament of the three estates, which has been called in later times the Model Parliament, because it first illustrated the type which was to be perpetuated in all subsequent parliaments. "What touches all," ran Edward's writ of summons, "should be approved of all, and it is also clear that common dangers should be met by measures agreed upon in common." The parliamentary constitution of England was established as the result of Edward's action.

Secure of his subjects' allegiance, Edward put down the Welsh revolt, and conquered Scotland in 1296. When quiet was restored to Britain, he hoped to throw all his energy into the recovery of Gascony, but new troubles arose at home which once more diverted him from his supreme purpose. Led by Archbishop Winchelsea, Peckham's successor, the clergy refused to pay taxes in obedience to the bull of Pope Boniface VIII., called *Clericis Laicos*. Edward declared that if the clergy would not contribute to support the state, the state could afford them no protection.

But the clerical opposition was soon joined by a baronial opposition. Headed by the earls of Hereford and Norfolk, many of the barons declined to join in an expedition to Gascony, and Edward was forced to sail to the French war, leaving them behind. Thereupon the recalcitrant barons forced upon the regency a fresh confirmation of the charters, to which new articles were added, safeguarding the people from arbitrary taxation. Edward at Ghent reluctantly accepted this *Confirmatio Cartarum*, but even his submission did not end the crisis.

Wallace.—In the same year (1297), all Scotland rose in revolt under the popular hero William Wallace, and next year (1298), Edward was forced to undertake its reconquest. The battle of Falkirk, won on July 22, was the greatest of Edward's military triumphs; but, though it destroyed the power of Wallace, it did not put an end to Scottish resistance. Bitter experience taught Edward that he could not fight the French and the Scots at the same time, and in 1299 he made peace with Philip, and, Eleanor having died in November 1290, he married the French king's sister Margaret (*c.* 1282–1318), and some years later obtained the restitution of Gascony. In the same spirit he strove to destroy the clerical and baronial opposition. He did not succeed in the former task until a complacent pope arose in his own subject, Clement V., who abandoned Winchelsea to his anger, and suffered the archbishop to be driven into exile. The baronial leaders could not be wholly overthrown by force, and Edward was compelled to make them fresh concessions.

Bruce.—It was not until 1303 that Edward was able to undertake seriously the conquest of Scotland. By 1305 the land was subdued, and Wallace beheaded as a traitor. But Edward had hardly organized the government of his new conquest when a fresh revolt broke out under Robert Bruce, grandson of the chief rival of Baliol in 1290. Bruce was soon crowned king of Scots, and at the age of 70 Edward had to face the prospect of conquering Scotland for the third time. He resolved to take the field in person; but the effort was too great, and on July 7, 1307 he died at Burgh-on-Sands, near Carlisle. His death destroyed the last faint hope of conquering Scotland, and showed that the chief ambition of his life was a failure. Yet his conquest of Wales, his legislation, his triumph over his barons, his ecclesiastics, and the greatest of French mediaeval kings indicate the strength and permanence of his work. He was buried at Westminster under a plain slab on which was inscribed *Edwardus primus Scottorum malleus hic est. Pactum serva.*

By Eleanor of Castile Edward had four sons, his successor Edward II. and three who died young, and nine daughters, including Joan, or Joanna (1272–1307), the wife of Gilbert de Clare, earl of Gloucester (d. 1295), and then of Ralph de Monthermer; Margaret (1275–1318), the wife of John II., duke of Brabant; and Eleanor (1282–1316), who married John I., count of Holland, and then Humphrey Bohun, earl of Hereford (d. 1322). By Margaret of France the king had two sons: Thomas of Brotherton, earl of Norfolk, and Edmund of Woodstock, earl of Kent.

The principal modern authorities for this reign are: W. Stubbs, *Constitutional History of England*, vol. ii. chaps. xiv. and xv. (1896); T. F. Tout, *Edward I.* (1893), and *Political History of England, 1216–1377*, pp. 136–235 (1905); R. B. Seeley, *Life and Reign of Edward I.* (1872); R. Pauli, *Geschichte von England*, iv. pp. 1–198 (Hamburg, 1864–75); W. Hunt, article on "Edward I." in *Dictionary of National Biography*; J. E. Morris, *Welsh Wars of Edward I.* (Oxford, 1901); and C. V. Langlois, *Philippe le Hardi* (Paris, 1887). (T. F. T.)

EDWARD II. (1284–1327), "of Carnarvon," king of England, the fourth son of Edward I. by his first wife Eleanor of Castile, was born at Carnarvon castle on April 25, 1284. The story that the king presented the new-born child to the Welsh as their future native prince is quite unfounded, for Edward was only made prince of Wales in the Lincoln parliament of 1301. When a few months old, he became by his elder brother's death the heir to the throne, and Edward I. took great pains to train him in warfare and statecraft. He took part in several Scots campaigns, but all his father's efforts could not prevent his acquiring the habits of extravagance and frivolity which he retained all through his life. The old king attributed his son's defects to the bad influence of his friend, the Gascon knight Piers Gaveston, and drove the favourite into exile. When Edward I. died, on July 7, 1307, the first act of the prince, now Edward II., was to recall Gaveston. His next was to abandon the Scots campaign on which his father had set his heart.

The new king was physically almost as fine a man as Edward I. He was, however, destitute of any serious purpose, and was, as Dr. Stubbs says, "the first king after the Conquest who was not a man of business." He cared for nothing but amusing himself, and found his chief delight in athletics and in the practice of mechanical crafts. He was not so much vicious as foolish, and wanting in all serious interests. He had so little confidence in himself that he was always in the hands of some favourite who possessed a stronger will than his own. In the early years of his reign Gaveston held this rôle, acting as regent when Edward went to France—where, on Jan. 25, 1308, he married Isabella, the daughter of Philip the Fair—and receiving the earldom of Cornwall with the hand of the king's niece, Margaret of Gloucester. The barons soon grew indignant at Edward's devotion to his "brother Piers," and twice insisted on his banishment. On each occasion Edward soon recalled his friend, whereupon the barons, headed by the king's cousin Thomas, earl of Lancaster, went to war against king and favourite, and in 1312 treacherously put Gaveston to death. Edward was forced to stand aside and suffer the realm to be governed by the baronial committee of 21 lords ordainers, who, in 1311, had drawn up a series of ordinances, whose effect was to substitute ordainers for the king as the effective government of the country. But in all the ordinances nothing was said about the commons and lower clergy. Parliament meant to the new rulers an assembly of barons just as it had done to the opponents of Henry III. in 1258. The effect of their triumph was to change England from a monarchy to a narrow oligarchy.

During the quarrels between Edward and the ordainers, Robert Bruce was steadily conquering Scotland. His progress was so great that he had occupied all the fortresses save Stirling, which he closely besieged. The danger of losing Stirling shamed Edward and the barons into an attempt to retrieve their lost ground. In June 1314 Edward led a great army into Scotland in the hope of relieving Stirling. On June 24, his ill-disciplined and badly led host was completely defeated by Robert Bruce at Bannockburn. Edward's disgraceful defeat made him more dependent on his barons than ever. His kinsman, Thomas of Lancaster had shown some capacity as a leader of opposition, but though he had great wealth, and was lord of five earldoms, he had small ability and no constructive power. In his desire to keep the king weak, he was suspected to have made a secret understanding with Robert Bruce. Before long the opposition split up under his incompetent guidance into fiercely contending factions. Under Aymer of Valence, earl of Pembroke, a middle party arose, which hated Lancaster so much that it supported the king to put an end to Lancaster's rule. After 1318 the effect of its influence was to restore Edward to some portion of his authority. However, the king hated Pembroke almost as much as Lancaster. He now found

a competent adviser in Hugh le Despenser, a baron of great experience. What was more important to him, he had in Despenser's son, Hugh le Despenser the younger, a personal friend and favourite, who was able in some measure to replace Gaveston. The fierce hatred which the barons manifested to the Despensers showed that they could hate a deserter as bitterly as they had hated the Gascon adventurer. They were indignant at the favours which Edward lavished upon the favourite and his father, and were especially alarmed when the younger Despenser strove to procure for himself the earldom of Gloucester in right of his wife, Edward's niece.

At last, in 1321, the barons met in parliament, and under Lancaster's guidance procured the banishment of the Despensers. The disasters of his friends inspired Edward to unwonted activity. In 1322 he recalled them from exile, and waged war against the barons on their behalf. Triumph crowned his exertions. Lancaster, defeated at Boroughbridge, was executed at Pontefract. For the next five years the Despensers ruled England. Unlike the ordainers, they took pains to get the Commons on their side, and a parliament held at York in 1322 revoked the ordinances because they trenched upon the rights of the crown, and were drawn up by the barons only. From this time no statute was technically valid unless the Commons had agreed to it. This marks the most important step forward in Edward II.'s reign. But the rule of the Despensers soon fell away from this wise beginning. They thought only of heaping up wealth for themselves, and soon stirred up universal indignation. In particular, they excited the ill-will of the queen, Isabella of France. Craftily dissembling her indignation, Isabella kept silence until 1325, when she went to France in company with her eldest son, Edward of Windsor, who was sent to do homage for Aquitaine to her brother, the new French king. When her business was over, Isabella declined to return to her husband as long as the Despensers remained his favourites. She formed a criminal connection with Roger Mortimer of Wigmore, one of the baronial exiles, and in September 1326 landed in Essex accompanied by Mortimer and her son, declaring that she was come to avenge the murder of Lancaster, and to expel the Despensers. Edward's followers deserted him, and on Oct. 2, he fled from London to the west, where he took refuge in the younger Despenser's estates in Glamorgan. His wife followed him, put to death both the Despensers, and, after a futile effort to escape by sea, Edward was captured on Nov. 16. He was imprisoned at Kenilworth castle, and a parliament met at Westminster in January 1327, which chose his son to be king as Edward III. It was thought prudent to compel the captive king to resign the crown, and on Jan. 20, Edward was forced to renounce his office before a committee of the estates. The government of Isabella and Mortimer was so weakly established that it dared not leave the deposed king alive. On April 3, he was secretly removed from Kenilworth and entrusted to the custody of two dependants of Mortimer. After various wanderings he was imprisoned at Berkeley castle in Gloucestershire. Every indignity was inflicted upon him, and he was systematically ill-treated in the hope that he would die of disease. When his strong constitution seemed likely to prevail over the ill-treatment of his enemies he was cruelly put to death on Sept. 21. It was announced that he had died a natural death, and he was buried in St. Peter's abbey at Gloucester, now the cathedral, where his son afterwards erected a magnificent tomb.

Edward's wife, Isabella (*c.* 1292–1358), bore him two sons, Edward III. and John of Eltham, earl of Cornwall (1316–36), and two daughters, Isabella and Joanna (1321–62), wife of David II., king of Scotland. After the execution of her paramour, Roger Mortimer, in 1330, Isabella retired from public life; she died at Hertford on Aug. 23, 1358.

See R. Pauli, *Geschichte von England*, iv. pp. 199–306; T. F. Tout, *Political History of England, 1216–1307*, pp. 236–304, and article in *Dictionary of National Biography;* W. Stubbs, *Constitutional History*, vol. ii. pp. 319–386; *Introductions to Chronicles of the Reigns of Edward I. and Edward II.* in Rolls series; J. C. Davies, *Baronial Opposition to Ed. II.* (1918); Selden Society, *Year books of Edward II.* vols. 1–8, 11–18 (1913–20); T. F. Tout, *The Place of the reign of Edward II. in English History* (1914); A. Bendetti, *Edoardo II. d'Inghilterra all' Abbazia di S. Alberto di Butrio* (1924). (T. F. T.)

EDWARD III. (1312–1377), "of Windsor," king of England, eldest son of Edward II. and Isabella of France, was born at Windsor on Nov. 13, 1312. In 1320 he was made earl of Chester, and in 1325 duke of Aquitaine, but he never received the title of prince of Wales. Immediately after his appointment to Aquitaine, he was sent to France to do homage to his uncle Charles IV., and remained abroad until he accompanied his mother and Mortimer in their expedition to England. To raise funds for this he was betrothed to Philippa, daughter of the count of Hainaut. On Oct. 26, 1326, after the fall of Bristol, he was proclaimed warden of the kingdom during his father's absence. On Jan. 13, 1327, parliament recognized him as king, and he was crowned on the 29th of the same month.

For the next four years Isabella and Mortimer governed in his name, though nominally his guardian was Henry, earl of Lancaster. In the summer he took part in an abortive campaign against the Scots, and was married to Philippa at York on Jan. 24, 1328. On June 15, 1330, his eldest child, Edward, the Black Prince, was born. Soon after, Edward made a successful effort to throw off his degrading dependence on his mother and Mortimer. In Oct. 1330 he entered Nottingham Castle by night, through a subterranean passage, and took Mortimer prisoner. On Nov. 29, the execution of the favourite at Tyburn completed the young king's emancipation. Edward ignored his mother's relations with Mortimer, and treated her with every respect.

Edward III.'s real reign now begins. Young, ardent and active, he strove with all his might to win back for England something of the position which it had acquired under Edward I. He resented the concession of independence to Scotland by the Treaty of Northampton of 1328, and the death of Robert Bruce in 1329 gave him a chance of retrieving his position. The new king of Scots, David, who was his brother-in-law, was a mere boy, and the Scottish barons, exiled for their support of Robert Bruce, took advantage of the weakness of his rule to invade Scotland in 1332. At their head was Edward Baliol, whose victory at Dupplin Moor established him for a brief time as king of Scots. After four months Baliol was driven out by the Scots, whereupon Edward for the first time openly took up his cause. In 1333 the king won in person the battle of Halidon Hill over the Scots, but his victory did not restore Baliol to power. The Scots despised him as a puppet of the English king, and after a few years David was finally established in Scotland. During these years England gradually drifted into hostility with France. The chief cause of this was the impossible situation which resulted from Edward's position as duke of Gascony. Contributing causes were Philip's support of the Scots and Edward's alliance with the Flemish cities, which were then on bad terms with their French overlord, and the revival of Edward's claim, first made in 1328, to the French crown. War broke out in 1337, and in 1338 Edward visited Coblenz, where he made an alliance with the emperor Louis the Bavarian. In 1339 and 1340 Edward endeavoured to invade France from the north with the help of his German and Flemish allies, but the only result of his campaigns was to reduce him to bankruptcy.

In 1340, however, he took personal part in the great naval battle off Sluys, in which he destroyed the French navy. In the same year he assumed the title of king of France. At first he did this to gratify the Flemings, whose scruples in fighting their overlord, the French king, disappeared when they persuaded themselves that Edward was the rightful king of France. The persistence with which he and his successors urged their pretensions to the French crown made stable peace impossible for more than a century, and led to the Hundred Years' War. Till the days of George III. every English king also called himself king of France.

Despite his victory at Sluys, Edward was forced before the end of 1340 to make a truce and return to England. He blamed his chief minister, Archbishop Stratford, for his financial distress, and immediately on his return vindictively attacked him. Before the truce expired a disputed succession to the duchy of Brittany gave Edward an excuse for renewing hostilities. In 1342 he went to Brittany and fought an indecisive campaign against the French.

He was back in England in 1343. He spent much time and money in rebuilding Windsor castle and instituting the order of the Garter, in fulfilment of a vow that he had taken to restore the Round Table of Arthur. His finances, therefore, remained embarrassed, although in 1339 he had repudiated his debt to his Italian creditors. A new phase of the French war begins when in July 1346 Edward landed in Normandy, accompanied by his eldest son, Edward, prince of Wales, a youth of 16. Edward marched from La Hogue to Caen, and from Caen almost to the gates of Paris. It was a plundering expedition on a large scale, and like most of Edward's campaigns showed some want of strategic purpose. But Edward's decisive victory over the French at Crécy, in Ponthieu, on Aug. 26, where he scattered the army with which Philip VI. attempted to stay his retreat from Paris to the northern frontier, signally demonstrated the tactical superiority of Edward's army over the French. Next year Edward effected the reduction of Calais. This was the most solid and lasting of his conquests, and its execution compelled him to greater efforts than the Crécy campaign. Other victories in Gascony and Brittany followed. In 1346, David, king of Scots, was also defeated and taken prisoner at Neville's Cross, near Durham. Want of money forced Edward to make a new truce in 1347. He was as far from the conquest of France as ever.

Edward returned to England in Oct. 1347. He celebrated his triumph by a series of splendid tournaments, and completed his scheme for the establishment of the Order of the Garter. In 1348 he rejected an offer of the imperial throne. In the same year the Black Death first appeared in England, and raged until 1349. Its horrors hardly checked the magnificent revels of Edward's court, and neither the plague nor the truce stayed the slow course of the French war. Edward's martial exploits during the next years were those of a gallant knight rather than of a responsible general. Conspicuous among them were his famous combat with Eustace de Ribemont, near Calais, in 1349, and the hard-fought naval victory over the Spaniards off Winchelsea, in 1350. Efforts to make peace, initiated by Pope Innocent VI., came to nothing, though the English Commons were now weary of the war. The result of this failure was the renewal of war on a large scale. In 1355 Edward led an unsuccessful raid out of Calais, and in Jan. and Feb. 1356 harried the Lothians, in the expedition famous as the Burned Candlemas. His exploits were eclipsed by those of his son, whose victory at Poitiers, on Sept. 19, 1356, resulted in the captivity of King John, and forced the French to accept a new truce. Edward entertained his captive magnificently, and in 1359 concluded with him the Treaty of London, by which John surrendered so much that the French repudiated the treaty. Edward thereupon resolved to invade France afresh and compel its acceptance. On Oct. 28 he landed at Calais, and advanced to Reims, where he hoped to be crowned king of France. The strenuous resistance of the citizens frustrated this scheme, and Edward marched into Burgundy, whence he made his way back towards Paris. Failing in an attack on the capital, he was glad to conclude, on May 8, 1360, preliminaries of peace at Brétigny, near Chartres. This treaty, less onerous to France than that of London, took its final form in the Treaty of Calais, ratified by King John on Oct. 9. By it Edward renounced his claim to France in return for the whole of Aquitaine.

The Treaty of Calais did not bring rest or prosperity either to England or France. Fresh visitations of the Black Death, in 1362 and 1369, intensified the social and economic disturbances which had begun with the first outbreak in 1348. Desperate, but not very successful, efforts were made to enforce the Statute of Labourers, of 1351, by which it was sought to maintain prices and wages as they had been before the pestilence. Another feature of these years was the anti-papal, or rather anti-clerical, legislation embodied in the statutes of Provisors and Praemunire. These measures were first passed in 1351 and 1353, but often repeated. In 1366 Edward formally repudiated the feudal supremacy over England, still claimed by the papacy by reason of John's submission. Another feature of the time was the strenuous effort made by Edward to establish his numerous family without too great expense. In the end the estates of the houses of Lancaster, Kent, Bohun, Burgh and Mortimer swelled the revenues of Edward's children and grandchildren, in whose favour also the new title of duke was introduced.

In 1369 the French king, Charles V., repudiated the Treaty of Calais and renewed the war. Edward's French dominions gladly reverted to their old allegiance. Edward resumed the title and arms of king of France, but left most of the fighting and administration of his foreign kingdoms to his sons, Edward and John. Meanwhile, Edward attacked the wealth and privileges of the Church. In 1371 a clerical ministry was driven from office, and replaced by laymen who proved, however, less effective administrators than their predecessors. Meanwhile Aquitaine was gradually lost; the defeat of Pembroke off La Rochelle deprived England of the command of the sea, and Sir Owen ap Thomas, a grand-nephew of Llewelyn ab Gruffyd, planned, with French help, an abortive invasion of Wales. In 1371 the Black Prince came back to England with broken health, and in 1373 John of Lancaster marched to little purpose through France, from Calais to Bordeaux. In 1372 Edward made his final effort to lead an army, but contrary winds prevented his even landing his troops in France. In 1375 he was glad to make a truce, which lasted until his death. By it the only important possessions remaining in English hands were Calais, Bordeaux, Bayonne and Brest.

Edward was now sinking into his dotage. After the death of Queen Philippa he fell entirely under the influence of a greedy mistress named Alice Perrers, while the Black Prince and John of Gaunt became the leaders of sharply divided parties in the court and council of the king. With the help of Alice Perrers John of Gaunt obtained the chief influence with his father, but his administration was neither honourable nor successful. His chief enemies were the higher ecclesiastics, headed by William of Wykeham, bishop of Winchester, who had been excluded from power in 1371. John further irritated the clergy by making an alliance with John Wycliffe. The opposition to John was led by the Black Prince and Edmund Mortimer, earl of March, the husband of Edward's grand-daughter, Philippa of Clarence. At last popular indignation against the courtiers came to a head in the famous Good Parliament of 1376. Alice Perrers was removed from court, and Duke John's subordinate instruments were impeached. But in the midst of the parliament the death of the Black Prince robbed the commons of their strongest support. John of Gaunt regained power, and in 1377 a new parliament, carefully packed by the courtiers, reversed the acts of the Good Parliament. Not long after, Edward III. died, on June 21, 1377.

Edward III. was not a great man like Edward I. He was, however, an admirable tactician, a consummate knight, and he possessed extraordinary vigour and energy of temperament. His court, described at length in Froissart's famous chronicle, was the most brilliant in Europe, and he was himself well fitted to be the head of the magnificent chivalry that obtained fame in the French wars. Though his main ambition was military glory, he was not a bad ruler of England. He was liberal, kindly, good-tempered and easy of access, and his yielding to his subjects' wishes in order to obtain supplies for carrying on the French war contributed to the consolidation of the Constitution. His weak points were his wanton breaches of good faith, his extravagance, his frivolity and his self-indulgence. Like that of Edward I. his ambition transcended his resources, and before he died even his subjects were aware of his failure.

Edward had 12 children, seven sons and five daughters. Five of his sons played some part in the history of their time, these being Edward the Black Prince, Lionel of Antwerp, duke of Clarence, John of Gaunt, duke of Lancaster, Edmund of Langley, afterwards duke of York, and Thomas of Woodstock, afterwards duke of Gloucester. John and Edmund are also important as the founders of the rival houses of Lancaster and York. Each of the last four was named from the place of his birth, and for the same reason the Black Prince is sometimes called Edward of Woodstock. The king's two other sons both died in infancy. Of his daughters, three died unmarried; the others were Isabella, who married into the family of Coucy, and Mary, who married into that of Montfort.

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EDWARD IV. (1442–1483), king of England, son of Richard, duke of York, by Cicely Neville, was born at Rouen on April 28, 1442. As a boy he was styled earl of March, and spent most of his time at Ludlow. After the Yorkist failure at Ludlow field in October 1459, Edward fled with the earls of Salisbury and Warwick, his uncle and cousin, to Calais. Thence in the following July he accompanied them in their invasion of England, to be welcomed in London, and to share in the victory over the Lancastrians at Northampton. After the acceptance of Richard of York as heir to the crown, Edward returned to the Welsh marches, where early in the new year he heard of his father's defeat and death at Wakefield. Hastily gathering an army he defeated the earls of Pembroke and Wiltshire at Mortimer's Cross on Feb. 2, 1461, and then marched on London. He was acclaimed by the citizens in an assembly at Clerkenwell, declared king by a Yorkist council, and took possession of the regality on March 4. Soon after the new king and the earl of Warwick went north, and on March 28, won a decisive victory at Towton.

Edward owed his throne to his kinsmen the Nevilles, and he was content for the time to be guided by them. For himself he was young and fond of pleasure. He fought in the north during 1462 and 1463, but he was absent from the final victory at Hexham on May 4, 1464, being engaged in contracting a secret marriage with Elizabeth, daughter of Richard Woodville, Lord Rivers, and widow of Sir John Grey of Groby (d. 1461). The marriage was disclosed at Michaelmas, much to the vexation of Warwick, who had projected a match with a French princess. Edward heaped favours on his new relatives; his father-in-law was made treasurer, and great marriages were found for his wife's sisters and brothers. In foreign affairs also Edward thwarted Warwick's plans by favouring an alliance with Burgundy rather than France. There was, however, no open breach till 1469, when Warwick, taking advantage of the unpopularity of the Woodvilles, and supported by the king's next brother George, duke of Clarence, appeared in arms. Edward was surprised and made prisoner at Middleham, and Rivers was beheaded. For six months Edward had to submit to Warwick's tutelage; then on the occasion of a rising in Lincolnshire he gathered an army of his own. Sir Robert Welles, the leader of this rebellion, made a confession implicating Warwick, who fled with Clarence to France. The king thought himself secure, but when Warwick and Clarence made terms with the Lancastrian exiles, Edward in his turn had to seek refuge in Holland (September 1470). His brother-in-law, Charles of Burgundy, at first refused him any assistance, but at last furnished him with money, and on March 14, 1471 Edward and his brother Richard landed with a small force at Ravenspur near Hull. Marching south he was welcomed at London on April 11, defeated Warwick at Barnet three days later, and the Lancastrians at Tewkesbury on May 4. From thenceforth Edward's possession of the crown was secure. His position was strengthened by the birth of a son (Nov. 2, 1470, during his exile), and by the wealth which he acquired through the confiscation of the estates of his opponents. Clarence had made his peace with Edward, but was at enmity with his other brother Richard of Gloucester, who now married Warwick's second daughter and claimed a share in the Neville inheritance. Their rivalry and Clarence's continued intrigues furnished Edward with his chief domestic difficulty; the trouble was ended by the judicial murder of Clarence in 1478.

The only serious enterprise of these latter years was the short French war of 1475, from which Edward was bought out by the treaty of Pecquigny. The peace shows a certain recognition of England's need to concentrate her energies on her own development. The annual subsidy from Louis XI. provided Edward with money for home government, and enabled him to avoid possible trouble through the necessity for too frequent parliaments and heavy taxation. So Edward's personal rule became in its character autocratic; but it was in the art of courting popularity and concealing despotism that he most shows himself as a type of tyranny. He could be ruthless, but was not habitually cruel. His strongest weapons were the fine presence, the affable manners (even with citizens), and the love of pleasure and entertainments which secured his personal popularity. In his last years he was given to self-indulgence and scandalous excesses, which did not, however, alienate the London citizens, with whose wives he was too familiar. Most of the power at court was in the hands of the Woodvilles, in spite of their unpopularity; the more arduous work of administration in the north was left to Richard of Gloucester. If as a prince of the Renaissance Edward was the first to rule tyrannically in England, he also deserves credit as a patron of the new culture and friend of Caxton; he further resembles his Italian contemporaries in the commercial purposes to which he applied his wealth in partnership with London merchants.

Edward died at Westminster on April 9, 1483, and was buried at Windsor. By Elizabeth Woodville, who died on June 8, 1492, he had two sons, Edward V. and Richard of York, who were murdered in the Tower; and five daughters, of whom the eldest, Elizabeth, married Henry VII. Of his numerous mistresses the most notorious was Jane Shore. Before his marriage he had been contracted to Lady Eleanor Butler, and this was alleged by Richard III. to have made his children by Elizabeth Woodville illegitimate.

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EDWARD V. (1470–1483), king of England, was the elder son of Edward IV. by his wife Elizabeth Woodville, and was born, during his father's temporary exile, in the sanctuary of Westminster Abbey on Nov. 2, 1470. In June 1471 he was created prince of Wales. When Edward IV. died in April 1483 a struggle for power took place between the young king's paternal uncle, Richard, duke of Gloucester, who had been appointed as his guardian by Edward IV., and his maternal uncle, Richard Woodville, Earl Rivers. Gloucester obtained possession of the king's person, and, having arrested Rivers and some of his supporters, assumed the crown himself after a very slight and feigned reluctance, on the ground that the marriage of Edward and Elizabeth Woodville was invalid, and consequently its issue was illegitimate. At this time Edward and his brother Richard, duke of York, were living in the Tower of London. Shortly afterwards a movement was organized to free them from captivity, and then it became known that they were already dead; but, though it was the general conviction that they had been murdered, it was 20 years before the manner of this deed was discovered. According to the narrative of Sir Thomas More, Sir Robert Brackenbury, the constable of the Tower, refused to obey Richard's command to put the young princes to death; but he complied with a warrant ordering him to give up his keys for one night to Sir James

Tyrell, who had arranged for the assassination. Two men, Miles Forest and John Dighton, then smothered the youths under pillows while they were asleep. The murder was committed most probably in Aug. or Sept. 1483. Horace Walpole has attempted to cast doubts upon the murder of the princes, and Sir C. R. Markham has argued that the deed was committed by order of Henry VII. Both these views, however, have been traversed by James Gairdner, and there seems little doubt that Sir Thomas More's story is substantially correct.

See RICHARD III.; and in addition, Horace Walpole, *Historic Doubts on the Life and Reign of Richard III.* (1768); Sir Thomas More, *History of Richard III.*, ed. J. R. Lumby (Cambridge, 1883); J. Gairdner and C. R. Markham in the *English Historical Review*, vol. vi. (1891); J. Gairdner, *Richard III.* (Cambridge, 1898); Sir C. R. Markham, *Richard III.* (1907).

EDWARD VI. (1537–1553), king of England and Ireland, born at Greenwich on Oct. 12, 1537, was the only child of Henry VIII. by his third wife, Jane Seymour, who died of puerperal fever 12 days later. The story that the mother's life was deliberately sacrificed by the performance of Caesarean section is unfounded, although Jane's death was little noticed amid the rejoicings which greeted the advent of a male heir to the throne. But in spite of Holbein's vivacious portrait of Edward at the age of two (now at Hanover), he was a frail child, and a short life was anticipated for him from his early years. This did not prevent a strenuous education. Sir John Cheke, Sir Anthony Cooke and Roger Ascham all helped to teach him Latin, Greek and French; and by the age of 13 he had read Aristotle's *Ethics* in the original and was himself translating Cicero's *De philosophia* into Greek.

Edward was duke of Cornwall from his birth, but he was never prince of Wales, and he was only nine when he succeeded his father as king of England and Ireland and supreme head of the church (Jan. 28, 1546/7). His nonage threw power into the hands of Somerset and then of Northumberland, and enabled Gardiner and Bonner to maintain that the royal supremacy over the church was, or should be, in abeyance. Projects for his marriage were hardly even the occasion, but only the excuse, for Somerset's war on Scotland and Northumberland's subsequent alliance with France. All factions sought to control his person; he was an indispensable adjunct to the wielder of authority. The Protector's brother tried to bribe him with pocket-money; Northumberland was more subtle and established a complete dominion over his mind, and then put him forward at the age of 14 as entitled to all the power of Henry VIII. But he was only Northumberland's mask; of his individual influence on the course of history during his reign there is hardly a trace. A posthumous effort was made to give him the credit of a humane desire to save Joan Bocher from the flames; but he recorded with apparently cold-blooded indifference the execution of both his uncles, and he made no attempt to mitigate the persecution of his sister Mary.

Edward showed signs of all the Tudor obstinacy, and he was a fanatic into the bargain, as no other Tudor was except Mary. The combination would probably have involved England in disasters far greater than any that ensued upon his premature death; and it was much better that the Anglican settlement of religion should have been left to the compromising temper of Elizabeth. His health began to fail in 1552, and in May 1553 it was known that he was dying. But his will and the various drafts of it only betray the agitated and illogical efforts of Northumberland to contrive some means whereby he might continue to control the Government and prevent the administration of justice. Mary and Elizabeth were to be excluded from the throne, as not sufficiently pliant instruments; Mary Stuart was ignored as being under Scottish, Catholic and French influence; the duchess of Suffolk, Lady Jane's mother, was excluded because she was married, and the duke her husband might claim the crown matrimonial. In fact, all females were excluded, except Jane, on the ground that no woman could reign; even she was excluded in the first draft, and the crown was left to "the Lady Jane's heirs male." But this draft was manipulated so as to read "the Lady Jane and her heirs male." That Edward himself was responsible for these delirious provisions is improbable, but his last recorded words were vehement injunctions to Cranmer to sign the will. He died at Greenwich on July 6, 1553, and was buried in Henry VII.'s chapel by Cranmer with Protestant rites on Aug. 8, while Mary had Mass said for his soul in the Tower.

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EDWARD VII. (Albert Edward) (1841–1910), king of Great Britain and Ireland, and of the British Dominions beyond the Seas, emperor of India, the eldest son and second child of Queen Victoria and of Albert, prince of Saxe-Coburg and Gotha, was born at Buckingham Palace on Nov. 9, 1841. He was created prince of Wales and earl of Chester on Dec. 4 following, and was baptized on Jan. 25, 1842. In his childhood he was educated by the dowager Lady Lyttleton; and in his boyhood successively by the Rev. Henry Mildred Birch, Mr. F. W. Gibbes, the Rev. C. F. Tarver and Mr. Herbert W. Fisher. He afterwards resided at Edinburgh, studying chemistry in its industrial applications under Professor (afterwards Lord) Playfair at the university; at Christ Church, Oxford; and at Trinity College, Cambridge. In Nov. 1858 he was made a knight of the Garter and a colonel in the army. In 1859 he travelled in Italy and Spain, and in 1860 paid a visit as "Lord Renfrew" to the United States and Canada.

Upon the completion of his Cambridge course in June 1861 he joined the camp at the Curragh. The prince consort died on Dec. 13, and in 1862 the prince of Wales went for a tour in the Holy Land (Feb.–June) under the guidance of Arthur Penrhyn Stanley, afterwards dean of Westminster. Early in 1863 he was sworn of the privy council, and took his seat in the House of Lords as duke of Cornwall. The estate of Sandringham, in Norfolk, was purchased for him out of the savings of his minority, and his town residence was fixed at Marlborough House.

His impending marriage to the princess Alexandra, daughter of Christian IX., king of Denmark (b. Dec. 1, 1844) had already been announced, and took place on March 10, at Windsor, the beauty and grace of the princess captivating the heart of the nation. Parliament granted the prince an income of £40,000 a year, exclusive of the revenues of the duchy of Cornwall, and he relinquished his right of succession to the duchy of Saxe-Coburg-Gotha. Prince Albert Victor, afterwards duke of Clarence, was the first off-spring of the marriage, being born on Jan. 8, 1864. The births followed of Prince George Frederick Ernest Albert, afterwards Duke of York (*see* GEORGE V.), on June 3, 1865; Princess Louise Victoria Alexandra Dagmar, by marriage duchess of Fife, princess royal, on Feb. 20, 1867; Princess Victoria Alexandra Olga Mary, on July 6, 1868; and Princess Maud Charlotte Mary Victoria, afterwards queen of Norway, on Nov. 26, 1869.

From the time of their marriage the prince and princess were prominently before the country. Queen Victoria remained in retirement, but they filled her place at important public functions. The prince's readiness to promote every worthy cause was most marked; no one was a more constant attendant at meetings for objects of public utility of a non-political nature, and his speeches were always characterized by excellent sense. The most important external event of these years was a tour to Egypt, undertaken in 1869 in company with the duke of Sutherland, Sir Samuel Baker and others, an account of which was published by Mrs. William Grey. The prince also visited Ireland more than once, and opened the International Exhibition of 1871.

On Nov. 23, 1871, it was announced that the prince would be prevented by a feverish attack from paying a visit which had been arranged to the Maharajah Dhuleep Singh. It soon appeared

that the malady was typhoid, contracted as was supposed on a visit to Scarborough. The case became so serious that on Nov. 29 the queen and Princess Alice hurried to Sandringham. On Dec. 1 there was a slight rally, but on the 8th so serious a relapse occurred that for some days the prince's life was despaired of. Under the skilful treatment of Sir William Jenner, Sir William Gull, Sir James Paget, and Sir Oscar Clayton, however, the crisis was surmounted by Dec. 16, and by Christmas day the danger was regarded as virtually over. On Feb. 27, 1872, a thanksgiving was held at St. Paul's, amid imposing demonstrations of public joy.

In Jan. 1874 the prince of Wales attended the marriage at St. Petersburg of his brother, the duke of Edinburgh, with the grand-duchess Marie of Russia. In the same year he paid a historic visit to Birmingham, where Joseph Chamberlain, not yet a member of parliament, received him officially as mayor. In March 1875 it was announced that he would make a visit to India, carrying out an idea originally conceived by the first Indian viceroy, Earl Canning. He was supposed to travel as heir-apparent, not as representative of the queen; but the characters could not be kept apart, and in fact the prince's visit was a political event of great importance. Leaving England on Oct. 11, he was received at Bombay by the viceroy, Lord Northbrook. Here he met a very large number of Indian feudatory princes, whose acquaintance he subsequently improved by visiting at their courts during the 17 weeks which he spent in the country. During these four months the prince travelled nearly 8,000 m. by land and 2,500 m. by sea, became acquainted with more rajahs than had all the viceroys who had reigned over India, and saw more of the country than any living Englishman. The visit led up to the queen's assumption of the title of empress of India in the following year.

The prince's life after this date was full of conspicuous public appearances. In 1885 he visited Ireland at a time of much political excitement, and was received enthusiastically in many quarters and without symptoms of ill-will in any. In 1886 he filled the presidency of the Indian and Colonial Exhibition, opened the Mersey Tunnel, and laid the first stone of the Tower Bridge. In 1887 a large share of the arrangements for the queen's Jubilee devolved upon him. On July 27, 1889, his eldest daughter, Princess Louise, was married to the duke of Fife. In the autumn he paid a semi-incognito visit to Paris, where he was always highly popular, viewed the Exhibition and ascended the Eiffel Tower. In 1890 he opened the Forth Bridge. On Jan. 14, 1892, however, a heavy blow fell upon him and his house by the death of his eldest son Prince Albert Victor, duke of Clarence, after a brief illness. The young prince, who with his brother George had made the tour of the world (1879–82) in H.M.S. "Bacchante" and after a short career at Oxford and Cambridge was just settling down to play his part in public life, had recently become engaged to Princess Victoria Mary of Teck (b. May 26, 1867), and the popularity of the heir to the crown had been increased by the expression of his satisfaction at his son's bride being an English princess. On July 6, 1893, the broken thread was reunited by her marriage to Prince George, duke of York.

The year 1894 was a busy one for the prince of Wales, who became a member of the royal commission on the housing of the poor, opened the Tower Bridge, attended the Welsh Eisteddfod and was duly initiated, and paid two visits to Russia—one for the marriage of the grand-duchess Xenia, the other for the funeral of the emperor, his brother-in-law. In 1896 he became first chancellor of the university of Wales, and his first act after his installation at Aberystwyth was to confer an honorary degree upon the princess. He had already been for some years a trustee of the British Museum, and a member of the Standing Committee, which he attended with great regularity. On July 22, 1896, his daughter, Princess Maud was married to Prince Charles of Denmark, who in 1905 was offered and accepted the crown of the new kingdom of Norway. The arrangements for the queen's Jubilee of 1897 depended upon the prince even more than those of the corresponding celebration in 1887: he rode on the queen's right at the great procession to St. Paul's, and as an admiral of the fleet presided at the naval review at Spithead. In July 1898 the prince had the misfortune to fracture his knee-cap while on a visit to Baron Ferdinand de Rothschild, but completely recovered from the effects of the accident. In Dec. 1899, while passing through Brussels on his way to St. Petersburg, he was fired at by a lad named Sipido, crazed by reading anarchist literature. Fortunately no injury was done.

It was the especial distinction of Albert Edward, while prince of Wales, to have been a substantial support of the throne before he was called upon to fill it. This cannot be said of any of his predecessors except Edward the Black Prince. He was exemplary in the discharge of his public duties, and in his scrupulous detachment from party politics. He was a keen patron of the theatre, and his thoroughly British taste for sport was as pronounced as his inclination for most of the contemporary amusements of society. His connection with the turf increased his personal popularity and it did him no disservice with the people to have twice won the Derby with his horses Persimmon (1896) and Diamond Jubilee (1900)—his third victory, in 1909, with Minoru, being the first occasion on which the race had been won by a reigning sovereign; and his interest in yacht-racing was conspicuously shown at all the important fixtures, his yacht "Britannia" being one of the best of her day. His activity in the life of the nation may be illustrated by his establishment (1897) of the Prince of Wales's (afterwards King Edward's) Hospital Fund, his devotion to the cause of Masonry (he was first elected grand master of the Freemasons of England in 1874), and his position as a bencher of the Middle Temple, where he also became (1887) treasurer.

On the death of Queen Victoria on Jan. 22, 1901, the question what title the new king would assume was speedily set at rest by the decision, made on his own initiative, that he would be called Edward the Seventh. This popular announcement was made at a privy council at St. James's Palace, at which the king declared his intention to follow in his predecessor's footsteps, and govern as a constitutional sovereign. On Feb. 14 the king and queen opened parliament in state. Shortly afterwards it was announced that the visit of the duke and duchess of York to Australia, in order to inaugurate the new Commonwealth, which had been sanctioned by Queen Victoria, would be proceeded with; and on March 16 they set out on board the "Ophir" with a brilliant suite. The tour lasted till Nov. 1, the duke and duchess having visited Australia, New Zealand, the Cape and Canada; and on their return the king, on Nov. 9, created the duke prince of Wales and earl of Chester. Meanwhile parliament had settled the new civil list at £470,000 a year, and the royal title had been enlarged to include the colonial empire by an act enabling the king to style himself "Edward VII., by the grace of God, of the United Kingdom of Great Britain and Ireland, and of all the British Dominions beyond the Seas, King, Defender of the Faith, Emperor of India." At the end of May 1902 the long-drawn-out war in South Africa came at last to an end, and the coronation was fixed for June 26. But on the 24th, amid general consternation, the king was announced to be suffering from perityphlitis, necessitating the immediate performance of an operation; and the coronation, for which unprecedented preparations had been made, had to be postponed. The operation—performed by Sir Frederick Treves—was, however so successful, and the king's progress towards recovery so rapid and uninterrupted, that within a fortnight he was pronounced out of danger, and soon afterwards it was decided to hold the coronation service on Aug. 9. Though shorn of much of the interest which would have been added to it in June by the presence of foreign royalties and the preparation for a great procession through London, the solemnity duly took place on that date in Westminster Abbey amid great rejoicings. The king spent several weeks (partly in a yachting trip round the coast and up to Stornoway) in recruiting his health, and on Oct. 25 he went in procession through the main streets of south London, when he was most enthusiastically received. Next day the king and queen attended St. Paul's cathedral in state to return thanks for his restoration to health. On New Year's day, 1903 the coronation was proclaimed in India in durbar at Delhi.

At home the king opened parliament in person in Feb. 1903, and on March 31 he sailed from Portsmouth to pay a visit to the king of Portugal at Lisbon, leaving Lisbon for Gibraltar on April 7. On the 11th he held a review of the garrison troops and next day left for Malta, and the tour was continued to Naples (April 23). On April 27 he was received at Rome by the king of Italy—the first time an English king as such had been there; and two days later he paid a visit to Leo XIII. at the Vatican. On May day he was received in Paris by President Loubet. Later in the year return visits were paid to England by President Loubet (July) and the king and queen of Italy (Nov.). On May 11 His Majesty paid his first formal visit to Edinburgh, and held courts at Holyrood. In July the king and queen went to Ireland, and though the Dublin corporation refused to vote a loyal address the reception was generally cordial. In September the king took his annual "cure" at Marienbad, and paid a visit to Vienna, where he was received by the Austrian emperor. In 1904, again the king and queen went to Ireland; in June the king was cordially received by the German emperor at the yacht-races at Kiel, and he included a visit to Hamburg, where the welcome was hearty. In November the king and queen of Portugal were entertained at Windsor and at the Guildhall.

The success of King Edward as a promoter of international friendliness, and the advantage of so efficient a type of kingship, attracted universal attention, and treaties of arbitration were concluded by Great Britain with France, Spain, Italy, Germany and Portugal, in 1903 and 1904. In his first two years the king had already earned the title of Edward the Peacemaker, and established his position as a source of new strength to the state. This reputation was confirmed in the years which followed, during which the royal hand was to be seen in the progress of foreign affairs in a manner somewhat new to politicians accustomed to the less conspicuous activities of Queen Victoria. The *entente* with France was promoted by his influence, notably by his reception of and by two French presidents of the Republic in Paris and London. It was noticed that the permanent under-secretary for foreign affairs, Sir Charles Hardinge, generally accompanied the king, as one of his suite, on his visits abroad; and the conclusion of the Anglo-Russian agreement (1907)—which was attributed with some reason to royal policy—was criticized in Radical quarters. It was pointed out that neither the foreign secretary (Sir E. Grey) nor any other secretary of state accompanied the king on his foreign visits. These objections were, however, scouted by the king's ministers and undeniably public opinion approved of the sovereign's personal activity in a sphere peculiarly his own. The strengthening of British influence in Europe, which was the marked result of the Anglo-French and Anglo-Russian *ententes,* and of the closer ties between England and countries like Portugal and Spain (whose young king Alfonso married Princess Ena of Battenberg, King Edward's niece), had, indeed, temporarily the effect of rousing German suspicion, the view taken being that the object of British foreign policy was to isolate Germany; and during 1907 and 1908 the political situation was coloured by the discussions in the press with regard to Anglo-Germany rivalry. But in Feb. 1909, in spite of the perfunctory attitude of the German press, the king and queen paid a state visit to the Kaiser in Berlin, where cordiality was displayed on all sides; the event was prepared for in both countries, as a means of dispelling the clouds which had gathered over the relations between England and Germany, and the success of the visit proved once more how powerful King Edward's personality could be as an agency for peace and international amity.

During the year 1909, however, the political situation at home was developing into an acute constitutional crisis, which seemed likely to involve the Crown in serious difficulties. Lloyd George's budget convulsed the House of Commons and the country, and was eventually rejected by the House of Lords; and the Liberal government now put in the forefront of its programme the abolition of the Peers' "veto." This grave political disturbance coincided with a failure in the king's physical powers, which had, for three years, caused anxiety to his intimate friends. Although certainly not prejudiced against a Liberal ministry, the king was seriously disturbed by the progress of events which culminated in the return of Asquith to office after the elections of Jan. 1910, and in his statement that, if necessary, guarantees would be sought from the Crown for the purpose of enforcing the will of the representative Chamber. A remarkable sign of the king's discomfort was his insertion in the official "King's Speech" at the opening of parliament, of the words "in the opinion of my advisers," in connection with the passage dealing with the House of Lords. The king while he was taking change and rest at Biarritz in the early spring of 1910 had a bronchial attack of unusual severity which caused some anxiety, although the public heard nothing of it. In the country at large there was indeed considerable confidence that the king's tact and experience would help to solve the grave difficulties that were confronting his government and the country, but this was not to be. Within two days the public heard with consternation that he was ill, and then he was dead. On May 5 it was announced that he had bronchitis; and he died at 11.45 p.m. on the 6th of heart failure. On May 17, 18 and 19 there was an impressive lying-in-state in Westminster Hall, attended by unprecedented crowds; and on May 20 the burial took place at Windsor, after a funeral procession through London, the coffin being followed by the new king, George V., and by eight foreign sovereigns—the German emperor, the kings of Greece, Spain, Portugal, Denmark, Norway, Belgium and Bulgaria—besides the archduke Franz Ferdinand of Austria (heir to the throne of Austria Hungary), the prince consort of Holland and many other royalties and a number of special ambassadors, including Roosevelt as representative of the United States. Mourning was as sincere as it was universal; for not only England and the British Empire, but the world, had lost a king who had rendered and was rendering great service to his people, and whose personal charm was recognized by men and women of every class.

Queen Victoria's long reign had solidly established the constitutional monarchy; it remained for her son to rehabilitate the popular aspect of English kingship. While prince of Wales he had had widespread knowledge of public affairs, but little training in state-craft. When he became king his genuine capacity for affairs was a matter of general surprise. Ably advised by such men as Lord Knollys and Lord Esher, he devoted himself to the work of removing the Throne from its former isolation and bringing it into touch with all sections of the community for the promotion of social happiness and welfare. His own love of pageantry and his interest in the stately ordering of court functions responded moreover to a marked inclination on the part of the public and of "society."

When all is said of the value of King Edward's intimate knowledge of foreign courts and of his personal popularity in foreign capitals, it is essential to insist that he undertook no formal negotiations, nor did he act except on the advice of his ministers. While helping to win for his country a high place in the councils of the world, he kept careful watch upon the course of events at home. The smoothness of his co-operation with his Ministers was not the least among his successes as a ruler and both Sir Henry Campbell-Bannerman (for whom the king came to have a strong personal regard) and Asquith were wise enough to recognize and to use his knowledge of international politics and his personal influence with Continental statesmen. It was significant that even Radicals and Socialists began to advocate extensions of the prerogative, and to insist on the active part which the Crown should play in public life. The king won the genuine affection and confidence of the people; and in Queen Alexandra he had an ideal consort to whom all hearts went out.

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Russell's *Diary* (1877), Sir Joseph Fayrer's *Recollections of My Life* (1900), and Sir Horace Rumbold's *Recollections*, etc. (1902), *Further Recollections* (1903), and *Final Recollections* (1905). For foreign impressions of King Edward VII., *see* J. Bardoux, *Victoria; Edward VII., Georges V.* (2nd ed. 1911) and Hermann, Freiherrn von Eckardstein *Persönliche Erinnerungen an König Eduard* (Dresden, 1927).
(H. C.; E.)

EDWARD, prince of Wales, known as "THE BLACK PRINCE" (1330–1376), the eldest son of Edward III. and Philippa of Hainaut, was born at Woodstock on June 15, 1330. Contemporaries called him Edward of Woodstock, and his surname of the Black Prince cannot be traced back earlier than the 16th century. It is supposed to have been derived from his wearing black armour. In 1333 he was made earl of Chester, and in 1337 duke of Cornwall, being the first duke ever created in England. Nominal warden of England during his father's absences abroad in 1338 and 1342, he was created prince of Wales in 1343, and in 1345 he first accompanied his father on a foreign expedition.

His real career begins, however, with Edward III.'s Norman campaign of 1346. He commanded the right wing of the English forces of Crécy, and, though hard pressed for a time by the French, took his full share in gaining the victory. Next year he was at the siege of Calais, and returned to England in October 1347 with his father. He was one of the original knights of the Garter, and participated in his father's chivalrous adventures at Calais in 1349 and in the battle of Winchelsea in 1350. In September 1355 he was sent to Gascony at the head of an English army, having been appointed his father's lieutenant there in July. He was warmly welcomed by the Gascons, and at once led a foray through Armagnac and Languedoc. By November he had got as far as Narbonne, whence he returned to Bordeaux, where he kept his Christmas court. In August 1356 he started from Bergerac on another marauding expedition, this time in a northerly direction. He penetrated as far as the Loire, but was there compelled to retire before the superior forces of King John of France. On Sept. 19, the two armies met in the battle of Poitiers, fought about 6 m. S.E. of the city. Edward's victory was due both to the excellence of his tactical disposition of his forces and to the superior fighting capacity of his army. The flank march of the Captal de Buch, which decided the fate of the day, was of Edward's own devising, and the captivity of King John attested the completeness of his triumph. He treated his prisoner with magnanimity, and took him to Bordeaux, whence they sailed to England in May 1357. On the 24th of that month he led his prisoner in triumph through the streets of London. In 1359 he took part in his father's invasion of northern France, and had a large share in the negotiations at Brétigny and Calais.

In October 1361 Edward married his cousin Joan, countess of Kent (1328–85), the daughter and heiress of Edmund of Woodstock, earl of Kent, the younger son of Edward I. by his second wife Margaret of France. The lady was the widow of Sir Thomas Holand, by whom she had had three children. Froissart says that the marriage was a love match, and that the king had no knowledge of it. But Edward III. approved of his son's choice, and in July 1362 handed over to him all his dominions in southern France, with the title of prince of Aquitaine. In February 1363 Edward and Joan took ship for Gascony, which became his ordinary place of residence for the next eight years. He maintained a brilliant court at Bordeaux and Angoulême, and did his best to win the support of the Gascons. He was not, however, successful in winning over the greater nobles, who, with John, count of Armagnac, at their head, were dissatisfied with the separation from France, and looked with suspicion upon Edward's attempts to reform the administration as being likely to result in the curtailment of their feudal rights. Edward was better able to conciliate the towns, whose franchises he favoured and whose trade he fostered, hoping that they would prove a counterpoise to the aristocracy. He kept the chief posts of the administration mainly in English hands, and never really identified himself with the local life and traditions of his principality. He succeeded in clearing Aquitaine of the free companies, and kept good peace for nearly six years.

In 1367 Peter the Cruel, the deposed king of Castile, visited Edward at Bordeaux, and persuaded him to restore him to his throne by force. In February 1367 Edward led an army into Spain over the pass of Roncesvalles. After a difficult and dangerous march Edward reached the Ebro, and on April 3 defeated Bertrand du Guesclin at Nájera, the last of his great victories. He then proceeded to Burgos, and restored Peter to the throne of Castile. He remained in Castile for four months, living principally at Valladolid. His army wasted away during the hot Spanish summer, and Edward himself contracted the beginnings of a mortal disease. In August 1367 Edward led the remnant of his troops back through the pass of Roncesvalles, and returned to Bordeaux early in September. He was now forced to seek from the estates of Aquitaine extraordinary sources of supply. A hearth tax for five years was willingly granted to him, and generally paid. The greater barons, however, found in this impost a pretext for revolt. The count of Armagnac appealed against the hearth tax to the parlement of Paris. Cited before this body in January 1369, Edward declared that he would answer at Paris with sixty thousand men behind him.

War broke out again, and Edward III. resumed the title of king of France. Thereupon Charles V. declared that all the English possessions in France were forfeited, and before the end of 1369 all Aquitaine was in full revolt. Though too ill to ride on horseback, the Black Prince insisted upon commanding his troops, and on Sept. 19, 1370 won his last barren success, by capturing the revolted city of Limoges and putting the population to the sword. Early in 1371 he returned to England, leaving the impossible task of holding Gascony to his brother John of Gaunt. In October he resigned his principality on the ground that he could not afford to retain any longer so expensive a charge. His health now rapidly declined, but he did what he could to support the constitutional opposition of the great ecclesiastics to the administration of John of Gaunt and the anti-clerical courtiers. His last public act was to inspire the attack on Lancaster's influence made by the Good Parliament in the spring of 1376. He died at Westminster on July 8. He was buried in the east end of Canterbury cathedral on Sept. 29, where his magnificent tomb, erected in accordance with the instructions in his will, may still be seen. By Joan, "the fair maid of Kent," who died on Aug. 7, 1385, the Black Prince left an only son, afterwards King Richard II.

For authorities *see* EDWARD III. To these may be added W. Hunt's article in the *Dict. Nat. Biog.*; A. Collins, *Life of Edward, Prince of Wales* (1740); G. P. R. James, *Life of Edward the Black Prince* (1839); J. Moisant, *Le Prince Noir en Aquitaine* (1894); R. P. Dunn-Pattison, *The Black Prince* (1910); W. H. St. T. Hope, *The Achievements of Ed., in the Cathedral Church of Canterbury* (1895); Sir I. Gollancz, *Ich Dene* (1921). (T. F. T.)

EDWARD, PRINCE OF WALES (1894–), eldest son of King George V. and Queen Mary, at that time duke and duchess of York, was born on June 23, 1894, at White Lodge, Richmond park, and baptised 23 days later by the archbishop of Canterbury as Edward Albert Christian George Andrew Patrick David. In 1902 H. P. Hansell was appointed his tutor, and remained with him from that time until Aug. 1914. During 1902–7 the prince was prepared for the navy, and in the spring of 1907 he entered Osborne, where he remained for two years before going on to the Royal Naval college, Dartmouth. While a cadet at Dartmouth he performed his first public duty on March 29, 1911, by presenting to the mayor and corporation of that town the silver oar which they had held formerly as a symbol of the rights associated with the bailiwick of the water of Dartmouth.

At the close of his Dartmouth training in June 1911, he was invested as a Knight of the Garter, and on July 13, 1911, after his father's accession he was created prince of Wales and earl of Chester. About the same time the duchy of Cornwall was bestowed upon him. He was shortly afterwards invested as prince of Wales in Carnarvon Castle, and on this occasion for the first time an English prince addressed the Welsh people in their own tongue. Shortly after this event the prince became a midshipman, and was appointed to H.M.S. "Hindustan," in which ship he served for three months. During the spring of 1912 the prince spent five months in Paris as the guest of the marquis de Breteuil, and was coached by Maurice Escoffier in the language and history of the country. In Oct. 1912 the prince entered

Magdalen college, Oxford, with Major the Hon. William Cadogan (10th Hussars) as equerry. At Oxford the prince took part in the corporate life of his college and the usual athletic amusements of the undergraduates. He resided in college rooms, dined in hall or at one of the university clubs, and mixed freely with his fellow undergraduates. Some of his vacations he spent in European travel, visiting Germany twice, in 1912 and 1913, and Denmark and Norway in 1914. The prince's university career was ended by the outbreak of the World War in Aug. 1914. On Aug. 7 he was gazetted to the Grenadier Guards, and on the 11th he joined the 1st Battalion at Warley barracks, Essex.

In Nov. 1914 the prince, who had been appointed aide-de-camp to Sir John French, arrived in France and took up his new duties at British G.H.Q. at St. Omer. During the next 18 months he served with the Expeditionary Force in Flanders and in France in various parts of the line, being first attached to the 2nd Division under Sir H. S. Horne, to the I. Corps under Sir Charles Monro, and later to the Guards Division under the Earl of Cavan. In March 1916 he was appointed to the staff of the general officer commanding the Mediterranean Expeditionary Force, and proceeded at once to Egypt. He took the opportunity of seeing the troops in various parts of the line, and also went as far south as Khartum. On his return journey he paid a visit to the Italian headquarters at Udine, and by the middle of June had returned to the British armies in France. He was then attached to the XIV. Corps (Lord Cavan) in Flanders and France and subsequently proceeded with this corps, in Oct. 1917, to the Italian front, where he remained till Aug. 1918. In May 1918 the Prince paid a semi-official visit to Rome; he then returned to France and was attached to the Canadian Corps, with whom he was serving at the time of the Armistice. He was attached to the Australian Corps in Belgium till the beginning of 1919 after which he visited the Army of Occupation on the Rhine, spending a few days with the New Zealand Division, and paying a short visit to General Pershing at the American headquarters at Coblenz.

On his return journey to England at the end of Feb. 1919 the prince almost immediately took up a number of public duties which had of necessity been deferred during the war, and on May 29 was admitted to the freedom of the City of London. On Aug. 5, 1919, he left Portsmouth in H.M.S. "Renown" for Newfoundland and Canada, first setting foot on Canadian soil on Aug. 15 at St. John, New Brunswick. His tour extended through the entire dominion from east to west, and five days after reaching Victoria on Sept. 23 the return journey began. The Canadian tour ended at Ottawa, and on Nov. 10 the prince left for Washington to pay a short official visit to the President of the United States. New York was subsequently visited, and after a long series of official engagements, the prince sailed for Halifax, where he bade good-bye to Canada, reaching Portsmouth on Dec. 1.

After a short stay in England, the prince sailed again in H.M.S. "Renown" on March 16, 1920 for New Zealand and Australia. The first port of call was Bridgetown, Barbados, and then, passing through the Panama Canal, the prince paid short visits to San Diego (Cal.), Honolulu and Fiji, Auckland being reached on April 24 after a voyage of 14,000 miles. A month was spent in New Zealand, all parts of the North and South islands were visited, and on May 26 the prince landed at Melbourne. During his stay in Australia he visited all the states of the Commonwealth, and eventually sailed from Sydney on Aug. 19. On the return journey he stopped at Fiji, Samoa, Honolulu and Acapulco, and, after passing once again through the Panama Canal, the prince spent three weeks in the West Indies. The last port of call was Bermuda, and H.M.S. "Renown" eventually reached Portsmouth on Oct. 11, 1920.

After a brief holiday, spent for the greater part in the hunting field, he resumed his public duties after Christmas 1920. During the first six months of 1921 he was occupied chiefly in London, but found time to visit, among other places, Oxford, Cambridge, Glasgow and the Clyde; his property in Devon, Cornwall and the Scilly Isles; Cardiff, Newport and Bristol. On Oct. 26 he sailed in the "Renown" on a state visit to India, visiting Gibraltar, Malta (where he opened the first Maltese parliament) and Aden, landing at Bombay on Nov. 17. After several weeks in India, he sailed from Calcutta for Rangoon (Jan. 2, 1922) and proceeded to Mandalay, returning thence to Madras (Jan. 13). There, as previously at Bombay, some rioting occurred in the native quarters on the day of his arrival; but on the whole he was splendidly received, even though attempts were made by the Swarajists, with occasional success, to persuade the population to remain indoors. At Delhi on Feb. 14 he received an address from the Indian legislature. After visiting the north-west frontier he eventually embarked at Karachi on March 7, sailing thence to Japan, touching on the way at Colombo, Port Swettenham, Singapore and Hong Kong, and reaching Tokio on April 12. He remained in Japan till May 9, and on the voyage home visited Manila, Borneo, Penang and Cairo, reaching Plymouth on June 20.

In April 1923 he paid a visit to Brussels in order to dedicate the monument erected by the British government to show British gratitude for kindness shown to British prisoners of war after the Armistice, and then revisited the battlefields in Flanders and northern France. On Sept. 5 he sailed for Canada on a private visit to his ranch in Alberta, returning to England on Oct. 20. On April 23, 1924, as president of the British Empire Exhibition at Wembley, he received King George at the opening ceremony. He was also present at the close on Nov. 1. In the meanwhile he had again spent a short time on his ranch in Canada; on his way there he visited the United States in a private capacity, in order to witness the international polo matches, and took the opportunity of calling on President Coolidge, with whom he had luncheon at the White House. During 1923–24 he visited various industrial areas, including west Yorkshire, Birmingham, Newcastle-on-Tyne, Nottingham, Dundee, North Wales and the Potteries district.

On March 28, 1925, he sailed in the "Repulse" for West and South Africa. Landing at Bathurst on April 4 he visited in turn Gambia, Sierra Leone, the Gold Coast and Nigeria. Leaving Lagos on April 22, he reached Cape Town on April 30, and after a short stay proceeded through the Cape Province and into the native territories of the Transkei. His journey was continued through the Orange Free State, and at Maseru he was greeted by 50,000 Basuto horsemen. During his stay in Natal he opened a new dock at Durban and was there welcomed by 23,000 Indians. He went through Zululand, Swaziland and thence to Pretoria and Johannesburg, where he opened the University of the Witwatersrand; then via Mafeking and the Bechuanaland Protectorate he travelled through Southern and Northern Rhodesia.

On the return journey to Cape Town he visited Kimberley. After spending three months in South Africa he sailed on July 29 for South America, having accepted an invitation conveyed to him in 1924 by the president of the Argentine republic, to visit that country. Touching only at St. Helena for two days, he arrived at Montevideo Aug. 14. After three days spent in Uruguay, he reached Buenos Aires on Aug. 17, stayed for a time in the capital, and made one or two tours in the country, including a journey of 1,500 miles to the cattle-raising districts in the provinces of Entre Rios and Corrientes. He crossed the Andes into Chile, visiting Santiago and Valparaiso, and after some delay, owing to avalanches of snow in the mountains, returned to Buenos Aires. Sailing from Mar del Plata for England on Sept. 27, he touched at the Cape Verde islands, Oct. 8, and reached Portsmouth on Oct. 16. In 1926 the prince underwent a slight operation for ear trouble which temporarily interfered with his public duties. Nevertheless, in that year he presided over the British Association at Oxford, and paid an official visit to Paris when, with the President, he opened the Canadian Students' hostel.

In 1927 he visited many of the great industrial centres in Great Britain. In August and September he paid a visit to Canada with Stanley Baldwin, the prime minister, to take part in the centenary celebrations of the Canadian confederation, and took the opportunity of visiting his Canadian ranch. He made many friends in Canada, and renewed earlier friendships. His passion for sport and for outdoor life found an outlet at home in the hunting-field. But he was punctilious in fulfilling his official duties, and in his

public speeches showed a wit and spontaneity which won him many friends.

Some indication of the pressure of his public life is given by the fact that in May 1928 an aeroplane was placed at his disposal, for travelling to his official duties.

In September 1928, he left London for East Africa, accompanied by his brother the Duke of Gloucester, landing at Mombassa on Sept. 29. While he was on a shooting expedition, the news of the King's illness caused him to abandon his tour and he reached London on Dec. 11, having travelled 6,000 miles in 14 days. In 1929 the prince made a tour of some of the most depressed coalfields. He arranged his visits himself, inspected paysheets and conditions and his comments drew much public attention to the miners' sufferings.

EDWARD, LAKE, in Central Africa, the southern of the two western reservoirs of the Nile, formerly known as Albert Edward Nyanza. It lies in the Albertine rift-valley between 0° 8′ and 0° 40′ S. and 29° 28′ and 29° 52′ E., at an elevation of 3,004 ft. above the sea. It is roughly oval in shape and has no deep indentations. On its N.E. side it is connected by a winding channel, 25 m. long and from a quarter of a mile to a mile wide, flowing between high banks, with a smaller sheet of water, Lake Dweru, which extends north of the equator. Lake Edward has a length of 44 m. and a breadth of 32 m. (maximum measurement). Dweru is about 20 m. long and 10 across at its widest part. The area of the two lakes is approximately 820 sq.m.

A swampy plain, traversed by the Ruchuru and other rivers, extends south of the Nyanza and was once covered by its waters. The plain contains several salt-pans, and at the S.E. corner are numerous geysers. Along the eastern shore the low land extends to Kamarangu, about midway between the south and north ends of the lake, a considerable stretch of ground intervening between the wall of the rift-valley and the water, two terraces being clearly defined. The euphorbia trees and other vegetation on the lower terrace are small and apparently recent. At some distance from the lake runs a belt of forest. North of Kamarangu the wall of the valley approaches the water in a series of bluffs some 300 to 350 ft. high. At the N.E. end the hills again recede and the plain widens to include Dweru. On the west side of the lake the wall of the rift-valley runs close to the lake shore and at the N.W. corner the mountains close in on the water. North of the lake a high alluvial plain stretches to the southern slopes of the Ruwenzori mountains. From Ruwenzori a subsidiary range, the Kipura mountains, runs due south to the lake shore, where it ends in a low rounded hill. In general, the plain rises above the lake in a series of bold bluffs, a wide margin of swamp separating them from the water. The Semliki, the only outlet of the lake, issues from its N.W. end. Round the north-eastern shore of the lake are numerous crater lakes, many salt, the most remarkable being that of Katwe. This lake lies west of the Dweru channel and is separated from Lake Edward by a ridge of land, not more than 160 ft. in breadth. The sides of this ridge run down steeply to the water on either side. The waters of the Katwe lake have a beautiful rose colour which becomes crimson in the shadows. The salt is highly prized and is exported to great distances.

The main feeder of Lake Edward, and western head-stream of the Nile, the Ruchuru, rises on the north side of the volcanoes north of Lake Kivu (*see* MFUMBIRO). On reaching the level plain 15 m. from the lake its waters become brackish, and the vegetation on its banks is scanty. The reedy marshes near its mouth form a retreat for a primitive race of fishermen. Lake Dweru, the shores of which are generally high, is fed by the streams from the eastern slopes of the Ruwenzori range. One of these, the Mpango, is a larger river than the Ruchuru. The outlet of the lake, the Semliki, and the part played by the lake in the Nile system are described under ALBERT, LAKE (A. NYANZA). (*See* also AFRICA: *Geography and Geology* and NILE.)

A feature of Lake Edward is the thick haze which overhangs the water during the dry season, blotting out from view the mountains. In the rains, when the sky is clear, the magnificent panorama of hills encircling the lake on the west and north-west is revealed. The lake water is clear, of a light green colour and distinctly brackish. Fish abound, as do waterfowl, crocodiles and, in the southern swamps, hippopotami. In the rainy season the lake is subject to violent storms.

The entire area of Lake Edward was found, by the work of the Anglo-German Boundary Commission of 1902–04, to lie within the limits of the sphere of influence of the Congo Free State as defined in the agreement of May 12, 1894, between that state and Great Britain. Dweru was discovered in 1875 by H. M. Stanley, then travelling westward from Uganda, and by him was named Beatrice gulf in the belief that it was part of Lake Albert. In 1888–89 Stanley, approaching the Nile region from the west, traced the Semliki to its source in Lake Edward, which lake he discovered, naming it after Albert Edward, prince of Wales, afterwards Edward VII. Stanley also discovered the connecting channel between the larger lake and Dweru. The accurate mapping of the lake was mainly the work of British officials and travellers, such as Scott Elliott, Sir F. D. Lugard, Ewart Grogan, J. E. Moore and Sir H. Johnston; while Emin Pasha and Franz Stuhlmann, deputy-governor (1891) of German East Africa, explored its southern shores.

EDWARDES, SIR HERBERT BENJAMIN (1819–1868), English soldier-statesman in India, was born at Frodesley, Shropshire, on Nov. 12, 1819. He was nominated in 1840 to a cadetship in the East India Company, and was posted (1841) ensign in the 1st Bengal Fusiliers. In November 1845 Edwardes was appointed aide-de-camp to Sir Hugh (afterwards Viscount) Gough, then commander-in-chief in India. He served with Gough through the Sikh war, then in a civil appointment in the trans-Sutlej territory, and on Dec. 18 he was severely wounded at the battle of Mudki. He soon recovered, however, and fought by the side of his chief at the decisive battle of Sobraon (February 10, 1846). He was soon afterwards appointed third assistant to the commissioners of the trans-Sutlej territory; and in January 1847 he was named first assistant to Sir Henry Lawrence, the resident at Lahore. He took part with Lawrence in the suppression of a religious disturbance at Lahore in the spring of 1846, and assisted him in reducing, by a rapid movement to Jammu, the conspirator Imam-ud-din. In 1847 he conducted an expedition to Bannu, a district on the Waziri frontier, where the revenue had fallen into arrear. Edwardes conquered the wild tribes of the valley without firing a shot, and concluded fiscal arrangements which obviated all difficulty of collection for the future. In the spring of 1848, after the murder of van Agnew and Anderson at Multan, by order of the diwan Mulraj, Edwardes occupied Leiah on the left bank of the Indus, was joined by Colonel van Cortlandt, and, although he could not attack Multan, held the enemy at bay and gave a check at the critical moment to their projects. He won a victory over a superior Sikh force at Kinyeri (June 18). Edwardes took part in the siege and capture (1849) of Multan under General Whish. His account of the campaign, *A Year on the Punjab Frontier in 1848–1849*, was written during a short period of leave in England, after which he returned to the Punjab. Lawrence, whose trusted lieutenant he was, sent him (1853) to the Peshawar frontier as commissioner. He was stationed there when the Indian Mutiny broke out. It was a position of enormous difficulty. Edwardes rose to the occasion. He effected a reconciliation with Afghanistan, and secured the neutrality of the amir and the frontier tribes during the war. So effective was his procedure for the safety of the border that he was able to raise a large force in the Punjab and send it to co-operate in the siege of Delhi. After three years rest in England (1859–62), during which he was created K.C.B. with the rank of brevet-colonel, he returned to India as commissioner of Umballa and agent for the Cis-Sutlej states. In February 1865 failing health compelled him to retire. In May 1866 he was created K.C.S.I. and early in 1868 was promoted major-general in the East Indian Army. He died in London on Dec. 23, 1868. The life of Sir Henry Lawrence on which he was engaged was finished by Herman Merivale after his death.

See *Memorials of the Life and Letters of Sir Herbert Benjamin Edwardes, by his wife* (2 vols., 1886); T. R. E. Holmes, *Four Soldiers* (1889); J. Ruskin, *Bibl. pastorum*, iv. "A Knight's Faith" (1883), passages from the life of Edwardes.

EDWARDS, ALFRED GEORGE (1848–), first archbishop of Wales, was born at Llanymawddwy on Nov. 2, 1848, and was educated at Jesus college, Oxford. He was ordained in 1874, and in 1875 became warden and headmaster of the college at Llandovery, holding this position until 1885, when he was appointed vicar of Carmarthen. In 1889 he was chosen bishop of St. Asaph. In 1920, after the disestablishment of the Welsh Church, of which disestablishment he had been an active opponent, he was elected first archbishop of Wales.

Among his publications may be mentioned *The Church in Wales* (1888); *Common Sense Patriotism* (1894); and *Landmarks in Welsh Church History* (1912).

EDWARDS, AMELIA (1831–1892), English author and Egyptologist, born in London. She wrote novels, the most successful of which were *Debenham's Vow* (1870) and *Lord Brackenbury* (1880). After her visit to Egypt in 1873 she devoted herself to Egyptology. Convinced that only proper scientific research could preserve the antiquities of Egypt, she helped to form the Egypt Exploration Fund. She published in 1877 *A Thousand Miles Up the Nile*, and in 1891 *Pharaohs, Fellahs and Explorers*, the substance of lectures delivered in America the previous year. She died in Weston-super-Mare, leaving her collections to University college, London, and endowing a chair of Egyptology.

See K. S. Macquoid, *Julia Kavanagh, Amelia Blandford Edwards* (1897).

EDWARDS, BRYAN (1743 to 1800), English politician and historian, was born at Westbury, Wilts., on May 21, 1743. About 1759 he went to join his uncle in Jamaica, and subsequently succeeded to his estates there. He sat in the colonial assembly of Jamaica and in 1796, by which time he had finally returned to England, became M.P. for Grampound, retaining his seat till his death at Southampton on July 15 or 16, 1800. A supporter of the slave trade, he was a powerful opponent of Wilberforce. His great book is a *History of the British Colonies in the West Indies* (3 vols.).

See the biographical sketch prefixed to the 1801 edition of his *History of the West Indies.*

EDWARDS, ENOCH (1852–1912), British Labour politician, was born at Talk-o'-the-Hill, Staffs., on April 10, 1852. He was the son of a pitman, and worked as a boy in a coal-mine. In 1870 he was appointed treasurer and in 1877 secretary of the North Staffordshire Miners' Association. In 1884 he became member of the school board and town council of Burslem, and later alderman and mayor. In 1880 he became president of the Midland Miners' Association; he was later president of the Miners' Federation of Great Britain and member of the Staffordshire county council. In 1906 he was elected Labour M.P. for Hanley. He died at Southport on June 28, 1912.

EDWARDS, GEORGE (1693–1773), English naturalist, was born at Stratford, Essex, on April 3, 1693. After travelling extensively over Europe, he was appointed librarian to the Royal College of Physicians in London in 1733. His *History of Birds* (4 vols., 1743–51) with three supplementary volumes, *Gleanings of Natural History* (1758–64), contain engravings and new descriptions of more than 600 subjects in natural history, and an index of Linnaean names supplied by Linnaeus himself with whom Edwards frequently corresponded. He also wrote *Essays of Natural History* (1770) and *Elements of Fossilogy* (1776). Edwards died at Plaistow, Essex, on July 23, 1773.

EDWARDS, HENRY THOMAS (1837–1884), Welsh divine, was born on Sept. 6, 1837, at Llan ym Mawddwy, Merioneth, where his father was vicar. He became vicar of Aberdare in 1866 and of Carnarvon in 1869, where he began his lifelong controversy with the Welsh Nonconformists. In 1870 he fought in vain for the principle of all-round denominationalism in the national education system, and in the same year addressed a letter to Gladstone on "The Church of the Cymry," pointing out that the success of Nonconformity in Wales was largely due to "the withering effect of an alien episcopate." One result of this was the appointment of the Welshman Joshua Hughes (1807–89) to the vacant see of St. Asaph. Edwards became dean of Bangor in 1876 and promoted a clerical education society for supplying the diocese with educated Welsh-speaking clergy. He died by his own hand on May 24, 1884 at Ruabon.

See V. Morgan, *Welsh Religious Leaders in the Victorian Era.*

EDWARDS, JONATHAN (1703–1758), American theologian, was born on Oct. 5, 1703, at East Windsor, Conn. His father, Timothy Edwards, was pastor of the Congregational church in East Windsor, and his mother, a daughter of Rev. Solomon Stoddard of Northampton, Mass., pastor of the church where Jonathan Edwards, himself, was afterwards installed.

He showed a certain abnormal mental precocity and wrote a tract on "The Nature of the Soul" when he was ten years old. At 12 he composed a treatise on "The Habits of Spiders." He entered Yale college at 13, read Locke's *Essay Concerning Human Understanding*, which impressed him deeply, at 14, and at 17 graduated from Yale at the head of his class of ten as valedictorian.

He remained in New Haven for two more years, studying theology, and became acting pastor of a small Presbyterian church in New York for eight months. He was then tutor in Yale for two years. In 1727 came the call to Northampton, where he won his fame and also suffered the keenest humiliation of his life.

Predestination.—He was ordained as assistant minister to his grandfather, Solomon Stoddard. In that same year he married Sarah Pierrepont, who was only 17, a daughter of one of the founders of Yale, a girl who combined piety with a bright, cheerful disposition. She proved a devoted wife, an efficient housekeeper, and the faithful mother of his 12 children. Two years later Solomon Stoddard died, leaving young Edwards in sole charge of one of the largest, wealthiest and most cultured congregations in Massachusetts.

He was brought up by godly parents so that pious habits were to him as second nature. Yet somewhere in that period of study, he entered into a new and deeper sense of his personal relation to God. He would scarcely have called it conversion because he had been faced toward the light from the first. Like John Wesley, however, his heart was "strangely warmed" until the doctrine of divine sovereignty, against which he had formerly rebelled, became a belief "exceedingly pleasant, bright, and sweet." It may have been so. We are told that the doctrine of "unconditional election," whereby certain souls are, by no act or choice of their own, predestined to eternal bliss, and other souls in similar fashion to eternal damnation, is very comforting to those who are convinced that they are numbered with the elect. When Edwards entered upon his duties as pastor of the Northampton church, he showed at once that he loved books and abstract ideas more than he loved people. He spent 13 hours a day in his study and hardly ever called upon his parishioners except in cases of extreme emergency. He inherited apparently his father's lack of amiability in that he displayed a certain intellectual satisfaction in picturing "sinners in the hands of an angry God." He seemed to find more joy in battering the strongholds of Arminianism and in rearing the stout defences of his own Calvinistic theology than in preaching good tidings to the poor, or binding up the broken-hearted.

His first public attack on Arminianism in an address at Boston in 1731 was published under the title, *God Glorified in Man's Dependence*. He maintained that, while it was fitting that God should in the beginning create man holy, it was of his good pleasure and "mere arbitrary grace" that any man was now made holy. He claimed that God might withhold this saving grace, if he chose, without any disparagement to his moral perfection. He insisted steadily that men had no rights which a just and holy God was under moral obligations to respect.

The fiery sermons of Edwards had an immediate effect upon his hearers, their own sense of the imminence of hell making them susceptible. In his *Life of Edwards*, A. V. G. Allen indicates the conditions in Northampton at that time. "A town predisposed to religion by all its antecedents; a moment in its history when no great external interest preoccupied the minds of the people; an isolated town where the want of healthy amusements had a tendency to breed as a substitute the merely

vulgar forms of immorality."

Fettered Will and Choice.—Within six months 300 new members were received into Edwards's own church, and there was a similar situation elsewhere. Hundreds of people were turned from lives of evil-doing, but in the light of certain larger considerations which must enter into any just appraisal of "the Great Awakening," this can not be regarded as an unmixed blessing. The particular type of conversion, singled out and exalted until it would almost seem that other modes of entrance into Christian life were deemed spurious, was abnormal. It was far less wholesome than the type of conversion advocated by Horace Bushnell in his *Christian Nurture*. And to compare Edwards with another great religious leader, born in the same year, "the necessity of conversion was asserted by John Wesley, the Founder of Methodism, with a vigour and success which Calvinism could not rival, embarrassed as it was by the prior distinction between the elect and the non-elect which Wesley totally rejected." Edwards's attempt to set that notion upon its feet again led to a confusion in New England theology which was a millstone upon its neck for many years. There was an inconsistency in his teaching which the discriminating people of his own day must have detected. He declaimed against "the freedom of the will," but went about calling upon men everywhere to use their wills in forsaking their sins and choosing the Christian way of life. He insisted that no man had power to repent (unless he was fortunate enough to have been foreordained to repentance), yet he urged men with all his might to repent and turn to the Saviour. He preached the terrors of hell, even to young children. "As innocent as young children seem to be to us, yet if they are out of Christ they are in God's sight young vipers, and infinitely more hateful than vipers." Yet he and his wife cheerfully brought into the world 12 children of their own and lived with them apparently on terms of friendly, affectionate intercourse.

Perpendicular Piety.—He was sadly lacking in the humanities. The human values were obscured by his passion for metaphysics in his ambitious theological treatises. He had little feeling for poetry or for the beauties of the natural world. It was a perpendicular piety which he preached—it did not find adequate expression in those horizontal relations and interests which make up the social order.

His tedious discussion of *The Freedom of the Will*, commonly regarded as his *magnum opus*, impresses the modern reader as a solemn bit of special pleading, rather than a disinterested effort to reach the truth. His methods of biblical interpretation as judged by the more competent scholarship of our own day are hardly worthy of consideration or of respect. He felt that he must demolish the freedom of the will in order to cut the ground from under the feet of his Arminian opponents. If the will were free, in the sense that a man can choose his way, thus giving evidence of a self-determining power, the people in their arrogance would despise the Calvinistic doctrines which spring from the idea of God's absolute sovereignty and his unconditional election of certain souls to eternal life. One of the foremost theologians in the American pulpit, George A. Gordon, has said of him, "No single treatise of Edwards can to-day commend itself to a free and informed mind. In his Freedom of the Will, the Religious Affections, the Nature of Virtue, God's final End in Creation, the Christian Church can not follow him as a whole and those who insist upon all or none, do their best to make it none."

Doctrine Home to Roost.—In 1748 there came the open rupture between this pastor and his congregation. Two causes for this dissension have ordinarily been assigned. First, a badly managed case of discipline, where the pastor instituted proceedings against a number of his young people for circulating "impure books." However just or unjust his estimate of certain popular volumes may have been, he managed to alienate the affection and interest of nearly all the young people of the town.

The other cause was his attitude toward "the Halfway Covenant," by which church members not consciously "converted" were not considered far enough from the Kingdom of God to be excluded from having their children admitted to the privileges of one sacrament, while they were so far outside a state of grace as to be debarred themselves from participating in the other sacrament at the Lord's table. Edwards stood for an even more rigorous exclusion and this meant a clash with established usage. The reasons for the opposition of the church lay deeper than these two causes. There was a ground-swell of dissent from the violent expressions employed against those who had not experienced what he regarded as thorough-going "conversion" and a profound distrust as to the wholesome influence of much of the teaching which had accompanied the Great Awakening. The effects of his overdone emphasis upon the fear of hell as a source of motive and of his low estimate of the human factor in redemption were coming home to roost. The members of the church voted by a majority of more than 200 to 23 to dismiss the pastor and the church council approved the action of the church. Then the town voted that Edwards should not be permitted to preach again in that community.

Wanderings.—He bore his disappointment as a Christian. His farewell sermon was dignified, temperate and without recrimination. But he had been turned out of his pastorate at the age of 47 with a large family to support and no immediate employment at hand by which he could earn a livelihood. He was offered a church in Virginia and there was an opening in Scotland. He declined both of these opportunities and in 1750 became pastor of the church in Stockbridge and missionary to the Housatonic Indians. He probably discharged his duties with fidelity, according to the habit of his life, but his missionary efforts were not greatly blessed. He loved books and theological disputation more than he loved Indians. He used his spare time at Stockbridge to write his *Original Sin, The Nature of True Virtue* and his *Essay Concerning the End for which God Created the World.* He also devoted four months to writing his great work on *The Freedom of the Will.*

In 1757 his son-in-law, Aaron Burr, president of the College of New Jersey, died quite suddenly. This institution had shown much more sympathy with the revival which Edwards sponsored than either Harvard or Yale. It was natural, therefore, that two days after the death of President Burr, Jonathan Edwards was elected president of what is now Princeton university. It was an attractive call, yet he hesitated about accepting it. His reluctance sprang from his desire to complete a *History of the Work of Redemption* which would set forth his theological conceptions as a finished whole. It may be just as well for his own fame and for the Christian religion that this projected work was never brought out.

He entered immediately upon his duties, preaching for several Sundays in the College hall and giving out "questions in Divinity" to the senior class. His period of service, however, was very brief. Smallpox was epidemic in New Jersey. The physician counselled inoculation and Edwards, with the approval of the college authorities, was inoculated on Feb. 13. For a time the symptoms indicated a speedy recovery, but there came a change for the worse and on March 22, 1758, he died in his fifty-fifth year. His wife died the following September.

Notable tributes to the vigour and range of his intellect in dealing with metaphysical problems have been paid by scholarly men on both sides of the Atlantic. He was an earnest, sincere, devoted Christian, according to the methods and standards of the period in which he wrought. His work is to be judged in the light of religious conceptions prevalent at that time; the potent influence which it exerted occasions wonder rather than grateful appreciation. His most sympathetic biographer concludes his accurate and kindly review with these significant words—"The great wrong which Edwards did, which haunts us as an evil dream throughout his writings, was to assert God at the expense of humanity."

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Churchill King, "Jonathan Edwards as Philosopher and Theologian," *Hartford Seminary Rec.*, vol. xiv., pp. 23–57 (1903); John De Witt, *Jonathan Edwards: A Study* (1912); W. Lyon Phelps, *Some Makers of American Literature* (1923). (C. R. Br.)

EDWARDS, LEWIS (1809–1887), Welsh Nonconformist divine, was born in the parish of Llanbadarn Fawr, Cardiganshire, on Oct. 27, 1809. In 1832 he settled as minister at Laugharne, Carmarthenshire, and the following year went to Edinburgh, where a special resolution of the senate allowed him to graduate at the end of his third session. He was now better able to further his plans for providing a trained ministry for the Calvinistic Methodists; he made his home at Bala, and there, in 1837, with David Charles, his brother-in-law, opened the school that ultimately became the denominational college for North Wales; a new college was built at Bala in 1867, for which he raised £10,000.

Edwards may fairly be called one of the makers of modern Wales. Through his hands there passed generation after generation of preachers, who carried his influence to every corner of the principality. It was due to him that the North and South Wales Calvinistic Methodist Associations united to form an annual General Assembly; he was its moderator in 1866 and again in 1876. He died on July 19, 1887.

See *Bywyd a Llythyrau y Parch.* (*i.e.*, Life and Letters of the Rev.) *Lewis Edwards, D.D.*, by his son T. C. Edwards.

EDWARDS, RICHARD (*c.* 1523–1566), English musician and playwright, was born in Somersetshire, became a scholar of Corpus Christi college, Oxford, in 1540, and took his M.A. degree in 1547. He was appointed in 1561 a gentleman of the chapel royal and master of the children, and entered Lincoln's Inn in 1564, where at Christmas in that year he produced a play which was acted by his choir boys. On Sept. 3, 1566 his play, *Palamon and Arcite,* was performed before Queen Elizabeth in the Hall of Christ Church, Oxford. Another play, *Damon and Pithias,* tragic in subject but with scenes of vulgar farce, entered at Stationers' Hall in 1567–68, appeared in 1571 and was reprinted in 1582; it may be found in Dodsley's *Old Plays,* vol. i., and *Ancient British Drama,* vol. i. It is written in rhymed lines of rude construction, varying in length and neglecting the *caesura.* A number of the author's shorter pieces are preserved in the *Paradise of Dainty Devices* (1575); one of these finishes a stanza to *Romeo and Juliet.* The *Historie of Damocles and Dionise* is assigned to him in the 1578 edition of the *Paradise.* Sir John Hawkins credited him with the part song "In going to my lonely bed"; the words are certainly his, and probably the music. The fine poem, "The Soul's Knell," is supposed to have been written by him when dying.

See *Grove's Dict. of Music;* the *Shakespeare Soc. Papers,* vol. ii. art. vi.; Ward, *English Dram. Literature,* vol. i.; Leicester Bradner, *Life and Poems of Richard Edwards* (1928).

EDWARDS, THOMAS CHARLES (1837–1900), Welsh Nonconformist divine and educationist, was born at Bala, Merioneth, on Sept. 22, 1837, the son of Lewis Edwards (*q.v.*). After graduating in London, he matriculated at St. Alban Hall, Oxford, in 1862, obtained a scholarship at Lincoln College in 1864, and took a first class in the school of Literae Humaniores in 1866. In 1867 he became minister at Windsor Street, Liverpool, but left it to become first principal of the University College of Wales at Aberystwyth in 1872. When the college was destroyed by fire in 1885 he collected £25,000 to rebuild it; the remainder of the necessary £40,000 being given by the government (£10,000) and by the people of Aberystwyth (£5,000). In 1891 he became principal of the theological college at Bala. He died on March 22, 1900. His chief works were a *Commentary on 1 Corinthians* (1885), the *Epistle to the Hebrews* (Expositor's Bible, 1888), and *The God-Man* (Davies Lecture, 1895).

EDWARDSVILLE, a city of Illinois, U.S.A., 18m. N.E. of Saint Louis, near Cahokia creek; the county seat of Madison county. It is on Federal highway 66, and is served by the Nickel Plate and the Wabash and electric railways. The population was 5,336 in 1920 and was estimated locally at over 8,000 in 1928. Coal is mined near by (3,530,848 tons in 1926), and it has numerous manufacturing industries, including canneries, marble works, flour and planing mills, brick and tile plants and factories making woodwork, brass, radiators, shirts and powdered milk. Adjoining Edwardsville is the plant of the N. O. Nelson Manufacturing company (plumbers' supplies, etc.), and the co-operative village Leclaire (unincorporated; pop. about 2,000) founded in 1890 by Nelson O. Nelson for his employés, with various welfare features in the village and some degree of profit-sharing in the business. Edwardsville was settled in 1812, laid out in 1815, and named after Ninian Edwards, governor of the Territory at the time. It was incorporated in 1819. The prehistoric Monk's mound is near.

EDWARDSVILLE, an anthracite-mining borough of Luzerne county, Pa., U.S.A., on the Susquehanna river, opposite Wilkes-Barre. The post-office is Kingston Station, Wilkes-Barre. In 1920 the population was 9,027 (32% foreign-born white). The borough was incorporated in 1884.

EDWIN, Aeduini or Edwine (585–633), king of Northumbria, was the son of Ella of Deira. On the seizure of Deira by Aethelfrith of Bernicia (probably 605), Edwin was expelled and is said to have taken refuge with Cadfan, king of Gwynedd. After the battle of Chester, in which Aethelfrith defeated the Welsh, Edwin fled to Roedwald, the powerful king of East Anglia, who after some wavering espoused his cause and defeated and slew Aethelfrith at the river Idle in 617. Edwin thereupon succeeded to the Northumbrian throne, driving out the sons of Aethelfrith. There is little evidence of external activity on the part of Edwin before 625. It is probable that the conquest of the Celtic kingdom of Elmet, a district in the neighbourhood of the modern Leeds, ruled over by a king named Cerdic (Ceredig) is to be referred to this period, and this may have led to the later quarrel with Cadwallon, king of Gwynedd. Edwin seems also to have annexed Lindsey to his kingdom by 625.

In this year he entered upon negotiations with Eadbald of Kent for a marriage with his sister Aethelberg. It was made a condition that Christianity should be tolerated in Northumbria, and accordingly Paulinus was consecrated bishop by Justus in 625, and was sent to Northumbria with Aethelberg. According to Bede, Edwin was favourably disposed towards Christianity owing to a vision he had seen at the court of Roedwald, and in 626 he allowed Eanfled, his daughter by Aethelberg, to be baptized. On the day of the birth of his daughter, the king's life had been attempted by Eomer, an emissary of Cwichelm, king of Wessex. Preserved by the devotion of his thegn Lilla, Edwin vowed to become a Christian if victorious over his treacherous enemy. He was successful in the ensuing campaign, and abstained from the worship of the gods of his race. A letter of Pope Boniface helped to decide him, and after consulting his friends and counsellors, among whom the priest Coifi later took a prominent part in destroying the temple at Goodmanham, he was baptized with his people and nobles at York, at Easter 627. In this town he granted Paulinus a see, built a wooden church and began one of stone. Besides York, Yeavering and Maelmin in Bernicia, and Catterick in Deira, were the chief scenes of the work of Paulinus. It was the influence of Edwin which led to the conversion of Eorpwald of East Anglia.

Bede notices the peaceful state of Britain at this time, and relates that Edwin was preceded on his progresses by a kind of standard like that borne before the Roman emperors. In 633 Cadwallon of North Wales and Penda of Mercia rose against Edwin and slew him at Hatfield near Doncaster. His kinsman Osric succeeded in Deira, and Eanfrith the son of Aethelfrith in Bernicia. Bede tells us that Edwin had subdued the islands of Anglesey and Man, and the *Annales Cambriae* record that he besieged Cadwallon (perhaps in 632) in the island of Glannauc (Puffin island). He was definitely recognized as overlord by all the other Anglo-Saxon kings of his day except Eadbald of Kent.

See Bede, *Hist. Eccl.* (ed. Plummer, Oxford, 1896), ii. 5, 9, 11, 12, 13, 15, 16, 18, 20; Nennius (ed. San Marte, 1844), § 63; *Vita S. Oswaldi*, ix. Simeon of Durham (ed. Arnold, 1882–85, vol. i. R.S.). (F. G. M. B.)

EDWIN, JOHN (1749–1790), English actor, was born in London on Aug. 10, 1749, the son of a watchmaker. His first London appearance was at the Haymarket in 1776 as Flaw in Samuel

Foote's *The Cozeners,* and when George Colman took over the theatre he became its leading actor. In 1779 he was at Covent Garden, and played there or at the Haymarket until his death on Oct. 31, 1790. Ascribed to him are *The Last Legacy of John Edwin,* 1780; *Edwin's Jests* and *Edwin's Pills to Purge Melancholy.*

His son, John Edwin (1768–1805), made a first appearance on the stage at the Haymarket as Hengo in Beaumont and Fletcher's *Bonduca* in 1778, and from that time acted frequently with his father. In 1791 he married Elizabeth Richards, an actress already well known in juvenile parts, and played at the Haymarket and elsewhere thereafter with her. He died in Dublin on Feb. 22, 1805. His widow joined the Drury Lane company (then playing, on account of the fire of 1809, at the Lyceum), and took all the leading characters in the comedies of the day. She died on Aug. 3, 1854.

EDWY (Eadwig), "The Fair" (*c.* 940–959), king of the English, eldest son of Edmund and Aelfgifu, succeeded his uncle Eadred in 955, when he was about 15 years old. He was crowned at Kingston by Archbishop Odo. At the coronation feast he retired with Aethelgifu (perhaps his foster-mother) and her daughter Aelfgifu, whom the king intended to marry. The nobles resented the king's withdrawal, and he was induced by Dunstan and Cynesige, bishop of Lichfield, to return to the feast. Edwy resented this interference, and in 957 at the instigation of Aethelgifu Dunstan was driven into exile. By the year 956 Aelfgifu had become the king's wife, but in 958 Archbishop Odo of Canterbury secured their separation on the ground of their being too closely akin. The chief men of Mercia and Northumbria were disgusted by Edwy's partiality for Wessex; and in the year 957 his brother, the Aetheling Edgar, was chosen as king by the Mercians and Northumbrians. It is probable that no actual conflict took place, and in 959, on Edwy's death, Edgar acceded peaceably to the combined kingdoms of Wessex, Mercia and Northumbria.

See *The Anglo-Saxon Chronicle* (ed. Plummer, 1892–99), *sub. ann.; Memorials of St. Dunstan* (ed. Stubbs, Rolls Series); William of Malmesbury, *Gesta regum* (ed. Stubbs, Rolls Series); Birch, *Cartularium Saxonicum,* vol. ii. Nos. 932–1046.

EECKHOUT, GERBRAND VAN DEN (1621–1674), Dutch painter, born at Amsterdam on Aug. 19, 1621, was a pupil of Rembrandt. He assumed Rembrandt's manner with such success that his pictures were confounded with those of his master. As evidence of the fidelity of Eeckhout's imitation we may cite his "Presentation in the Temple," at Berlin, which is executed after Rembrandt's print of 1630, and his "Tobit with the Angel," at Brunswick, which is composed on the same background as Rembrandt's "Philosopher in Thought." His earliest pieces are probably those in which he more faithfully reproduced Rembrandt's peculiarities. Exclusively his is a tinge of green in shadows marring the harmony of the work, a certain gaudiness of jarring tints, uniform surface, and a touch more quick than subtle. Besides the pictures already mentioned we should class amongst early productions on this account the "Woman taken in Adultery," at Amsterdam, the "Resurrection of the Daughter of Jairus" at Berlin; the "Presentation in the Temple" at Dresden; the "Lady at the Dressing table" (1643) at Vienna; "Anna presenting her Son to the High Priest," in the Louvre, Paris; the "Epiphany," at Turin; and the "Circumcision," at Cassel. Eeckhout matriculated early in the Gild of Amsterdam. As he grew older he succeeded best in portraits, a very fair example of which is that of the historian Dappers (1669), in the Städel collection and that of the four chiefs of the Wine Gild at the National Gallery, London. Eeckhout occasionally varied his style so as to recall in later years the "small masters" of the Dutch school. Waagen justly draws attention to his following of Terburg in "Gambling Soldiers," and a "Soldiers' Merrymaking," in the collection of the marquess of Bute. A "Sportsman with Hounds," probably executed in 1670, now in the Vander Hoo gallery, and a "Group of Children with Goats" (1671), in the Hermitage, Leningrad, hardly exhibit a trace of the artist's first education. Amongst the best of Eeckhout's works "Christ in the Temple" (1662), at Munich, and the "Haman and Mordecai" of 1665, at Luton House, occupy a good place. He also executed some engravings. Eeckhout died at Amsterdam on Sept. 22, 1674.

EEDEN, FREDERIK WILLEM VAN (1860–), Dutch poet, novelist and playwright, was born at Haarlem on April 3, 1860, and educated for the medical profession. He was one of the leaders of the literary revival of 1880, and founded in 1885 with D. Kloos and A. Verwey the *Nieuwe Gids,* the organ of the younger men of letters. In that paper appeared his most famous novel *De kleine Johannes* (1887; Eng. trans. *Little Johannes,* 1895), to which two later parts were added in 1905 and 1906. It was followed by *Ellen* (1891), a cycle of elegies full of the melancholy mysticism which informs van Eeden's verse; *Johannes Viator* (1892), a story which was hailed as "a new Bible" when it first appeared; *Lioba* (1897), a drama; *Van de koele Meren des Doods* (1900; Eng. trans. *The Deeps of Deliverance,* 1902); *De Nachtbruid* (1909); *Sirius en Siderius* (1912, etc.) and other works. In 1898 van Eeden founded at Bussum the agricultural and industrial community known as the Walden Colony from the title of Thoreau's book.

See P. Verschave, "Un converti hollandais—Le poète Frédéric van Eeden," *Correspondant,* Tome 296, pp. 311–338 (Paris, 1924); *Het roode lamp je, signifische gepeinzen* (Amsterdam, 1921).

EEL, the name given generally to fishes of the order Apodes, and particularly to the common or fresh-water eel of Europe (*Anguilla anguilla*). The Apodes are soft-rayed fishes with a duct to the air-bladder, elongate, with small gill-openings, without pelvic fins, and generally with long dorsal and anal fins confluent with the reduced caudal. The congers and the morays (*Muraena*) are well known members of this large group of marine fishes, all of which have compressed transparent pelagic larvae, known as *Leptocephali.*

Anguilla anguilla is found on the coasts and in the rivers of western Europe and the Mediterranean countries. It has an elongate, subcylindrical body, covered with small oblong scales embedded in the slimy skin, and arranged in little groups at right angles to each other; the mouth is terminal, with bands of pointed teeth; the back is greenish or brownish, the sides generally yellowish. The eels inhabit not only rivers and lakes but small brooks and isolated ponds; they are also found in harbours and estuaries and on muddy shores. They often burrow during the day and feed principally at night, eating any kind of animal food. A length of 5ft. and a weight of 20lb. may be reached. Towards the autumn some eels cease feeding and become silvery; the snout also becomes sharp, the eyes larger and the pectoral fins more pointed. These silver eels descend to the sea, and it has been established by Dr. Johannes Schmidt that they travel across the Atlantic to breed in an area south-east of Bermuda, and die after breeding. The transparent larvae, which have needle-shaped teeth, live near the surface of the ocean, and as they spread out across the Atlantic grow from about 10mm. to 75mm. long in about 2½ years; the full-grown larvae occur off the Atlantic coast of Europe and in the western Mediterranean during the summer; they cease feeding, lose their larval teeth, shrink in depth and length, and change into the elvers, or little eels, which enter rivers in large numbers during the winter and spring. Scale investigations have shown that male eels assume their breeding dress 4½ to 8½ years after the elver stage, when they are 12 to 20in. long, and female eels usually after 6½ to 8½ years, when they are 14 to 26in. long; but larger females 3ft. long have lived 10½ to 12½ years since the elver stage. The silver eels have the flesh full of fat, and in the most important fisheries they are intercepted on their way to the ocean, as on the Bann, which runs out of Lough Neagh. Denmark has valuable eel fisheries, and at Commachio, on the Adriatic, eels are farmed in extensive brackish lagoons, the natural supply of elvers replenishing the stock. Schmidt's researches are of great economic importance, showing that for a particular fishery it is useless to allow silver eels to escape, as plenty from other regions will reach the breeding place. The American eel (*Anguilla chrysypa*) differs from the European eel chiefly in the fewer vertebrae, 104 to 110 instead of 111 to 118; it breeds in an area overlapping the breeding area of the European species, but extending westwards from it. It has a

shorter larval history, the elvers being one year old instead of three; this difference keeps the species distinct, for if larvae of the American eel travel east they change into elvers in the middle of the Atlantic, and those of the European eel going west reach America as small larvae. Other species of *Anguilla* are from Japan, Indian ocean and western Pacific. (*See* FISHES.) (C. T. R.)

EEL-GRASS or **GLASS-WRACK** (*Zostera*), the name applied to certain salt-water plants, growing on gently sloping shores in temperate regions. The lower part of the stem is creeping, the branches growing upwards and dividing. The leaves are long and narrow. Two of the six species are British and three occur off the shores of North America. The pollen grains have the same specific gravity as water, so that they float at any depth. *Zostera* belongs to the family Potamogetonaceae, which also includes the pond-weeds (*q.v.*).

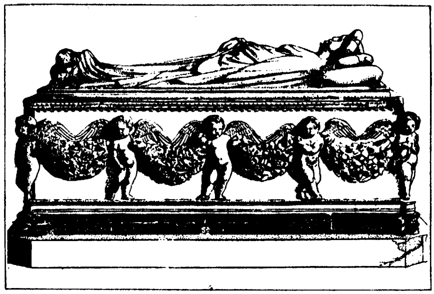
EFFENDI, a title of respect, equivalent to the English "sir," in Turkey and some other eastern countries. It follows the personal name, when that is used, and is generally given to members of the learned professions and to government officials who have no higher rank, such as Bey, Pasha etc. It may also indicate a definite office, as *Hakim effendi,* chief physician to the sultan. The possessive form *effendim* (my master) is used by servants and in formal intercourse.

EFFIGIES, MONUMENTAL, a term usually associated with the figures carved in relief, or in the round, on the sepulchral monuments of the Christian era. However, close prototypes may be found on the Etruscan sarcophagi, which in some cases date as far back as the 6th or 5th century B.C. In the Flavian period, Ulpia Epigone is represented in relief in precisely the same manner as on Italian tombs of the 15th century. Portrait busts are found on the fronts of the early Christian sarcophagi, but full length carved effigies appear to be completely non-existent between the Roman period and the 11th century A.D. It is possible that royal, and perhaps some of the most important ecclesiastical effigies, were comparatively faithful portraits as early as the 14th century, but other effigies before the 15th century were probably made from stock workshop patterns. The details of costume seem to have been most carefully reproduced and form an extremely valuable contribution to our knowledge of the attire of the different periods. The materials used for the effigies varied, marble and bronze being used throughout Europe, stone and wood chiefly in the more northern countries, the latter being particularly well represented in England. Purbeck marble was largely used in England for the earlier figures, and alabaster during the 15th century.

THE WOODEN EFFIGY IN GLOUCESTER CATHEDRAL CHURCH CALLED ROBERT, DUKE OF NORMANDY, PROBABLY MADE ABOUT 1290

Romanesque and Gothic.—The characteristic sepulchral monument throughout northern Europe in the 12th century is the flat slab tomb with the effigy in low, later in higher, relief. With the 13th century the base frequently takes the form of a sarcophagus, the decoration of which becomes gradually more elaborate and which is sometimes surmounted by an architectural canopy. Though horizontal, the figure in the earlier tombs is represented standing, but in the 13th century assumes a recumbent position, some of the earliest examples of the change being found in France. The upright position is, however, characteristic of the whole period in Germany.

Flat slab monuments are perhaps the most characteristic form throughout the Gothic period in Germany, those of the 14th century being well represented at Bamberg, and there is a long series of effigies, extending over several centuries, at Mainz. Slab tombs of the 12th century in France generally follow the same lines as in Germany but are much more rare. The monuments of the 13th and 14th centuries follow the usual development, the effigy being treated in increasingly high relief and frequently supported on a tomb chest with or without an architectural canopy. Unfortunately the unrivalled series of royal effigies at St. Denis have suffered severely from restoration but they still form a most valuable record. The few remaining 12th century tombs in England are of the usual slab form with the figure in low relief, but the series of effigies of the 13th century, mainly carved in Purbeck marble, are exceptionally rich in quantity and vigorous in style. A distinct group of effigies is that representing knights in chain-mail; after the middle of the century the legs are usually crossed but there seems to be no foundation for the popular theory that this position indicates a crusader. A notable group of such effigies is in the Temple church in London. Another fine example is the wooden effigy, at Gloucester, called Robert, Duke of Normandy (*c.* 1290). After the middle of the century miniature chapels and shrines were frequently built up over the tomb, a good example being the monument of Bishop Giles Bridport at Salisbury. The whole series of effigies, from the late Romanesque to the end of the Gothic period form, both in number and variety, one of the most characteristic developments of English sculpture. The flat slab tombs of the 12th and 13th centuries of northern Europe are not frequent in Italy. A very characteristic type of mural monument was evolved by the Cosmati school, chiefly in Rome, in the second half of the 13th century; this shows the recumbent effigy on a high draped sarcophagus, frequently inlaid with mosaic, under an arched canopy with, in most cases, a fresco or mosaic of the Virgin and Child in the lunette. But to Arnolfo di Cambio (*c.* 1232–1300) is due a very fine development of this composition, the monument of Cardinal de Braye at Orvieto, the prototype of the magnificent series of 15th century monuments, which are one of the glories of Italian art.

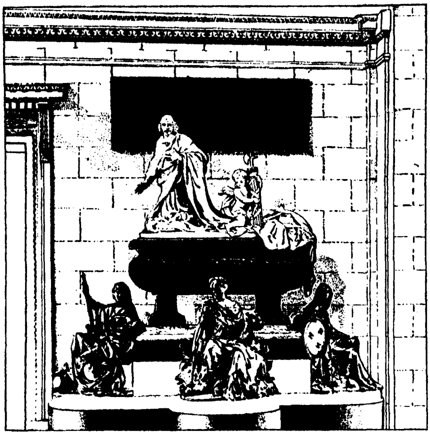


EFFIGY OF ILARIA DEL CARRETTO BY JACOPO DELLA QUERCIA, IN THE CATHEDRAL S. MARTINO IN LUCCA

The Renaissance.—The long series of 15th and 16th century tombs in Italy embrace some of the finest Italian figure sculpture and they were frequently the work of the foremost artists of the day. Few works of art are more moving than the lovely effigies of Santa Justina by Agostino di Duccio (now at South Kensington museum, London), or of Ilaria del Carretto, at Lucca, this latter by Jacopo della Quercia. The typical Tuscan form of the 15th century is the mural monument showing the recumbent portrait effigy lying on a bier supported on a sarcophagus with a relief of the Virgin and Child above in the lunette under the round arched frame. To the first quarter of the 16th century belongs the masterpiece of late Renaissance monumental sculpture in Italy, the tombs of the Medici by Michelangelo in San Lorenzo at Florence. The two seated effigies are idealized figures rather than portraits, but the whole conception is one of the noblest works of Italian art and one which exercised an overpowering influence on most of the remaining tombs of the century.

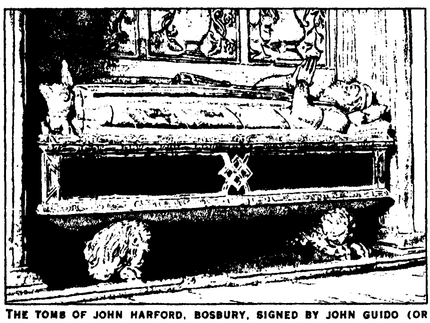
The style of the transitional Gothic-Renaissance period finds

expression in Germany in the magnificent tombs of Margaret of Austria and Philibert of Savoy (*c.* 1526–32) at Brou, by Conrad Meit. These show the double effigies especially popular on French tombs of the 16th and 17th centuries though they appear earlier, as in the 15th century in England—above is the robed figure, below, the skeleton.



SARCOPHAGUS WITH KNEELING FIGURE OF CARDINAL MAZARIN BY COYSEVOX (NOW IN THE LOUVRE). THE LOWER FIGURES REPRESENT PRUDENCE, PEACE, FIDELITY

In the first half of the 16th century some very elaborate free-standing and mural monuments were produced in France. The effigies are usually shown kneeling or reclining as in life. A typical example of the mural tomb with minutely characterized kneeling figures is the monument of the Cardinals d'Amboise at



THE TOMB OF JOHN HARFORD, BOSBURY, SIGNED BY JOHN GUIDO (OR GILDON) OF HEREFORD, 1573

Rouen. One of the most magnificent of the huge free-standing monuments is that of Henry II. and Catherine de' Medici at St. Denis (1563–70) by Germain Pilon. In England, the recumbent effigy is still the usual form on tombs of the transitional Gothic-Renaissance period, the most characteristic type of monument being perhaps the large free-standing tomb chest without an architectural canopy.

Baroque.—If Michelangelo's design for the Medici tombs was the dominating factor in the monumental style of the 16th century in Italy, Bernini's tombs of the popes at St. Peter's, Rome, are characteristic for the 17th and 18th centuries.

In France, a distinct change comes over the treatment of the effigy in the 17th century; hitherto the figure has been represented in repose, but with the 17th century emotion and dramatic feeling are aimed at. The tomb of Richelieu at the Sorbonne in Paris, by Girardon, with its weeping mourner, is a case in point, as, too, is the gesticulating reclining effigy of Turenne by Tuhy at the Invalides. Really fine, however, is the very life-like kneeling figure of Mazarin, by Coysevox, on his tomb now in

MONUMENT BY BERNINI TO POPE URBAN VIII. IN THE CHURCH OF ST. PETER, ROME

the Louvre. The imposing but rather theatrical effects of the 18th century are well represented by the kneeling effigy, at Nancy, of the Polish queen, Opalinska, being escorted to heaven by an angel.

In Germany, the monumental sculpture of the 17th and 18th centuries shows neither distinction nor originality. In English monuments of the early part of the 17th century, the mural or free-standing tomb with recumbent effigy and elaborate canopy is still found, as in the tombs of Queen Elizabeth and Mary, Queen of Scots, at Westminster Abbey (1603–12).

The Neo-Classical Revival.—The revival of monumental sculpture in the last half of the 18th century, which found almost simultaneous expression throughout Europe is perhaps best represented in Italy by the work of Canove (1757–1822), in England by that of Flaxman (1755–1826) and in Denmark by that of Thorwaldsen (1770–1844). (*See* also SARCOPHAGUS; TOMB; SCULPTURE.) (M. H. L.)

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EFFINGHAM, a city of Illinois, U.S.A., midway between Terre Haute and Saint Louis, on Federal highways 40 and 45, and near the Little Wabash river; the county seat of Effingham county. It is served by the Illinois Central, the Pennsylvania and the Wabash railways. The population was 4,024 in 1920 (96% native white). It is the commercial centre of a rich farming and dairying region. Its principal manufactures are condensed milk, ketchup, canned vegetables and butchers' blocks. The city was settled about 1853 and incorporated in 1867.

EFFLORESCENCE, the evaporation of water of crystallization from a hydrate (*q.v.*) when it is exposed to ordinary air at ordinary temperatures; *e.g.*, washing soda loses part of its water of crystallization and forms a lower hydrate, as is shown by the powdery appearance of its surface.

EGAN, PIERCE (1772–1849), English sporting writer, was born in London. He was soon recognized as the best sporting reporter of his day. In 1814 he wrote, set and printed himself *The Mistress of Royalty*, about the prince regent and Miss Robinson. His best-known work is *Life in London* (1821), a book typical of the "fast" life of the day, illustrated by Cruikshank. It was one of Thackeray's early favourites (*see* his *Roundabout Papers*). It was much imitated, and dramatic versions were produced. A sequel more concerned with the country was perhaps what suggested *Pickwick Papers* and the *Jorrocks* books. Among his other books are *Boxiana* (1818), *Life of an Actor* (1824), Book of Sports (1832), and *Pilgrims of the Thames* (1838). He was an authority on slang and contributed to Grose's *Dictionary of the Vulgar Tongue* (1823).

EGEDE, HANS (1686–1758), Norwegian missionary, was born in the vogtship of Senjen, on Jan. 31, 1686. He studied at the university of Copenhagen, and in 1706 became pastor at Vaagen in the Lofoten islands. In 1721 he sailed to Greenland but found to his dismay that the Northmen were entirely superseded by the Eskimo. He converted many of them to Christianity, founded the colony of Godthaab and established a considerable commerce with Denmark. Ill-health compelling him to return home in 1736, he was made principal of a seminary at Copenhagen, in which workers were trained for the Greenland mission; and from 1740 to 1747 he was superintendent of the mission. Egede died on Nov. 5, 1758. He is the author of a book on Greenland (last ed. 1923, Eng. trs. 1745).

His work in Greenland was continued, on his retirement, by his son Paul Egede (1708–1789), who afterwards succeeded his father as superintendent of the Greenland mission, and became professor of theology in the mission seminary. He published a Greenland-Danish-Latin dictionary (1,50), Greenland grammar (1760) and Greenland catechism (1756). In 1766 he completed the translation begun by his father of the New Testament into the Greenland tongue; and in 1787 he translated Thomas à Kempis. In 1789 he published a journal of his life in Greenland.

EGER, AQIBA (1761–1837), Jewish scholar, and from 1812 rabbi of Posen. He was a rigorous casuist of the old school, and his chief works were legal notes on the Talmud and the code of Qaro (*q.v.*). He opposed the establishment of secular schools, and also the reform movement.

EGER (Czech, Cheb), is a large manufacturing town in western Bohemia, Czechoslovakia, on the right bank of the river Ohře. Situated about 1,500 ft. above sea-level, beneath a spur of the Fichtelgebirge, it lies in the centre of a German-speaking district and has a long history closely associated with its frontier position. The strategical value of the site is emphasized by the stormy nature of its record, for between the 12th and 14th centuries Bohemia and the Empire constantly struggled to possess the region in which it lies. To this period belong the ruined 12th century castle, lying on a height to the north-west of the town, where in 1634 Albrecht Wallenstein was murdered, and the imposing 13th century church of St. Nicholas. Final incorporation with Bohemia was effected in 1350 when Charles IV. united the two warring powers; but its position still influenced its history and the town suffered severely in the Hussite war, the Swedish invasions of the 17th century and the War of the Austrian Succession.

To-day it is a prosperous and important industrial centre with several textile factories, pottery and earthenware works, breweries, engineering and motor works. Pop. (1923), 27,524 of whom 23,125 are Germans.

EGER, the capital of the county of Heves in Hungary, is situated near the eastern foot-hills of the Mátra mountains, on the river Eger, a tributary of the Tisza. As the see of an archbishopric since 1814 it contains numerous ecclesiastical buildings and is known as "the Hungarian Rome." The cathedral in Italian style dates from 1831–34, but the ruined mosque and a Greek church indicate both the course of the history of the town and its situation near a religious frontier. The bishopric dated from 1010 and, as one of the richest in Hungary, was responsible for much of the early importance of the town which, in 1552, attracted the attention of the Turks who, after a long resistance, occupied it from 1596–1687. Its present activities are chiefly concerned with the preparation of Erlauer wine from the Mátra vineyards, with milling, soap and candle-making and the preparation of tobacco besides the usual work of an agricultural market-centre. The beautiful surroundings of the town are in harmony with its many fine ecclesiastical and municipal buildings, notably, in addition to those mentioned above, the observatory, lyceum and town-hall. Pop. (1920), 28,753.

EGERIA, the spirit or Lumpa (*see* Nymphs) of a stream just outside the Porta Capena of Rome in the grove of the Camenae; also of a stream in the grove of Diana near Aricia. A wholly artificial story makes her the wife and counsellor of king Numa; they met in the grove of the Camenae, and on his death she retired to Aricia, where because of her lamentations Diana changed her into a stream. She was worshipped by pregnant women, and apparently as a prophetic goddess, in connection with Diana and the Camenae. She seems to have had a masculine counterpart Egerius, at Aricia.

See Wissowa, *Religion und Kultus*, 2nd ed. (1912), p. 248, and in Roscher, *Lexikon;* Buchmann, *De Numae regis Romanorum fabula* (1912), p. 38 ff.

EGFRITH (d. 685), king of Northumbria, succeeded his father Oswio in 671. He was married to Aethelthryth, daughter of Anna of East Anglia, who, however, took the veil shortly after Egfrith's accession, a step which possibly led to his long quarrel with Wilfrid archbishop of York. Egfrith married a second wife, Eormenburg, before 678, the year in which he expelled Wilfrid from his kingdom. Early in his reign he defeated the Picts who had risen in revolt. Between 671 and 675 Egfrith defeated Wulfhere of Mercia and seized Lindsey. In 679, however, he was defeated by Aethelred of Mercia, who had married his sister Osthryth, on the river Trent. Egfrith's brother Aelfwine was killed in the battle, and the province of Lindsey was given up when peace was restored at the intervention of Theodore of Canterbury. In 684 Egfrith sent an unsuccessful expedition to Ireland under his general Berht. In 685 he led a force against the Picts, was lured into their mountain fastnesses and slain at Nechtanesmere (now Dunnichen) in Forfarshire. Bede dates the beginning of the decline of Northumbria from his death. He was succeeded by his brother Aldfrith.

See Eddius, *Vita Wilfridi* (Raine, *Historians of Church of York*, Rolls Series, 1879–94), 19, 20, 24, 34, 39, 44; Bede, *Hist. Eccl.* (ed. Plummer, 1896), iii. 24, iv. 5, 12, 13, 18, 19, 21, 26.

EGG, AUGUSTUS LEOPOLD (1816–1863), English genre painter, was born on May 2, 1816, in London, the son of a gunmaker. He was a pupil of Henry Sass, and then studied at the Royal Academy; he became R.A. in 1860. He travelled in Italy with Dickens and Wilkie Collins in 1853. Egg was an excellent actor and played in Dickens's company of amateurs; one of his best parts was as John Want in Collins's *Frozen Deep*. He was famous in his day for small anecdotal pictures, of which the London public galleries possess several examples. He died at Algiers on March 26, 1863.

Among his principal pictures may be named: 1843, the "Introduction of Sir Piercie Shafton and Halbert Glendinning" (from Scott's *Monastery*); 1846, "Buckingham Rebuffed"; 1848, "Queen Elizabeth discovers she is no longer young"; 1850, "Peter the Great sees Catharine for the first time"; 1854, "Charles I. raising

the Standard at Nottingham" (a study); 1855, the "Life and Death of Buckingham"; 1857 and 1858, two subjects from Thackeray's *Esmond;* 1858, "Past and Present, a triple picture of a faithless wife"; 1859, the "Night before Naseby"; 1860, his last exhibited work, the Dinner Scene from *The Taming of the Shrew.*

EGG, the female reproductive cell or ovum of animals, which gives rise generally only after fertilization to a new individual. The largest eggs are those of birds; this because, to the minute essential portion of the egg, or germ, from which the young bird grows, there is added a large store of food-material—the yolk and white of the egg—destined to nourish the growing embryo, while the whole is enclosed within a hard shell.

The relative sizes of eggs depend on the amount of the food-yolk thus enclosed; while the form and texture of the outer envelope are determined by the nature of the environment to which the egg is exposed. Where the food material is infinitesimal in quantity the egg is either not extruded—the embryo being nourished by the maternal tissues—or passes out of the parental body and gives rise at once to a free-living organism or "larva," as is the case in many types of lowly freshwater and marine animals.

The number of eggs periodically produced by any given individual depends on the risks of destruction to which they, and the young to which they give rise, are exposed; not more than a single egg being annually laid by some species, while with others the number may amount to millions.

Birds' Eggs.—The egg of the bird affords the readiest example of the modifications imposed by the external environment. Since it must be incubated by the warmth of the parent's body, the outer envelope is a hard shell to protect the chick from pressure, while the dyes which commonly colour the surface of this shell may serve to hide it from egg-eating animals.

Carbonate of lime forms the principal constituent of the shell. In section, it will be found to be made up of three crystalline layers, traversed by vertical canals, whereby it is made porous to admit air to the developing chick.

The outermost layer is often a glaze, as in the ostrich, or it may assume the character of a thick, chalky layer as in some cuckoos (*Guira, Crotophaga*), cormorants, grebes and flamingoes; while in some birds as in the auks, gulls and tinamous, this outer layer is wanting; yet the tinamous have the most highly glazed eggs of all birds, the second layer of the shell developing a burnished surface.

While some birds' eggs have the shell so thin as to be translucent, *e.g.*, kingfisher, others display considerable thickness, the maximum being reached in the egg of the extinct *Aepyornis.*

Though in shape differing little from that of the familiar hen's egg, certain well-marked modifications of form are to be met with. Thus the eggs of the plover are pear-shaped, of the sand-grouse cylindrical, of owls and titmice spherical and of grebes biconical.

In coloration birds' eggs present a remarkable range. The pigments to which this is due have been shown, by their absorption spectra (Sorby, *Proc. Zool. Soc.*, 1875), to be seven in number. While many eggs are colourless or of one uniform tint, the majority present spots or lines, or both, of varying tints, the pigment being deposited as the egg passes down the lower portion of the oviduct. That the egg during this passage turns slowly on its long axis is shown by the fact that the spots and lines have commonly a spiral direction; though some of the markings are made during periods of rest, as is shown by their sharp outlines, movement giving a blurred effect. Where the egg is pyriform, the large end proceeds first. Many eggs display, in addition to the strongly marked spots, fainter spots embedded in a deeper layer of the shell; *e.g.*, rails and plovers.

Among some species, as in birds of prey, the intensity of this coloration is said to increase with age up to a certain point, when it as gradually decreases. Frequently, especially where but two eggs are laid, all the dye will be deposited, sometimes on the first, sometimes on the last laid, leaving the other colourless. But although of a number of eggs in a "clutch"—as the full complement in a nest is called—no two are exactly alike, they commonly bear a close resemblance. Among certain species, however, which lay several eggs, one of the number differs markedly from the rest, as in the eggs of the house sparrow. In variability the eggs of the guillemot (*Uria troile*) exceed all others; both in the hue of the ground colour and in the form of the superimposed markings, these eggs exhibit a range for which no adequate explanation has yet been given. Individual peculiarities of coloration are commonly reproduced, not only with this species but also in others, year after year.

Significance of Colour.—The coloration of the egg bears no relation to that of the bird which lays it; but it may bear a more or less direct relation to the nature of the environment during incubation. White eggs may generally be regarded as representing the primitive type, since they agree in this with the eggs of reptiles. And it will usually be found that eggs of this hue are deposited in holes or in domed nests. This is because coloured eggs would be invisible in dimly lighted chambers, and therefore constantly exposed to the risk of being broken by the sitting bird, or rolling out of reach where the chamber was large enough to admit of this, whereas white eggs are visible so long as they can be reached by the faintest rays of light. Birds which have reverted to the more ancient custom of nesting in holes after having developed pigmented eggs (*e.g.*, puffins) cover the pigmented surface of the shell with a light-reflecting chalky incrustation.

Eggs deposited on the bare ground are usually protectively coloured. The eggs of the plover tribe afford striking examples.

But the majority of birds deposit their eggs in a more or less elaborately constructed nest, and in such cases the egg, far from being protectively coloured, often displays tints that would appear rather to attract attention; bright blue or blue spotted with black being commonly met with. It may be, however, that coloration of this kind is less conspicuous than is generally supposed, but in any case the safety of the egg depends less on its coloration than on the harmony of the nest.

The size of the egg depends partly on the number produced, on its surroundings and on conditions determining the state of the young at hatching; hence great disparity in the relative sizes of the eggs of different birds. Young birds which emerge blind, naked and helpless are the product of relatively small eggs, while young hatched from relatively large eggs are down-clad and active from birth.

The fact that the eggs must be brooded by the parent is also a controlling factor in so far as number is concerned, for no more can be hatched than can be covered by the sitting bird. Other less understood factors, however, also exercise an influence. Thus the ostrich lays 12 to 16, the teal 15, the partridge 12–20, while among many species the number is strictly limited, as in the hornbills and guillemots, which lay a single egg, the apteryx, divers, petrels, and pigeons never lay more than two, while gulls and plovers never exceed four. Tropical species are said to lay fewer eggs than their representatives in temperate regions.

Partly owing to the uniformity of shape, size and texture of the shell, birds' eggs are by no means easy to identify, except in so far as their family resemblances are concerned; that is to say, except in particular cases, they cannot be specifically distinguished, and hence they are of little value for classification.

Save among the megapodes, all birds brood their eggs, the period of incubation varying from 13 days in small passerine birds, to eight weeks in the cassowary. Megapodes deposit their eggs in mounds of decaying vegetable matter or in sand in the neighbourhood of hot springs, and there leave them. Where the nestling is active from the moment of hatching, the eggs have a relatively longer incubation period than in cases where the nestlings are for long helpless.

Eggs of Mammals.—Only in the *Echidna* (*q.v.*), and the duck-billed platypus (*q.v.*), among the Mammalia, are the eggs provided with a large store of yolk, enclosed within a shell and extruded to undergo development apart from the maternal tissues. In *Echidna* the eggs, two in number, are about as large as those of a sparrow, similar in shape, and have a white, parchment-like shell. After expulsion they are transferred by the beak of the mother

to a pouch resembling that of the kangaroos, and there develop. The platypus lays two to four eggs, which in size and general appearance resemble those of the *Echidna*. They are, however, deposited in a loosely constructed nest at the end of a long burrow and there brooded. In Marsupials, the eggs, which are never extruded, are smaller than those of *Echidna* and the platypus, but contain a larger proportion of yolk than occurs in higher mammals.

Eggs of Reptiles.—The eggs of reptiles are invariably provided with a large amount of food-yolk and enclosed with a firm shell, which though generally parchment-like in texture may be calcareous as in birds, *e.g.*, many of the tortoises and turtles and the crocodiles. The egg is white or yellowish, while the number laid often far exceeds that in birds. The tuatara of New Zealand, however, lays but ten—white hard-shelled, long and oval—at intervals between November and January. The long intervals between the appearance of the successive eggs is a characteristic feature of the reptiles, but is met with among the birds only in the megapodes, which, like the reptiles, do not incubate their eggs.

The eggs of the lizards are generally soft-shelled; but the geckos and the green lizard lay hard-shelled eggs. Many of the soft-shelled eggs increase in size after extrusion, owing to the stretching of the membranous shell by the growing embryo. Lizards are less prolific than many chelonians, a dozen eggs being the general number, though as many as 30 may be produced at a time, as in the common chameleon.

While as a rule the eggs of lizards are laid in burrows or buried, some are retained within the body of the parent until the young are ready to emerge; or may even hatch within the oviduct. This occurs with some chameleons and some lizards, *e.g.*, the common English lizard. Normally the young leaves the egg immediately after its extrusion, but if this is delayed it escapes while yet in the oviduct.

The majority of snakes lay eggs, but most vipers and aquatic snakes are viviparous. The shell is always soft and parchment-like. As a rule the number of eggs produced is not large—20 or 30 being common—but some pythons lay as many as a hundred. Generally, among oviparous snakes the eggs are buried, but some boas jealously guard them, enclosing them within the coils of the body.

Eggs of Amphibia.—Among the Amphibia a greater variety obtains in the matter of the investment of the egg, as well as in the number, size and method of their disposal. The outer covering is formed by a toughening of the surface of a thick gelatinous coat which surrounds the essential parts of the egg.

Viviparity occurs among the limbless and the tailed Amphibia, the eggs hatching before they leave the oviduct or immediately after extrusion. The number of young so produced is generally not large, but the common salamander (*Salamandra maculosa*) may produce as many as 50 at a birth, though 15 is the more normal figure. When the higher number is reached the young are relatively small and weak.

As a rule the young leave the egg as larvae ("tadpoles"); but many species produce eggs containing sufficient food material to enable the whole larval phase to be completed before hatching.

Among the tailless Amphibia (frogs and toads) there are wide differences in the number of eggs produced, while the methods by which these eggs are disposed of present a marvellous variety. As a rule vast quantities of eggs are shed by the female into the water in the form of "spawn." In the common toad as many as 7,000 eggs may be extruded at a time. These leave the body in two long strings—one from each oviduct—of translucent globules, gelatinous in texture, and enclosing a central sphere of yolk, the upper pole of which is black. The spawn of the common frog differs from that of the toad in that the eggs adhere to form a jelly-like mass. But in many species the number of eggs produced is few; and these may be sufficiently stored with food-yolk to allow of the tadpole stage being passed before hatching, as in frogs of the genus *Hylodes*. In many cases the eggs are deposited out of the water and often in remarkable ways. In *Phyllomedusa* the edges of two leaves of a willow overhanging the water are fastened together and the eggs poured into the bag thus formed. The larvae emerging drop into the water. In the midwife toad (*Alytes*) the eggs are carried about on the hind legs of the male. In the pouched frog, the eggs are carried in a pouch on the back of the female; and in the Surinam toad (*Pipa*) the eggs become embedded in the back of the female, the larval stage being passed within the egg.

Eggs of Fishes.—The eggs of fishes present a wide range both of form, and of number. Most sharks and rays are viviparous, but in the oviparous species the eggs present some peculiar forms. Large in size, the outer coat or "shell" is horn-like and flexible, but varies greatly in shape. Thus in the egg of the larger spotted dog-fish it is oblong, flattened from side to side, and has the angles produced into long, slender tendrils. As the egg is laid the lower tendrils project from the vent, and the mother rubs herself against some fixed body. The tendrils catch in some projection when the egg is dragged forth to remain till hatching. A couple of narrow slits at each corner of the upper end admit fresh water to the embryo during the later stages; when development is complete escape is made through the end of the shell. In the rays, long spines take the place of tendrils, the egg simply resting at the bottom of the sea. The empty egg-cases of the rays are often found on the seashore and are known as "Mermaids' purses."

Among the bony fishes the eggs generally take the form of small spheres, enclosed within a tough membrane or capsule. But they present important differences, some being heavy and remaining at the bottom of the water, others light and floating on the surface; in some species they are distributed separately, in others, they adhere together in masses. The eggs of the salmon, for example, are heavy, hard and smooth, and deposited separately in a trough dug by the parent and afterwards covered to prevent them from being carried away by the stream. In the perch they are adhesive and form long band-like masses of spawn adhering to water plants. In the gobies the egg is spindle-shaped, and attached by one end by means of a network of fibres, resembling rootlets; while in the smelt it is loosely suspended by a membrane formed by the peeling off of part of the outer sheath of the capsule. The eggs of the garfish (*Belone vulgaris*) and of the flying-fish (*Exocoetus*), attach themselves to foreign objects, or to one another by threads developed at opposite poles.

In many fishes the eggs float at the surface of the sea, often in enormous masses, when they are carried about at the mercy of tides and currents. An idea of the size which such masses attain may be gathered from the fact that the spawn of the angler-fish, *Lophius piscatorius* is a sheet 2 to 3ft. wide, and 30ft. long. Another remarkable feature of these floating eggs is their transparency, and hence they probably escape spawn-eating animals. The cod tribe and flat-fishes lay floating eggs of this description.

The maximum number of eggs laid by fishes varies greatly, but in all cases the number increases with the weight and age of the fish. Thus it has been calculated that the number laid by the salmon is roughly about 1,000 to every pound weight of the fish. The sturgeon lays about 7,000,000; the herring 50,000; the turbot 14,311,000; the sole 134,000; the perch 280,000. Briefly, the number is greatest where the risks of destruction are greatest.

The eggs of the lampreys and hag-fishes—creatures more primitive than the true fishes—are remarkable; in the latter they are large, cylindrical, and provided at each end with hooklets whereby they adhere one to another; while in the lampreys they are small and embedded in jelly.

Molluscs.—Among the Mollusca, Crustacea and Insecta yolk-stored eggs of remarkable forms are produced.

In variety, in this connection, the Mollusca must perhaps be given the first place. This diversity is illustrated by the eggs of the Cephalopoda. In the squids (*Loligo*), the eggs are enclosed in long cylindrical cases, of which there are several hundreds, attached by one end to a common centre; the whole series looking like a rough mop-head. Each case, in such a cluster, contains about 250 eggs, or about 40,000 in all. By way of contrast the eggs of the cuttle-fish (*Sepia*) are deposited separately, each enclosed in a tough, black, pear-shaped capsule which is fastened by a stalk to fronds of sea-weed or other object. They appear to be

extruded at short intervals, till the full complement is laid, the whole forming a cluster looking like a bunch of grapes. The octopus differs again, its eggs being small, berry-like, and attached to a stalk which runs through the centre of the mass.

The eggs of the univalve Mollusca are hardly less varied. In the common British *Purpura lapillus* they resemble delicate pink grains of rice set on stalks; in *Busycon* they are disc-shaped, and attached to a band nearly 3ft. long. The eggs of the shell-bearing slugs (*Testacella*) are large, and have the outer coat so elastic that if dropped on a stone floor, they will rebound several inches; while some of the snails (*Bulimus*) lay eggs having a white calcareous and slightly iridescent shell, in size and shape resembling the egg of the pigeon. The beautiful marine violet-snail (*Ianthina*) carries its eggs on the under side of a gelatinous raft. The eggs of the whelk, like those of the squids, are enveloped in capsules, and these to the number of many hundreds form the large, ball-like masses commonly met with on the seashore.

With the Mollusca, as with other groups where the eggs are exposed to great risks, they are small, produced in great numbers, and give rise to larvae. Thus the common oyster annually disperses about 60,000,000 eggs. But where the risk of destruction is slight, the eggs are large and produce young differing from the parent only in size, as in the pigeon-like eggs of *Bulimus*.

Crustaceans.—Among the higher Crustacea, as a rule, the eggs are carried by the female, attached to special appendages on the under side of the body. But in some—Squillas—they are deposited in burrows. Generally they are small so that the young which emerge therefrom differ markedly in appearance from the parents, but in deep-sea and freshwater species the eggs are large, when the young, on emerging, differ little from the adults in appearance.

Insects, etc.—The eggs of insects though minute, are also remarkable for variety of form, while they are frequently objects of great beauty owing to the sculptured markings of the shell. They are generally laid in clusters on the ground, on the leaves of plants, or in the water. Some of the gnats (*Culex*) lay them on the water. Cylindrical in shape they are packed closely together, set on end, the whole mass forming a floating raft. Frequently, as in the stick and leaf insects, the eggs are enclosed in capsules of elaborate shapes and highly ornamented.

The eggs of butterflies and moths present a surprising range of variety in shape, sculpturing and coloration. As to the rest of the Invertebrata—above the Protozoa the eggs are laid in water, or in damp places. In the former case they are as a rule small, and give rise to larvae; while eggs hatched on land are sometimes enclosed in capsules, "cocoons," as in the earthworm, in which case this capsule is filled with a milky nutritious fluid on which the embryos feed.

Among some invertebrates two different kinds of eggs are laid. The water-flea, *Daphnia* (a crustacean), lays two kinds known as summer and winter eggs. The summer eggs are carried by the female in a brood-pouch on the back. The winter eggs, produced at the approach of winter, differ markedly in appearance from the summer eggs, being larger, darker in colour, thicker shelled, and enclosed in a capsule formed from the carapace of the parent's body. Winter eggs, however, may be produced in the height of summer. While the summer eggs are unfertilized, the winter eggs are fertilized by the male, and may lie dormant for months or even years before they develop. The production of these two kinds of eggs is a device to overcome the cold of winter, or the drying up of the pools in which the species lives, during the heat of the summer. The power of resistance such eggs possess may be seen in the fact that a sample of mud which had been kept dry for ten years still contained living eggs. In deep water where neither drought nor winter cold can seriously affect *Daphnia*, it propagates all the year round by unfertilized summer eggs.

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EGG AND DART MOULDING, in architecture, a decorated moulding (*q.v.*), in which the convex portion is carved with egg-shaped forms in raised frames, alternating with long, narrow, raised, dart shapes. The egg and dart is a Greek development from the Egyptian and west Asiatic tri-lobe lotus, the dart being the central of the three petals, and half the frame of each of the two adjoining eggs representing the curved side petals. In fact, certain Egyptian bands in which lotus flowers and lotus buds are alternated, have identically the same rhythmic composition as the egg and dart. At first using it as a painted horizontal band, the Greeks came later to employ it as a moulding decoration, and carved it in deep relief. It has remained one of the most popular moulding decorations through all the classic styles.

EGG COOKERY. Eggs are valuable food, containing proteids, fat, salts (notably iron), water and small quantities of carbohydrates. They also contain "a" and "b" vitamins. The white is almost pure albumin dissolved in water and thus blends, when raw, with cold water. The yolk has a high content of fat in the form of oil and also lecithin, an important substance useful for nourishing nerves and for aiding growth. The shell consists chiefly of calcium carbonate and is more or less porous, therefore eggs will not keep unless the shell is hermetically sealed. Raw eggs are easier to digest than cooked ones, and lightly cooked eggs are digested better than those which are subjected to long cooking or great heat, which renders them tough, as albumin coagulates slightly at 134° F and is wholly coagulated at 160° F.

Various kinds of eggs are used in cookery. Hens' eggs are those most commonly eaten but ducks' eggs contain more fat. Plovers' eggs are usually regarded as a delicacy, while those of other birds, turtle and terrapin eggs are eaten in different parts of the world. Eggs have many uses in cookery. The whites are employed as clarifying agents for soups, jellies and sugar, etc., and for making meringues; and the whole egg is used as a gum-like agent in coating foods with crumbs, etc., for frying and baking; it is also a binding medium or leavening agent in such foods as mushes, rissoles, cakes, etc. Again in invalid cookery (*q.v.*) eggs form a very large part of the ingredients; raw eggs and crackers for instance, make a complete meal, while egg drinks furnish a nutritive liquid food. In addition, egg blends with almost all kinds of foods and adds to the richness of dishes. Hard-cooked eggs are also used as garnishes for salads and vegetable dishes. Egg dishes should be very carefully prepared. Over-heating and the addition of foods containing acids, if insufficiently blended with the eggs, will cause curdling. Where starch is an ingredient greater heat can be applied than if plain eggs are used. When it is desired to achieve a "spongy" effect in cakes or soufflés, etc., add the whites and yolks separately, folding the whites in last of all, immediately before cooking, so that they have not time to fall. If acids are mixed with eggs, a thorough beating should be given in order to froth the mixture, in this way effecting complete blending of egg and acid.

In cooking eggs whole, the simplest method is coddling; much depends on the freshness of the egg. A newly-laid egg should be placed in boiling water and allowed to remain at simmering point for 3 to 4 minutes. If a hard-cooked egg is required, allow 20 to 30 min. in order to produce a floury texture. To poach an egg, have ready a shallow oiled pan with salted water and a few drops of vinegar or lemon juice to keep the white from spreading. Spoon the white over the top of the egg so that the yolk is entirely covered. A muffin ring or egg poacher is a great help in keeping the shape of a poached egg. Fried eggs are cooked in hot bacon or other fat until set. Baked or steamed eggs are cooked in small buttered receptacles with or without other foods. Lightly or well-beaten eggs are used in a large number of dishes; *e.g.*, scrambled eggs (beaten and stirred with butter and occasionally

milk), omelettes with other foods, in batter for frying, in preparing soufflés, etc.

Dried or desiccated eggs are occasionally used in place of fresh eggs, but must be mixed with water and allowed to soak before cooking (*see* PRESERVING AND BOTTLING). (J. A. SI.)

EGGENBERG, HANS ULRICH VON, PRINCE (1568–1634), Austrian statesman, was a son of Siegfried von Eggenberg (d. 1594), and began life as a soldier in the Spanish service, becoming about 1596 a trusted servant of the archduke of Styria, afterwards the emperor Ferdinand II. He was soon the chancellor and chief adviser of Ferdinand, whose election as emperor he helped to secure in 1619. He directed the imperial policy during the earlier part of the Thirty Years' War, and was in general a friend and supporter of Wallenstein, and an opponent of Maximilian I., duke of Bavaria, and of Spain. He died at Laibach on Oct. 18, 1634. Eggenberg's influence with Ferdinand was so marked that it was commonly said that Austria rested upon three hills (*Berge*): Eggenberg, Questenberg and Werdenberg. He was made a prince of the Empire in 1623 and duke of Krumau in 1625.

See H. von Zwiedineck-Südenhorst, *Hans Ulrich, Fürst von Eggenberg* (Vienna, 1880); and F. Mares, *Beiträge zur Geschichte der Beziehungen des Fürsten J. U. von Eggenberg zu Kaiser Ferdinand II. und zu Waldstein* (Prague, 1893).

EGGLESTON, EDWARD (1837–1902), American writer, was born in Vevay (Ind.), Dec. 10, 1837, of Virginia and Kentucky stock. Because of his father's early death and his mother's re-marriage the family moved to New Albany and to Madison, and he himself spent some time with relatives in Virginia and southern Indiana, living through the "sharp contrasts of corn-shuckings and camp-meetings, of wild revels followed by wild revivals" which he later described. Before he was nineteen, he had chosen as his own the heroic frontier profession of circuit rider, but within six months the toils and hardships involved broke down his health. After a stay in the Minnesota pine woods to recuperate, he held pastorates in St. Paul and elsewhere in the Minnesota Methodist Conference for several years, and in later life (1874–79) was minister of the Church of Christian Endeavour in Brooklyn. The remainder of his time was spent in literary work as associate editor of the *Little Corporal* (1866–67), a juvenile paper, and editor of the *National Sunday School Teacher* (1867–70), in Chicago; for a short period as literary editor and later editor-in-chief of the *Independent* and editor of *Hearth and Home* in New York; and during the latter part of his life in retirement at his home on Lake George (N. Y.). He died Sept. 4, 1902.

In all of his work he was true to his early ideal—to write with "photographic exactness" of the real West. The earliest of his books for adults, *The Hoosier Schoolmaster* (1871), is also the best known, a vivid study of the backwoods Hoosiers, which was translated into French, German, Dutch and Danish. *The End of the World* (1872) has as its theme the expectation of the end of the world about the middle of the 19th century; *The Mystery of Metropolisville* (1873) portrays a typical Minnesota boom town; *The Circuit Rider* (1874), less a novel than a series of sketches, contributes to our knowledge of frontier religious phenomena; *Roxy* (1878) illuminates politics on the border; *The Graysons* (1888), a good novel, shows Abraham Lincoln as a young lawyer in Illinois. *The Faith Doctor* (1891), *Duffels* (1893) and the children's books are of less significance.

Since Eggleston constantly stressed the fact that "no man is worthy to be called a novelist who does not endeavour with his whole soul to produce the higher form of history, by writing truly of men as they are, and dispassionately of those forms of life that come within his scope," it was but natural that he should turn near the end of his life to the writing of pure history. Although he produced several popular compendiums for school and home, he lived to complete only two volumes of his projected *History of Life in the United States—The Beginners of a Nation* (1896) and *The Transit of Civilization* (1900). As a pioneer in the field of social history, he deserves credit. Some of his novels have faults of exaggeration and structure, but as a first-hand picture of a phase of life that has long since passed away and as an antidote to the thrilling concoctions of the dime novelist they will long be important.

See Meredith Nicholson, *The Hoosiers* (1900) and his article in the *Atlantic Monthly*, vol. xc.; G. C. Eggleston, *The First of the Hoosiers* (1903); also an autobiographical article in the *Forum* (Nov. 1890).

EGG-PLANT (*Solanum Melongena*), a perennial plant of the nightshade family (Solanaceae), closely allied to the potato, and known also as egg-fruit, aubergine and guinea-squash. It is probably a native of southern Asia, where since remote antiquity it has been cultivated for its fleshy fruit used as a vegetable. For this purpose it is usually grown as an annual. It has an erect, bushy, rather scurfy stem, sometimes armed with a few spines, and large ovate, slightly lobed leaves, and nodding, violet, usually solitary flowers, about 2 in. across. The fruit is a large, pendent, egg-shaped, oblong or somewhat pear-shaped berry, varying in length from 2 in. to 12 in., dark purple, white or yellowish in colour, sometimes striped, and with a shining surface. The snake egg-plant is a curious variety (var. *serpentinum*) with very narrow, elongated fruit, sometimes a foot long and curled at the end. The dwarf egg-plant (var. *depressum*) is a small, nearly smooth and spineless form, with nearly entire leaves and purple fruit about 4 in. long. In the southern United States egg-plant is extensively grown in kitchen gardens for home consumption and also as a market crop, the total value of which in 1926 amounted to $935,000. (*See* AUBERGINE.)

EGGS. In a number of countries an attempt is made to enumerate the stock of poultry but it is evident that the result can only be roughly approximated and that returns of the number of eggs would be still more untrustworthy.

In Great Britain returns were obtained, for the first time, in 1908 of the number of poultry kept on agricultural holdings, and similar returns have been collected at intervals in later years. In the special enquiry made in 1925 in connection with the Census of Production Act (*see* AGRICULTURE, CENSUS OF) the Ministry of Agriculture endeavoured also to obtain particulars of egg production on farms. Occupiers owning about 20 per cent of the fowls on agricultural holdings furnished particulars of egg production. On the basis of these returns it was calculated that the number of eggs produced on farms in England and Wales was 1,458 millions. Large numbers of fowls are kept by private persons outside agricultural holdings, and it is estimated that one-third should be added to allow for this supply. The total number of hen's eggs would thus reach nearly 2,000 millions. The production of duck's eggs is estimated at 43 millions.

Great Britain has long been an importer of eggs. As far back as 1710 there was a duty on imported eggs which was from time to time increased from 2d. per "long hundred" (120) to 10d. in 1853, when it was reduced to 4d. and was finally abolished in 1860. At that time the imports amounted to about 2 million eggs.

In 1870 the imports had increased to 431 millions and thereafter rose steadily, decade by decade, up to the time of the World War, thus:—

1880	747	1900	2025
1890	1235	1913	2590

After the trade began to recover from the effects of the World War the total rose to 1,639 millions in 1922. In 1927 the total reached 2,921 millions, but as supplies from the Irish Free State, which, before 1923, were regarded as home produce, have since that date been treated as imports, the figure is not comparable. The imports from the Irish Free State in 1927 amounted to 606 millions, so that the total comparable with that prior to 1923 is 2,315 millions.

Preserved eggs are not distinguished in the returns but it may be assumed that fresh eggs are mostly subjected to some form of preservative process for shipment. In many cases, as in this country, surplus supplies in the season of greatest plenty are "pickled" for a time and sent forward when fresh supplies are smaller.

British Supplies.—The chief British sources of supply and the quantity in "long hundreds" received from each in 1927 are shown in the following table:—

Denmark	5,679,640
Irish Free State	5,051,523
Poland	2,387,956
Netherlands	2,359,895
China	688,183
Egypt	668,544
France	429,509
Above and other countries (total)	24,347,523

There is also a large British importation of eggs not in shell—*i.e.*, egg albumen and yolk, dried eggs and egg powder. In 1927 the total quantity imported was 35,000 tons, of which nearly 98% came from China. These products are used in various industrial processes and also, to some extent, in the confectionery and baking trades.

Before the war more than 50% of the eggs, in shell, imported into the United Kingdom came from Russia. That country, as will be seen from the table above, does not now appear among the chief contributing countries shown in the trade returns, and does not in fact send more than 5% of the total. It should be noted, however, that about 11% of the pre-war supplies came from Poland, Latvia and Lithuania which were then included in Russia, while Estonia and Finland, formerly part of Russia, also sent quotas.

Calculations of egg consumption can only be approximate. In Great Britain the imports, which are accurately recorded, amount (excluding eggs not in shell) to one egg per week per head of the population, and it is estimated that the home supplies would be about equal. On this basis the consumption works out to approximately 110 eggs per annum per head of the population.

Similar calculations give the following estimated annual consumption per head in various countries as follows: Canada, 313; Belgium, 213; U.S.A., 180; France, 133; Germany, 117; Sweden, 86; Denmark, 75; Norway, 61.

A great impetus has been given to poultry-keeping in recent years both by improving the breed of fowls and by adopting better systems of management. A hindrance to increased consumption has been the unreliability of a large proportion of the home supply of eggs and the lack of organized marketing. Active steps are now being taken to remedy these defects and to place British eggs on an equality with their imported rivals in regard to regularity of supply and reliability of quality. (R. H. R.)

United States.—The United States ranks first among all countries in egg production. Farm chicken egg production in 1879 amounted to 456,911,000 doz. eggs and increased to 1,293,662,000 doz. in 1899, 1,654,045,000 doz. in 1919 and to 1,913,245,000 doz. in 1924. These totals, based on census figures, do not include eggs produced on premises not classed as farms or the eggs of poultry other than chickens.

Eggs are produced in every county and on nearly 90% of all the farms in the United States. Specialized egg farming has been increasing rapidly in the last few years, but the eggs from such farms still constitute only a small proportion of the total production. General farm flocks are the source of much the greater part of the production, more than 50% of all eggs coming from the East North Central and the West North Central States, where the farm flocks greatly predominate. Specialized egg farms are most common in the Atlantic coast States, in close proximity to the large consuming markets, and in the Pacific coast States, where climatic conditions are especially favourable.

Eggs produced in the United States are used largely within the country. There is, however, some export business of eggs in the shell. It amounted in 1927 to 28,707,000 dozen. These eggs are shipped mainly to Canada, Cuba and Mexico, with fairly regular quantities going to South American countries, notably Argentina. Smaller quantities of egg products in the form of frozen, dried and canned eggs and egg yolks are also exported, these amounting in 1927 to about 660,000 pounds.

Imports of shell eggs are small, amounting to about 250,000 doz. in 1927. Imports of egg products are much greater, amounting in 1927 to the following: dried whole eggs 962,000 lb.; frozen whole eggs 2,774,000 lb.; dried yolks 3,525,000 lb.; frozen yolks 2,778,000 lb.; dried egg albumen 2,960,000 lb.; frozen, prepared or preserved egg albumen 2,341,000 lb. The shell eggs imported come principally from Canada, while China furnishes the great bulk of the frozen and dried egg products. (R. R. Sl.)

EGHAM, a town in the Chertsey parliamentary division of Surrey, England, on the Thames, 21 m. W.S.W. of London on the Southern railway. Pop. of urban district (1921) 13,725. The church of St. John the Baptist is a reconstruction of 1817; it contains monuments by John Flaxman. Above the right bank of the river a low elevation, Cooper's hill, commands fine views over the winding river valley, and over Windsor Great Park to the west. On the hill was the Royal Indian Civil Engineering college, commonly called Cooper's Hill college. Cooper's hill also gave its name to a famous poem of Sir John Denham (1643). A large and handsome building, surrounded by extensive grounds, houses the Royal Holloway College for Women (1886), founded by Thomas Holloway. In the neighbourhood is the sanatorium of the same founder (1885) for the treatment of mental ailments. Within the parish, bordering the river, is the famous field of Runnymede, with the eyot or small island of Magna Charta lying off it in the stream (but situated in Buckinghamshire). The parish also includes the picturesque grounds and artificial lake of Virginia Water at the south end of Windsor Park, formed *c.* 1750, by the brothers Thomas and Paul Sandby.

EGILL SKALLAGRIMSSON (*c.* 900–983), an Icelandic skald, was forced to emigrate by Harold Fairhair, and after some years in the service of the English king, Aethelstan, returned to Norway, and took revenge by killing the son of Erik Blódöx in 934. Later he gained the favour of the king by his poem, *Höfudhlausn* (partial Swedish trans. by Sörenssen in 1866 and by Åkerblom in 1899).

His other works include the sagas *Sonatorrek, Arinbjarnardrápa* (Swedish trans. by Björlin in 1864) and *Skjaldardrápa.* The well known Icelandic poem, *Egill's Saga,* has been edited by F. Jónsson (Copenhagen, 1886; 2nd ed., 1924; Eng. trans., 1893). Some critics attribute it to Snorri Sturlason, *e.g.*, A. Bley, *Eigla-Studien* (Ghent, 1909). *See* also F. Khull, *Die Gesch. des Skalden E. Skallagrimsson* (1888).

EGIN or **KEMALIEH,** a kaza in the Mamuret el-Aziz vilayet of Asiatic Turkey (altitude 3,300 ft.). Pop. (1927) 22,975. It is picturesquely situated in a theatre of lofty, abrupt rocks, on the right bank of the western Euphrates, which is crossed by a wooden bridge. The stone houses stand in terraced gardens and orchards, and the streets are mere rock ladders. Egin was settled by Armenians who emigrated from Van in the 11th century with Senekherim.

EGLANTINE has been the subject of much discussion, both as to its exact meaning and as to the shrub to which it properly belongs. (*See* R. C. A. Prior: *Popular Names of British Plants.*) The eglantine of the herbalists was the sweet-brier, *Rosa rubiginosa,* but the name is more properly applied to *Rosa Eglanteria.* The sweet-brier has become extensively naturalized in eastern North America, growing abundantly in pastures, thickets and road-sides from Nova Scotia and Ontario south-westward to Tennessee and Kansas. Eglantine is frequently alluded to in the writings of English poets, from Chaucer downwards. Milton, in *L'Allegro,* is thought by the term "twisted eglantine" to denote the honeysuckle, *Lonicera Periclymenum,* which is still known as eglantine in north-east Yorkshire.

EGLINTON, EARLS OF. The title of earl of Eglinton has been held by the famous Scottish family of Montgomerie since 1508. The attempts made to trace the descent of this house to Roger of Montgomery, earl of Shrewsbury (d. 1094), one of William the Conqueror's followers, will not bear examination, and the sure pedigree of the family only begins with Sir John Montgomerie, lord of Eaglesham, who fought at the battle of Otterbourne in 1388 and died about 1398. His grandson, Sir Alexander Montgomerie (d. *c.* 1460), was made a lord of the Scottish parliament about 1445 as Lord Montgomerie, and Sir Alexander's great-grandson Hugh, the 3rd lord (*c.* 1460–1545), was created earl of Eglinton, or Eglintoun, in 1508. Hugh, who was a person of importance during the minority of James V., was succeeded by his grandson Hugh (d. 1546), and then by the latter's son Hugh (*c.* 1531–1585), who became 3rd earl of Eglinton. The 3rd earl

was a firm supporter of Mary queen of Scots, for whom he fought at Langside, and of the Roman Catholic Church; his son and successor, Hugh, was murdered in April 1586 by the Cunninghams, a family with which his own had an hereditary blood feud. In 1612, by the death of Hugh, the 5th earl, the male line of the Montgomeries became extinct.

The most famous of the earls of Eglinton are the 6th earl, commonly called "Greysteel," a prominent covenanter who fought against Charles I. at Marston Moor, and the 13th earl, Archibald William, who is remembered for the tournament which took place at Eglinton Castle, described by Disraeli in *Endymion.* He became lord-lieutenant of Ireland in 1852 under the Derby ministry and again in 1858–59.

See Sir W. Fraser, *Memorials of the Montgomeries, earls of Eglinton* (1859).

EGMONT, EARLS OF. JOHN PERCEVAL, 1ST EARL OF EGMONT (1683–1748), Irish politician, and partner with J. E. Oglethorpe in founding the American colony of Georgia, was created earl in 1733. He claimed descent from the Egmonts of Flanders, but his title was taken from the place in County Cork where the family residence stood. The first earl of Egmont (who had been made Baron Perceval in 1715, and Viscount Perceval in 1723) is chiefly important for his connection with the colonization of Georgia, and for his voluminous letters and writings on biography and genealogy.

JOHN PERCEVAL, 2ND EARL OF EGMONT (1711–1770), his eldest son, was first lord of the admiralty (1763–66). One of his younger sons was SPENCER PERCEVAL, prime minister of England.

EGMONT (EGMOND), **LAMORAL,** COUNT OF, prince of Gavre (1522–1568), was born in Hainaut in 1522. He was the younger of the two sons of John IV., count of Egmont, by his wife Françoise of Luxemburg, princess of Gavre. On the death of his elder brother Charles, about 1541, he succeeded to his titles and estates. He served in the expedition (1541) of the emperor Charles V. to Algiers. In 1544 he married Sabina, sister of the elector palatine Frederick III. Created knight of the Golden Fleece in 1546, he accompanied Philip of Spain in his tour through the Netherland towns, and in 1554 he was sent to England to ask the hand of Mary of England for Philip; he was present at the wedding ceremony at Winchester. In the summer of 1557 Egmont was appointed commander of the Flemish cavalry in the war between Spain and France; and the victory of St. Quentin was determined by the brilliant charge which he led against the French. In 1558 he encountered the French army under de Thermes at Gravelines, on its march homewards after the invasion of Flanders, totally defeated it, and took Marshal de Thermes prisoner. The battle was fought against the advice of the duke of Alva, and the victory made Alva Egmont's enemy. But the count now became the idol of his countrymen, who looked upon him as the saviour of Flanders from the devastations of the French. He was nominated by Philip stadtholder of Flanders and Artois. At the conclusion of the war by the Treaty of Cateau-Cambrésis, Egmont was one of the four hostages selected by the king of France as pledges for its execution.

The attempt made by King Philip to convert the Netherlands into a Spanish dependency and to govern it by Spanish ministers excited the resentment of Egmont and other leading members of the Netherlands aristocracy (*see* NETHERLANDS: *History*). As a member of the council of state Egmont joined the prince of Orange in a vigorous protest addressed to Philip (1561) against Granvella's administration; and two years later he again protested in conjunction with the prince of Orange and Count Horn. In the spring of 1564 Granvella left the Netherlands, and the malcontent nobles once more took their places in the council of state. But Philip's determination to enforce the decrees of the council of Trent throughout the Netherlands once more aroused their resentment; and, in Jan. 1665, Egmont went on a special mission to Spain to inform Philip of the state of affairs. At Madrid the king steadily evaded any serious discussion of the object of his mission, and Egmont finally returned home without having accomplished anything. At the same time Philip sent further instructions to the regent to abate nothing of the severity of the persecution.

In 1566 a confederacy of the lesser nobility was formed (*Les Gueux*) whose principles were set out in a document known as the Compromise. From this league Egmont held aloof; he declined to take any step savouring of actual disloyalty to his sovereign. He withdrew to his government of Flanders, and as stadtholder took active measures for the persecution of heretics. But in the eyes of Philip he had long been a marked man. In the summer of 1567 the duke of Alva was despatched to the Netherlands at the head of an army of veterans to supersede the regent Margaret and restore order in the discontented provinces. Orange fled to Germany after having vainly warned Egmont and Horn of the dangers that threatened them. Alva was at pains to lull their suspicions, and then suddenly seized them both and threw them in the castle of Ghent. Their trial was a farce, for their fate had already been determined before Alva left Spain. After some months of imprisonment they were removed to Brussels, where sentence was pronounced upon them (June 4) by the infamous Council of Blood erected by Alva. They were condemned to death for high treason. Egmont was beheaded at Brussels in the square before the town hall, on the day after his sentence had been publicly pronounced (June 5, 1568). He met his fate with calm resignation; and in the storm of terror and exasperation to which this tragedy gave rise Egmont's failings were forgotten, and he and his fellow-victim to Spanish tyranny were glorified in the popular imagination as martyrs of Flemish freedom. From this memorable event, which Goethe made the theme of his play *Egmont* (1788), is usually dated the beginning of the famous revolt of the Netherlands. In 1865 a monument to Counts Egmont and Horn, by Fraiken, was erected on the spot where they were beheaded.

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EGO (Latin for I), the Self, in contrast with Alter (Lat. for other), another person, or NON-EGO, anything other than the self. Different views have been put forward as to the development of the consciousness of the self and of other selves. According to some, each of us has an immediate intuition both of his own self and of other selves. Others maintain that we each begin with an apprehension of his own self, and only arrive at an apprehension of other selves by a process of projection or "ejection" of our own self into other bodies, so to say. Others, again, hold that we get to know other selves and then discover each his own self by a process of interpretation based on our knowledge of others. The prevailing view among psychologists is that the two processes of knowing one's own self and of knowing other selves go on simultaneously, and that our knowledge of each is made richer by contrast with the other.

EGOISM, a modern philosophical term used generally, in opposition to "Altruism," for any ethical system in which the happiness or the good of the individual is the main criterion of moral action (from Gr. and Lat. *ego*, I, the 1st personal pronoun). Another form of the word, "Egotism," is really interchangeable, though in ordinary language it is often used specially (and similarly "egoism," as in George Meredith's *Egoist*) to describe the habit of magnifying one's self and one's achievements, or regarding all things from a selfish point of view. Both these ideas derive from the original meaning of *ego*, myself, as opposed to everything which is outside myself. This antithesis of ego and non-ego, self and not-self, may be understood in several senses according to the connection in which it is used. Thus the self may be held to include one's family, property, business and an indefinitely wider range of persons or objects in which the individual's interest is for the moment centred, *i.e.*, everything which I can call "mine." In this, its widest, sense "a man's Self is the sum total of all that he *can* call his" (Wm. James, *Principles of Psychology*, ch. x.). This self may be divided up in many ways according to the various forms in which it may be expressed. Thus James (*ibid.*) classifies the various "selves" as the material, the spiritual, the social and the "pure." Or again the self may be narrowed

down to a man's own person, consisting of an individual mind and body. In the true philosophical sense, however, the conception of the ego is still further narrowed down to the individual consciousness as opposed to all that is outside it, *i.e.*, can be its object. This conception of the self belongs mainly to metaphysics and involves the whole problem of the relation between subject and object, the nature of reality and the possibility of knowledge of self and of object. The ordinary idea of the self as a physical entity, obviously separate from others, takes no account of the problem as to how and in what sense the individual is conscious of himself; what is the relation between subject and object in the phenomenon of self-consciousness, in which the mind reflects upon itself both past and present? The mind is in this case both subject and object, or, as William James puts it, both "I" and "me." The phenomenon has been described in various ways by different thinkers. Thus Kant distinguished the two selves as rational and empirical, just as he distinguished the two egos as the noumenal or real and the phenomenal from the metaphysical standpoint. A similar distinction is made by Herbart. Others have held that the self has a complex content, the subject self being, as it were, a fuller expression of the object-self (so Bradley); or again the subject self is the active content of the mind, and the object self the passive content which for the moment is exciting the attention. The most satisfactory and also the most general view is that consciousness is complex and unanalysable.

The relation of the self to the not-self need not to be treated here (*see* METAPHYSICS). It may, however, be pointed out that in so far as an object is cognized by the mind, it becomes in a sense part of the complex self-content. In this sense the individual is in himself his own universe, his whole existence being, in other words, the sum total of his psychic relations, and nothing else being *for him* in existence at all. A similar idea is prominent in many philosophico-religious systems wherein the idea of God or the Infinite is, as it were, the union of the ego and the non-ego, or subject and object. The self of man is regarded as having limitations, whereas the Godhead is infinite and all-inclusive. In many mystical oriental religions the perfection of the human self is absorption in the infinite, as a ripple dies away on the surface of water. The problems of the self may be summed up as follows. The psychologist investigates the ideal construction of the self, *i.e.*, the way in which the conception of the self arises, the different aspects or contents of the self and the relation of the subject to the object self. At this point the epistemologist takes up the question of empirical knowledge and considers the kind of validity, if any, which it can possess. What existence has the known object for the knowing subject? The result of this enquiry is generally intellectual scepticism in a greater or less degree, namely, that the object has no existence for the knower except a relative one, *i.e.*, in so far as it is "known." Finally the metaphysician, and in another sphere the theologian, consider the nature of the pure or transcendental self apart from its relations, *i.e.*, the absolute self.

In ethics, egoistic doctrines disregard the ultimate problems of selfhood, and assume the self to consist of a man's person and those things in which he is or ought to be directly interested. The general statement that such doctrines refer all moral action to criteria of the individual's happiness, preservation, moral perfection, raises an obvious difficulty. Egoism merely asserts that the self is all-important in the application of moral principles, and does not in any way supply the material of these principles. It is a purely formal direction, and as such merely an adjunct to a substantive ethical criterion. A practical theory of ethics seeks to establish a particular moral ideal; if it is an absolute criterion, then the altruist would place first the attainment of that ideal by others, while the egoist would seek it for himself. The same is true of ethical theories which may be described as material. Of the second type are those, *e.g.*, of Hobbes and Spinoza, which advocate self-preservation as the ideal, as contrasted with modern evolutionist moralists who advocate race-preservation. Again, we may contrast the early Greek hedonists, who bade each man seek the greatest happiness (of whatever kind), with modern utilitarian and social hedonists, who prefer the greatest good or the greatest happiness of the greatest number. It is with hedonistic and other empirical theories that egoism is generally associated. As a matter of fact, however, egoism has been no less prominent in intuitional ethics. Thus the man who seeks only or primarily his own moral perfection is an egoist par excellence. Such are ascetics, hermits and the like, whose whole object is the realization of their highest selves.

The distinction of egoistical and altruistic action is further complicated by two facts. In the first place, many systems combine the two. Thus Christian ethics may be said to insist equally on duty to self and duty to others, while crudely egoistic systems become unworkable if a man renders himself obnoxious to his fellows. On the other hand, every deliberate action based on an avowedly altruistic principle necessarily has a reference to the agent; if it is right that A should do a certain action for the benefit of B, then it tends to the moral self-realization of A that he should do it. Upon whatsoever principle the rightness of an action depends, its performance is right *for the agent*. The self-reference is inevitable in every action in so far as it is regarded as voluntary and chosen as being of a particular moral quality.

It is this latter fact which has led many students of human character to state that men do in fact aim at the gratification of their personal desires and impulses. The laws of the State and the various rules of conduct laid down by religion or morality are merely devices adopted for general convenience. The most remarkable statement of this point of view is that of Friedrich Nietzsche, who went so far as to denounce all forms of self-denial as cowardice:—let every one who is strong seek to make himself dominant at the expense of the weak.

EGORIEVSK, a town in the Moscow province of the Russian S.F.S.R., connected by a branch line with the Moscow to Ryazan railway. Lat. 55° 23′ N., long. 38° 57′ E. Pop. (1926) 27,991. Its manufactures include dyes and dyed fabrics, cotton goods, ready made garments and buttons. There is a municipal electric plant.

EGREMONT, EARLS OF. In 1749 Algernon Seymour, 7th duke of Somerset, was created earl of Egremont, and on his death without heirs in Feb. 1750 this title passed by special remainder to his nephew, Sir Charles Wyndham or Windham, Bart. (1710–1763), a son of Sir William Wyndham of Orchard Wyndham, Somerset. Charles was a member of parliament from 1734 to 1750, and in Oct. 1761 he was appointed secretary of State for the southern department in succession to William Pitt. His term of office, during which he acted in concert with his brother-in-law, George Grenville, was mainly occupied with the declaration of war on Spain and with the negotiations for peace with France and Spain, a peace the terms of which the earl seems to have disliked.

The 2nd earl's son and successor, GEORGE O'BRIEN WYNDHAM (1751–1837), was more famous as a patron of art and an agriculturist than as a politician. For some time the painter Turner lived at his Sussex residence, Petworth House, and in addition to Turner, the painter Leslie, the sculptor Flaxman and other talented artists received commissions from Egremont, who filled his house with valuable works of art. Generous and hospitable, blunt and eccentric, the earl was in his day a very prominent figure in English society. On the death of his nephew and successor, George Francis Wyndham, the 4th earl (1785–1845), the earldom of Egremont became extinct. Petworth, however, and the large estates had already passed to George Wyndham (1787–1869), a natural son of the 3rd earl, who was created Baron Leconfield in 1859.

EGREMONT, market town, urban district, Whitehaven parliamentary division, Cumberland, England, 5 m. S.E. of Whitehaven on the L.M.S. railway. Pop. (1921) 6,582. It is pleasantly situated in the valley of the Ehen. Ruins of a castle command the town. It was founded *c.* 1120 by William de Meschines; it is moated, and retains a Norman doorway and some of the original masonry, as well as fragments of later date. In the church of St. Mary, modern reconstruction embodies some of the Norman features of the old church. Iron ore and limestone are raised in the neighbourhood. Henry I. gave the barony of Coupland to

William de Meschines, who erected a castle at Egremont around which the town grew. The barony passed to the families of Lucy and Multon, and finally to the Percys, earls of Northumberland, from whom are descended the present lords of the manor of Egremont. In a charter in the reign of King John, the town is called a borough. The borough was represented by two members in the parliament of 1295, but in the following year was disfranchised. In 1267 Henry III. granted a market every Wednesday and a fair every year on the eve, day and morrow of the Nativity of the Virgin Mary. There was also another weekly market on Saturday. The market rights were purchased from Lord Leconfield in 1885, and the market on Saturday is still held. Richard de Lucy's charter shows that dyeing, weaving and fulling were carried on in the town in his time.

EGRESS, in astronomy, the end of the apparent transit of a small body over the disk of a larger one; especially of a transit of a satellite of Jupiter over the disk of that planet. It designates the moment at which the smaller body is seen to leave the limb of the other.

EGRET, the name given to those birds of genus *Egretta,* which are characterized by a white plumage, and, in the breeding season, by long dorsal plumes, from which the barbules are absent, thus giving them a silky appearance. They are known to the feather trade as "ospreys" and are highly valued as ornaments. The largest form is *E. occidentalis* from Florida and Cuba, about 4ft. long. The European *E. alba* is slightly smaller. The American egret, *E. egretta,* measures about three feet. The snowy egret, *E. candidissima,* is smaller. Other species occur in Asia and Australia. In certain parts of the world (*e.g.,* southern U.S.A.) egrets were in danger of becoming scarce or extinct owing to the depredations of the plume-hunters. But protection by the Audubon Societies and legislation on the importation of plumage are now bringing about a revival in numbers in some places. The American egret wanders northward in summer, often visiting the north Atlantic states.

EGYPT, a country forming the north-eastern extremity of Africa. It is bounded north by the Mediterranean, south by the Anglo-Egyptian Sudan, north-east by Palestine, east by the Red sea, west by Tripoli and the Sahara. The western frontier starts from the Gulf of Sollum in the Mediterranean, runs in a slightly south-westerly direction, leaving the oasis of Jarabub in Tripoli and the oasis of Siwa in Egypt, until it reaches the 25th meridian, and then follows it south to the 22nd parallel, which forms throughout the boundary between Egypt and the Sudan. The north-east frontier is an almost direct line drawn from Taba, near the head of the Gulf of Akaba, the eastern of the two gulfs into which the Red sea divides, to the Mediterranean at Rafa in 34° 15′ E. The peninsula of Sinai, geographically part of Asia, is thus included in the Egyptian dominions. The total area of the country is about 386,000 sq.m., or more than three times the size of the British Isles. Of this area $\frac{14}{15}$ is desert. Canals, roads, date plantations, etc., cover 1,900 sq.m.; 2,850 sq.m. are comprised in the surface of the Nile, marshes, lakes, etc.; and the cultivable area is about 12,000 sq. miles. A line drawn just south of Cairo, divides the country into Lower and Upper Egypt, or the Delta and the Nile valley. By the Arabs Lower Egypt is called Er-Rif, the cultivated or fertile; Upper Egypt Es Sa'id, the happy or fortunate. Another division of the country is into Lower, Middle and Upper Egypt, Middle Egypt in this classification being the district between Cairo and Assiut.

General Character.—The distinguishing features of Egypt are the Nile and the desert. But for the river there would be nothing to differentiate the country from other parts of the Sahara. The Nile, however, piercing the desert, and at its annual overflow depositing rich sediment brought from the Abyssinian highlands, has created the Delta and the fertile strip in Upper Egypt. Beyond the Nile valley east and west stretch great deserts, containing here and there fertile oases. The Delta is a level plain, richly cultivated, and varied alone by the lofty dark-brown mounds of ancient cities, and the villages set in groves of palm-trees, standing on mounds often, if not always, ancient. In Upper Egypt the Nile valley is very narrow and is bounded by mountains of no great height. They form the edge of the desert on either side of the valley, of which the bottom is level rock. The bright green of the fields, the reddish-brown or dull green of the great river, contrasting with the bare yellow rocks, seen beneath a brilliant sun and a deep-blue sky, present views of great beauty. In form the landscape varies little and is not remarkable; in colour its qualities are always splendid, and under a general uniformity show a continual variety.

GEOGRAPHICAL FEATURES

Egypt has a coast-line which extends to over 600 m. on the Mediterranean and to about 1,200 m. on the Red sea. The Mediterranean coast extends from the Gulf of Sollum on the west to Rafa on the east. From the gulf to the beginning of the Delta the coast possesses no good harbourage, and is fringed by the cliffs of a stony plateau, which southward joins the more arid and uninhabitable wastes of the Libyan desert. The Delta coast-line, composed of sandhills and, occasionally, limestone rocks, is low, with cape-like projections at the Nile mouths formed by the river silt. Beyond the Delta eastward the coast is again barren and without harbours. It rises gradually southward, merging into the plateau of the Sinai peninsula. The Red sea coast is everywhere mountainous, in continuation of the Abyssinian tableland, and some of the peaks are over 6,000 ft. above the sea.

The Nile Valley (*see* also NILE). Entering Egypt proper, a little north of the Second Cataract, the Nile flows through a valley in sandstone beds as far as 25° N., and throughout this part of its course the valley is extremely narrow, rarely exceeding 2 m. in width. At two points, namely, Kalabsha—the valley here being only 170 yd. wide and the river over 100 ft. deep—and Aswan (First Cataract), the course of the river is interrupted by outcrops of granites and other crystalline rocks, forming the mass of islands, with numerous small rapids, which are described not very accurately as cataracts. From 25° N. northwards for 518 m. the valley is of the "rift-valley" type, a level depression in a limestone plateau, enclosed usually by steep cliffs, which rise to 1,800 ft. between Esna and Kena. The average width of the cultivated land is about 10 m., of which the greater part lies on the left bank of the river; and outside this is a belt, varying from a few hundred yards to 3 or 4 m. of stony and sandy ground, reaching up to the foot of the limestone scarp. This continues as far as 29° N., after which the hills that close in the valley become lower, and the higher plateaus lie at a distance of 10 or 15 m. back in the desert. West of the Nile, and separated from it by a narrow strip of desert, between the 29th and 30th parallels, lies the Fayum. It contains the Sweetwater lake, the Birket-el-Kurun, about 140 ft. below sea-level, and is fertilized by an old branch of the Nile, the Bahr-Yusuf, which has been canalized and enters the Fayum through a gap in the desert hills by the 12th dynasty pyramids of Lahun and Hawara.

The Delta.—About 30° N., where the city of Cairo stands, the hills which have hitherto run parallel with the Nile turn outwards, and the triangular area between them is wholly deltaic. The Delta is a wide alluvial plain sloping gently towards the sea, measuring 100 m. from south to north and resting on 155 m. of sea-front from Alexandria to Port Said. The Nile alluvium, containing alumina (about 48%) and calcium carbonate (18%) is believed to increase at the rate of 4½ in. in a century; so fine are its particles that at places it becomes almost a stiff clay. It ranges in thickness from 55 to 70 ft., and underneath it lies a series of yellow quartz sands, intermixed with pebbles, gravel and clay, the rocky base of which has not yet been disclosed by borings. The surface of the Delta is the most fertile part of Egypt, and is irrigated by the Damietta and Rosetta arms of the Nile, as well as by a network of canals. On the sea face it degenerates into a shore of low sand-hills, with a line of lagoons and salt marshes behind them.

The Lakes.—The lagoons or lakes of the Delta, going from west to east, are Mareotis (Mariut), Edku, Burlus and Menzala. The land separating them from the Mediterranean is nowhere more than 10 m., and in some places only a few hundred yards, wide. All the lakes are shallow and the water in them salt or brack-

ish. Mareotis, which bounds Alexandria on the south side, varies considerably in area according to the rise or fall of the Nile; when the Nile is low there is a wide expanse of marsh, when at its highest the lake covers about 100 sq. miles. In ancient times the lake was the centre of fertile country, famous for its wine. Later, it shrank in area, and villages sprang up on its dry bed. In April 1801 the British army besieging Alexandria cut through the land between Aboukir and the lake, admitting the waters of the sea and laying under water the large area then in cultivation. This precedent was twice imitated, first by the Turks in 1803 and a second time by the British in 1807. Mareotis has no outlet, and the water is kept at a uniform level by means of powerful pumps which neutralize the effect of the Nile flood. A western arm has been cut off from the lake by a dyke, and in this arm a thick crust of salt is formed each year after the evaporation of the flood water. East of Mariut and reaching to within 4 m. of the Rosetta branch of the Nile, lies Edku, 22 m. long and in places 16 wide, with an opening, supposed to be the ancient Canopic mouth of the Nile, into Aboukir bay. Burlus begins a little eastward of the Rosetta channel, and stretches bow-shaped for 64 miles. Its greatest width is about 16 m., and through it ran the ancient Sebennytic branch of the Nile. Burlus is noted for its water-melons, which are yellow within and come into season after those grown on the banks of the Nile.

Menzala greatly exceeds the other Delta lakes in size, covering over 780 sq. miles. It extends from very near the Damietta branch of the Nile to Port Said, and receives the waters of the canalized channels which were once the Tanitic, Mendesian and Pelusiac branches. The northern shore is separated from the sea by an extremely narrow strip of land, and the Suez canal runs along its eastern edge. It contains a large number of islands, one of which, Tennis (anciently Tennesus), contains ruins of the Roman period. The lake supports a considerable population of fishermen, who dwell in villages on the shore and islands and live upon the fish of the lake. The reeds are cover for waterfowl of various kinds, which the traveller sees in great numbers, and wild boars are found in the marshes to the south. East of Menzala is the site of Serbonis, another dried-up lake, which had the general characteristics of the Delta lagoons. In the Isthmus of Suez are Lake Timsa and the Great and Little Bitter lakes, occupying part of the ancient bed of the Red sea. All three were dry or marshy depressions until the cutting of the Suez canal let the waters of the Mediterranean and Red sea into them (*see* SUEZ CANAL).

A chain of natron lakes (seven in number) lies in a valley in the western desert, 70 to 90 m. W.N.W. of Cairo. In the Fayum province farther south is the Birket-el-Kurun, some 30 m. long and 5 wide at its broadest part, being all that now represents the storied Lake of Moeris. Near the lake are several sites of ancient towns, and the temple called Kasr-Karun, dating from Roman times, distinguishes the most important of these.

The Desert Plateaux.—From the southern borders of Egypt to the Delta in the north, the desert plateaux extend on either side of the Nile valley. The eastern region, between the Nile and the Red sea, varies in width from 90 to 350 m. and is known in its northern part as the Arabian desert. The western region has no natural barrier for many hundreds of miles; it is part of the vast Sahara. North of Aswan it is called the Libyan desert. In the north the desert plateaux are comparatively low, but from Cairo southwards they rise to 1,000 and even 1,500 ft. above sea-level. The weathering of this desert area is probably fairly rapid, the agents at work being principally the rapid heating and cooling of the rocks by day and night, and the erosive action of sand-laden wind on the softer layers; these, aided by the occasional rain, are ceaselessly at work, and produce the successive plateaux, dotted with small isolated hills and cut up by valleys (wadis) which occasionally become deep ravines, thus forming the principal type of scenery of these deserts. East of the Nile the desert meets the line of mountains which runs parallel to the Red sea and the Gulf of Suez. In the western desert, however, those large sand accumulations which are usually associated with a desert are met with. They occur as long, narrow lines of dunes formed of rounded grains of quartz, lying in the direction of the prevalent wind; in places they cover immense areas, rendering them absolutely impassable except in a direction parallel to the lines themselves. East of the oases of Baharia and Farafra is a very striking line of these sand dunes; rarely more than 3 m. wide, it extends for a length of nearly 550 miles.

Oases.—In the western desert lie the five large oases of Egypt, namely, Siwa, Baharia, Farafra, Dakhla and Kharga or Great oasis, occupying depressions in the plateau or, in the case of the last three, large indentations in the face of limestone escarpments which form the western versant of the Nile valley hills. Their fertility is due to a plentiful supply of water furnished by a sandstone bed 300 to 500 ft. below the surface, whence the water rises through natural fissures or artificial boreholes. These oases were known and occupied by the Egyptians as early as 1600 B.C., and Kharga rose to special importance at the time of the Persian occupation. Here, near the town of Kharga, the ancient Hebi, is a temple of Ammon built by Darius I., and in the same oasis are other ruins of the period of the Ptolemies and Caesars. The oasis of Siwa (Jupiter Ammon) is about 150 m. S. of the Mediterranean at the Gulf of Sollum and about 300 m. W. of the Nile. The other four oases lie parallel to and distant 100 to 150 m. from the Nile, between 25° and 29° N., Baharia being the most northerly and Kharga the most southerly.

Besides the oases the desert is remarkable for two other valleys. The first is that of the natron lakes already mentioned. It contains four monasteries, the remains of the famous anchorite settlement of Nitriae. South of the Wadi Natron, and parallel to it, is a sterile valley called the Bahr-bela-Ma, or "River without Water."

The Sinai Peninsula.—The triangular-shaped Sinai peninsula has its base on the Mediterranean, the northern part being an arid plateau, the desert of Tih. The apex is occupied by a massif of crystalline rocks, which rise bare and steep (in places to a height of over 8,500 ft.) from the valleys and support hardly any vegetation. In some of the valleys wells or rock-pools filled by rain occur, and furnish drinking-water to the few Arabs who wander in these hills.

CLIMATE AND GEOLOGY

Geology.—The oldest formation in the eastern part of the country is a great tract of uneven crystalline schists, which runs from the Sinai peninsula to the north border of Abyssinia. Overlying the crystalline rock in this area is a thick volcanic series, in which are numerous intrusions of granite, which furnished the chief material for the ancient monuments. At Aswan (Syene) the well-known syenite of Werner occurs. It is, however, a hornblende granite and does not possess the mineralogical composition of the syenites of modern petrology. On the western side of the country, from Thebes to Khartoum, the crystalline formation is overlaid by Nubian sandstone, which extends westward from the river to the edge of the great Libyan desert, where it forms the bed rock. Above the sandstone in many places lie a series of clays: and over them in turn rests the thick layer of soft white limestone which lines the Nile valley south of Cairo and furnishes fine building stone. In the Kharga oasis the upper portion consists of variously coloured unfossiliferous clays with intercalated bands of sandstone containing fossil silicified woods (*Nicolia Aegyptiaca* and *Araucarioxylon Aegypticum*). They are conformably overlain by clays and limestones with *Exogyra Overwegi* belonging to the Lower Danian, and these by clays and white chalk with *Ananchytes ovata* of the Upper Danian. The fluvio-marine deposits of the Upper Eocene and Oligocene formations contain an interesting mammalian fauna; *Arsinoitherium* is the precursor of the horned Ungulata; while *Moeritherium* and *Palaeo-mastodon* undoubtedly include the oldest known elephants. Miocene strata are absent in the southern Tertiary areas, but are present at Moghara and in the North. Marine Pliocene strata occur to the south of the pyramids of Giza and in the Fayum province, where, in addition, some gravel terraces, at a height of 500 ft. above sea-level, are attributed to the Pliocene period. The Lake of Moeris, as a large body of fresh water,

appears to have come into existence in Pleistocene times. It is represented now by the brackish-water lake of the Birket-el-Kurun. The superficial sands of the deserts and the Nile mud form the chief recent formations. The Nile deposits its mud over the valley before reaching the sea, and consequently the Delta receives little additional material. The superficial sands of the desert region, derived in large part from the disintegration of the Nubian sandstone, occupy the most extensive areas in the Libyan desert. The other desert regions of Egypt are elevated stony plateaux, which are diversified by extensively excavated valleys and oases. These regions present magnificent examples of dry erosion by wind-borne sand, which acts as a powerful sand blast etching away the rocks and producing most beautiful sculpturing. The rate of denudation in exposed positions is exceedingly rapid; while spots sheltered from the sand blast suffer a minimum of erosion, as shown by the preservation of ancient inscriptions. Many of the Egyptian rocks in the desert areas and at the cataracts are coated with a highly polished film, of almost microscopic thinness, consisting chiefly of oxides of iron and manganese with salts of magnesia and lime. It is supposed to be due to a chemical change within the rock and not to deposition on the surface.

Minerals.—Egypt possesses considerable mineral wealth. In ancient times gold and precious stones were mined in the Red sea hills. Efforts were made to re-establish the industry at the beginning of this century, but they have not been encouraging. Manganese, however, has been mined in increasing quantities during the last ten years, and its output in 1926 rose to over 120,000 metric tons. Another new industry is petroleum, for which prospecting is active: but the production of 1926 was only 173,000 tons. The salt obtained from Lake Mareotis supplies the salt needed for the country, except a small quantity used for curing fish at Lake Menzala; while the lakes in the Wadi Natron, 45 m. N.W. of the pyramids of Giza, furnish carbonate of soda in large quantities. Alum is found in the western oases. Nitrates and phosphates are also found in various parts of the desert and are used as manures. The turquoise mines of Sinai, in the Wadi Maghara, are worked regularly by the Arabs of the peninsula, who sell the stones in Suez; while there are emerald mines at Jebel Zubara, south of Kosseir. Considerable veins of haematite of good quality occur both in the Red sea hills and in Sinai. At Jebel ed-Dukhan are porphyry quarries, extensively worked under the Romans, and at Jebel el-Fatira are granite quarries. At El-Hammamat, on the old way from Coptos to Philoteras Portus, are the breccia verde quarries, worked from very early times, and having interesting hieroglyphic inscriptions. The quarries of Syene (Aswan) are famous for extremely hard and durable red granite (syenite), and have been worked since the days of the earliest Pharaohs. Large quantities of this syenite were used in building the Aswan dam (1898–1902). The cliffs bordering the Nile are largely quarried for limestone and sandstone.

Climate.—Part of Upper Egypt is within the tropics, but the greater part of the country is north of the Tropic of Cancer. Except a narrow belt along the Mediterranean shore, Egypt lies in an almost rainless area, where the temperature is high by day and sinks quickly at night in consequence of the rapid radiation under the cloudless sky. The mean temperature at Alexandria and Port Said varies between 57° F in January and 81° F in July; while at Cairo, where the proximity of the desert begins to be felt, it is 53° F in January, rising to 84° F in July. January is the coldest month, when occasionally in the Nile valley, and more frequently in the open desert, the temperature sinks to 32° F, or even a degree or two below. The mean maximum temperatures are 99° F for Alexandria and 110° F for Cairo. Farther south the range of temperature becomes greater as pure desert conditions are reached. Thus at Aswan the mean maximum is 118° F, the mean minimum 42° F.

The relative humidity varies greatly. At Aswan the mean value for the year is only 38%, that for the summer being 29%, and for the winter 51%; at Cairo the corresponding figures are about 45% and 70%. A white fog, dense and cold, sometimes rises from the Nile in the morning, but it is of short duration and rare occurrence. In Alexandria and on all the Mediterranean coast of Egypt rain falls abundantly in the winter months, from 8 to 12 in. in the year; but southwards it rapidly decreases, and south of 31° N. little rain falls.

Records at Cairo show that the rainfall is very irregular, and is furnished by occasional storms rather than by any regular rainy season; still, it is growing more frequent and approximates 2 in. in the year. In the open desert rain falls even more rarely, but it is by no means unknown, and from time to time heavy storms burst, causing sudden floods in the narrow ravines, and drowning both men and animals. Snow is unknown in the Nile valley, but on the mountains of Sinai and the Red sea hills it is not uncommon, and a temperature of 18° F at an altitude of 2,000 ft. has been recorded in January.

The atmospheric pressure, with a mean of just under 30 in., varies between a maximum in January and a minimum in July, the mean difference being about 0·29 in.

The most striking meteorological factor in Egypt is the persistence of the north wind throughout the year, without which the climate would be very trying. At Cairo, in the winter months, south and west winds are frequent; but after this the north blows almost continuously for the rest of the year. Farther south the southern winter winds decrease rapidly, becoming westerly, until at Aswan and Wadi Halfa the northerly winds are almost invariable throughout the year. The *khamsin,* hot sand-laden winds of the spring months, come invariably from the south. They are preceded by a rapid fall of the barometer for about a day, when the wind starts in a southerly quarter, and drops about sunset. The same thing is repeated on the second and sometimes the third day, by which time the wind has worked round to the north again. During a khamsin the temperature is high and the air extremely dry, while the dust and sand carried by the wind form a thick yellow fog obscuring the sun. Another remarkable phenomenon is the *zobaa,* a lofty whirlwind of sand resembling a pillar, which moves with great velocity.

One of the most interesting phenomena of Egypt is the mirage, which is frequently seen both in the desert and in the waste tracts of uncultivated land near the Mediterranean; and it is often so truthful in its appearance that one finds it difficult to admit the illusion.

FLORA AND FAUNA

Flora.—Egypt possesses neither forests nor woods and, as practically the whole of the country which will support vegetation is devoted to agriculture, the flora is limited. The most important tree is the date-palm, which grows all over Egypt and in the oases. The dom-palm is first seen a little north of 26° N., and extends southwards. The vine grows well, and in ancient times was largely cultivated for wine; oranges, lemons and pomegranates also abound. Mulberry trees are common in Lower Egypt. The sunt tree (*Acacia nilotica*) grows everywhere, as well as the tamarisk and the sycamore. In the deserts halfa grass and several kinds of thorn bushes grow; and wherever rain or springs have moistened the ground, numerous wildflowers thrive. This is especially the case where there is also shade to protect them from the midday sun, as in some of the narrow ravines in the eastern desert and in the palm groves of the oases, where various ferns and flowers grow luxuriantly round the springs. Among many trees which have been imported, the "lebbek" (*Albizzia lebbek*), a thick-foliaged mimosa, thrives especially, and has been very largely employed. The weeping-willow, myrtle, elm, cypress and eucalyptus are also used in the gardens and plantations.

The most common of the fruits are dates, of which there are nearly 30 varieties, which are sold half-ripe, ripe, dried, and pressed in their fresh moist state in mats or skins. The pressed dates of Siwa are among the most esteemed. The Fayum is celebrated for its grapes, and chiefly supplies the market of Cairo. The best-known fruits, besides dates and grapes, are figs, sycamore-figs and pomegranates, apricots and peaches, oranges and citrons, lemons and limes, bananas, different kinds of melons (including some of aromatic flavour, and the refreshing water-melon), mulberries, Indian figs or prickly pears, the fruit of the lotus and olives. Among the more usual cultivated flowers are the rose

(which has ever been a favourite among the Arabs), the jasmine, narcissus, lily, oleander, chrysanthemum, convolvulus, geranium, dahlia, basil, the henna plant (*Lawsonia alba*, or Egyptian privet), the helianthus and the violet. Of wild flowers the most common are yellow daisies, poppies, irises, asphodels and ranunculuses. The *Poinsettia pulcherrima* is a bushy tree with leaves of brilliant red.

Many kinds of reeds are found in Egypt, though they were formerly much more common. The famous byblus or papyrus no longer exists in the country, but other kinds of *cyperi* are found. The lotus, greatly prized for its flowers by the ancient inhabitants, is still found in the Delta, though never in the Nile itself.

Fauna.—The chief quadrupeds are all domestic animals. Of these the camel and the ass are the most common. The ass, often a tall and handsome creature, is indigenous. When the camel was first introduced into Egypt is uncertain—it is not pictured on the ancient monuments. Neither is the buffalo, which with the sheep is very numerous in Egypt. The horses are of indifferent breed, apparently of a type much inferior to that possessed by the ancient Egyptians. Wild animals are few. The principal are the hyena, jackal and fox. The wild boar is found in the Delta. Wolves are rare. Numerous gazelles inhabit the deserts. The ibex is found in the Sinaitic peninsula and the hills between the Nile and the Red sea, and the mouflon, or maned sheep, is occasionally seen in the same regions. The desert hare is abundant in parts of the Fayum, and a wild cat, or lynx, frequents the marshy regions of the Delta. The ichneumon (Pharaoh's rat) is common and often tame; the coney and jerboa are found in the eastern mountains. Bats are very numerous. The crocodile is no longer found in Egypt, nor the hippopotamus, in ancient days a frequenter of the Nile. Among reptiles are several kinds of venomous snakes—the horned viper, the hooded snake and the echis. Lizards of many kinds are found, including the monitor. There are many varieties of beetle, including a number of species representing the scarabaeus of the ancients. Locusts are comparatively rare. The scorpion, whose sting is sometimes fatal, is common. There are many large and poisonous spiders and flies; fleas and mosquitoes abound. Fish are plentiful in the Nile, both scaled and without scales. The scaly fish include members of the carp and perch kind, and over 100 species have been classified.

Some 300 species of birds are found in Egypt, and one of the most striking features of a journey up the Nile is the abundance of bird life. Birds of prey are very numerous, including several varieties of eagles—the osprey, the spotted, the golden and the imperial. Of vultures the black and white Egyptian variety (*Neophron percnopterus*) is most common. The griffon and the black vulture are also frequently seen. There are many kinds of kites, falcons and hawks, kestrel being numerous. The long-legged buzzard is found throughout Egypt, as are owls. The so-called Egyptian eagle owl (*Bubo ascalaphus*) is rather rare, but the barn owl is common. The kingfisher is found beside every water-course, a black and white species (*Ceryle rudis*) being much more numerous than the common kingfisher. Pigeons and hoopoes abound in every village. There are various kinds of plovers—the black-headed species (*Pluvianus Aegyptius*) is most numerous in Upper Egypt; the golden plover and the white-tailed species are found chiefly in the Delta. The spurwing is supposed to be the bird mentioned by Herodotus as eating the parasites covering the inside of the mouth of the crocodile. Of game-birds the most plentiful are sandgrouse, quail (a bird of passage) and snipe. Red-legged and other partridges are found in the eastern desert and the Sinai hills. Of aquatic birds there is a great variety. Three species of pelican exist, including the large Dalmatian pelican. Storks, cranes, herons and spoonbills are common. The sacred ibis is not found in Egypt, but the buff-backed heron, the constant companion of the buffalo, is usually called an ibis. The glossy ibis is occasionally seen. The flamingo, common in the lakes of Lower Egypt, is not found on the Nile. Geese, duck and teal are abundant. The most common goose is the white-fronted variety; the Egyptian goose is more rare. Several birds of gorgeous plumage come north into Egypt in spring, such as the golden oriole, the sun-bird, the roller and the blue-cheeked bee-eater.

POPULATION

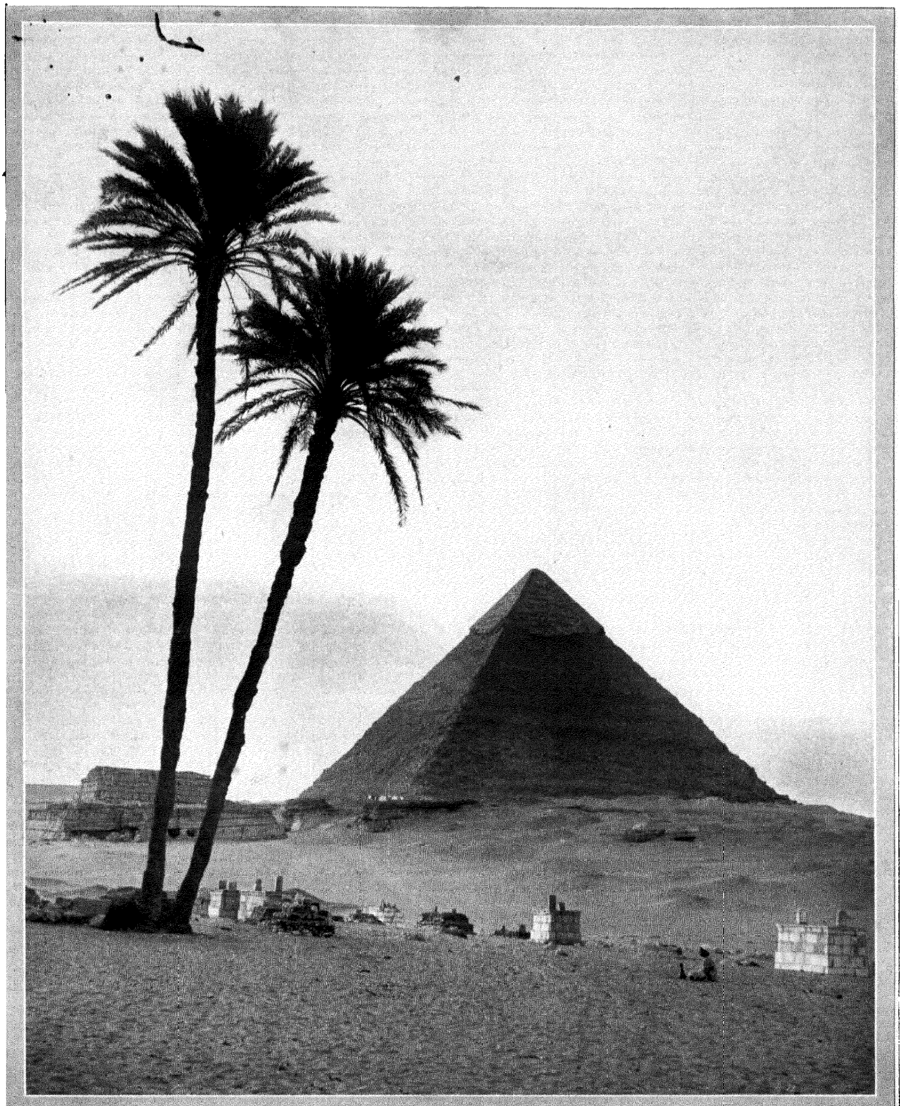
Few countries have suffered more, reckoned in terms of human life, from misgovernment, and few countries have recovered more promptly under humane administration, than Egypt. In 1800 the French estimated the population at no more than 2,460,000. At the beginning of British occupation (census of 1882) it was 6,813,919. In 1917, after 35 years of the British connection, the figure had risen to 12,750,918; and the census held in 1927 put it at 14,168,756. The result is a wholly abnormal density of population on the soil: if the desert regions be excluded, it is over 1,000 per sq.m., far in excess of Belgium or of Bengal.

Of the total population, about 20% is urban. In addition to pure nomads, there are half-a-million Bedouins described as "semi-sedentaries," *i.e.*, tent-dwelling Arabs, usually encamped in those parts of the desert adjoining the cultivated land. The rural classes are mainly engaged in agriculture, which occupies over 62% of the adults. The professional and trading classes form about 10% of the whole population, but 50% of the foreigners are engaged in trade.

Chief Towns.—Cairo, the capital and the largest city in Africa, stands on the Nile, at the head of the Delta, and has been called by the Arabs "the diamond stud in the handle of the fan of Egypt." Next in importance of the cities of Egypt and the chief seaport is Alexandria, on the shore of the Mediterranean at the western end of the Delta. Port Said, at the eastern end of the Delta, and at the north entrance to the Suez canal, is the second seaport. Between Alexandria and Port Said are the towns of Rosetta and Damietta, each built a few miles above the mouth of the branch of the Nile of the same name. The other ports of Egypt are Suez at the south entrance of the canal, Kosseir on the Red sea, the seat of the trade carried on between Upper Egypt and Arabia, Mersa Matruh, near the Tripolitan frontier, and El-Arish, on the Mediterranean, near the frontier of Palestine, and a halting-place on the caravan route from Egypt to Syria. In the interior of the Delta are many flourishing towns, the largest being Tanta, Damanhur, Mansura, Zagazig and Belbes. Ismailia is situated midway on the Suez canal. All these towns, which depend largely on the cotton industry, are separately noticed.

Other towns in Lower Egypt are: Mehallet el-Kubra, with manufactories of silk and cottons; Salihia on the edge of the desert south of Lake Menzala, and the starting-point of the caravans to Syria; Mataria on Lake Menzala and headquarters of the fishing industry; Zifta on the Damietta branch and the site of a barrage; Samanud, also on the Damietta branch, noted for its pottery, and Fua where large quantities of tarbushes are made, on the Rosetta branch. Shibin el-Kom is a cotton centre, and Menuf in the fork between the branches of the Nile, is the chief town of a rich agricultural district. There are many other towns in the Delta with populations between 10,000 and 20,000.

In Upper Egypt the chief towns are nearly all in the narrow valley of the Nile, except Medinet-el-Fayum, the capital of that oasis, with a pop. of 40,000. The chief towns on the Nile, taking them in their order in ascending the river from Cairo, are Beni Suef, Minia, Assiut, Akhmim, Suhag, Girga, Kena, Luxor, Esna, Edfu, Assuan and Korosko. Beni Suef, 77 m. from Cairo by rail, is the capital of a *mudiria* and a centre for the manufacture of woollen goods. Minia, 77 m. by rail farther south is also the capital of a *mudiria*, has a considerable European colony, possesses a large sugar factory and some cotton mills. Assiut, 235 m. S. of Cairo by rail, is the most important commercial centre in Upper Egypt. At this point a barrage is built across the river. Suhag, 56 m. by rail S. of Assiut, is the headquarters of Girga *mudiria* and has two ancient and celebrated Coptic monasteries in its vicinity. A few miles above Suhag, on the opposite (east) side of the Nile is Akhmim, where silk and cotton goods are made. Girga, 22 m. S. by rail of Suhag, is noted for its pottery. Kena, on the east bank of the Nile, 145 m. by rail from Assiut, is the chief seat of the manufacture of the porous earthenware water-bottles used all over Egypt. Luxor, 418 m. from Cairo, marks the site of Thebes. Esna is another place where pottery is made in large quantities. It is on the west bank of the Nile, 36 m. by rail south of Luxor;



PHOTOGRAPH, DONALD M'LEISH

THE PYRAMID OF KHEFREN, GIZEH, EGYPT

The pyramid of Khefren (Kha-f-Ra, IV. dynasty), perpendicular height 447½ ft., is the second largest of the three great pyramids of Gizeh. At the top a fragment remains of the original coating of limestone and unpolished granite slabs

and Edfu, 30 m. farther south, is chiefly famous for its ancient temple. Aswan is at the foot of the First Cataract and 551 m. S. of Cairo by rail. Three miles farther south, at Shellal, the Egyptian railway terminates. Korosko, 118 m. by river above Aswan, was the northern terminus of the old caravan route from the Sudan across the Nubian desert.

Ancient Cities and Monuments.—To many visitors the remains of Egypt's remote past are of deeper interest than the activities of her modern cities. They will find the present and the past closely mingled: for the larger towns of to-day are, in many cases, built on the sites of ancient cities, and they generally contain some monuments of the time of the Pharaohs, Greeks or Romans. The sites of other ancient cities now in complete ruin may be indicated. Memphis, the Pharaonic capital, was on the west bank of the Nile, some 14 m. above Cairo, and Heliopolis lay some 5 m. N.N.E. of Cairo. The pyramids of Giza or Gizeh, on the edge of the desert, 8 m. W. of Cairo, are the largest of the many pyramids and other monuments, including the famous Sphinx, built in the neighbourhood of Memphis. Thebes has been replaced in part by Luxor. Syene stood near to where the town of Aswan now is; opposite, on an island in the Nile, are scanty ruins of the city of Elephantine, and a little above, on another island, is the temple of Philae. The ancient Coptos (Keft) is represented by the village of Kuft, between Luxor and Kena. A few miles north of Kena is Dendera, with a famous temple. The ruins of Abydos, one of the oldest places in Egypt, are 8 m. S.W. of Balliana, a small town in Girga mudiria. The ruined temples of Abu Simbel are on the west side of the Nile, 56 m. above Korosko. On the Red sea, south of Kosseir, are the ruins of Myos Hormos and Berenice. Of the ancient cities in the Delta there are remains, among others, of Sais, Iseum, Tanis, Bubastis, Onion, Sebennytus, Pithom, Pelusium, and of the Greek cities Naucratis and Daphnae. There are, besides the more ancient cities and monuments, a number of Coptic towns, monasteries and churches in almost every part of Egypt, dating from the early centuries of Christianity. The monasteries, or *ders,* are generally fort-like buildings and are often built in the desert. Tombs of Mohammedan saints are also numerous, and are often placed on the summit of the cliffs overlooking the Nile. The traveller in Egypt thus views, side by side with the activities of the present day, memorials of every race and civilization which has flourished in the valley of the Nile.

SOCIOLOGICAL CHARACTERISTICS

Races and Religion.—The population is generally divisible into (1) the *fellahin* or peasantry, and the townsmen of the same blood: Mohammedans and Copts far predominating in both cases; (2) the Bedouins, or nomad Arabs of the desert, comprising the Arabic-speaking tribes who range as far south as 26° N., and the racially distinct tribes (Hadendowa, Aisharin, Abahda, etc.) inhabiting the desert from Kosseir to Suakin: (3) the Nuba Nubians or Berberin, who occupy the Nile valley between Aswan and Dongola: they are mainly agriculturists, though they take kindly to trading, and seem to be chiefly of mixed negro and Arab blood; and (4) foreigners, over 150,000 in number, and chiefly Greeks, whose great centre is Alexandria—Italians, British and French. Syrians and Levantines abound, and there is a Persian colony. The Turkish element is only a few thousand strong, but holds a high social position.

The great majority of the people are Mohammedans (11,624,000 out of 12,718,000 in 1917). Christians in 1917 numbered 1,026,000, composed mainly of Copts (857,000), with an admixture of Armenian, Syrian and Maronite sects, Roman Catholics (108,000) and a variety of Protestant bodies (47,000). There were 60,000 Jews at the same census.

The Mohammedans are Sunnites, principally of the persuasion of the *Shafi'is,* whose celebrated founder, the imam ash-Shafi'i, is buried in the great southern cemetery of Cairo. Many of them are, however, *Hanifis* (to which persuasion the Turks chiefly belong), and in parts of Lower, and almost universally in Upper, Egypt, *Malikis.* Among the Muslims the *Sheikh-el-Islam,* appointed by the khedive from among the *Ulema* (learned class), exercises the highest religious and, in certain subjects, judicial authority. Valuable property is held by the Mohammedans in trust for the promotion of religion and for charitable purposes, and is known as the Wakfs administration. The revenue derived is over £250,000 yearly.

The Coptic organization is ruled by the Patriarch of Alexandria, whose jurisdiction extends over Ethiopia also, and who is assisted by three metropolitans and twelve bishops.

Manners and Customs.—In physique the Egyptians are of full average height (the men are mostly 5 ft. 8 in. or 5 ft. 9 in.), and both sexes are remarkably well proportioned and strong. The Cairenes and the inhabitants of Lower Egypt generally have a clear complexion and soft skin of a light yellowish colour; those of Middle Egypt have a tawny skin, and the dwellers in Upper Egypt a deep bronze or brown complexion. The face of the men is of a fine oval, forehead prominent but seldom high, straight nose, eyes deep set, black and brilliant, mouth well formed, but with rather full lips, regular teeth beautifully made, and beard usually black and curly but scanty. Moustaches are worn, while the head is shaved save for a small tuft (called *shusheh*) upon the crown. As to the women, "from the age of about 14 to that of 18 or 20, they are generally models of beauty in body and limbs; and in countenance most of them are pleasing, and many exceedingly lovely; but soon after they have attained their perfect growth, they rapidly decline." Tattooing is common with both sexes, and the women stain their hands and feet with henna.

Dress is being materially altered, at least in urban society, by the growing adoption of European clothing, and by the emancipation of women from a seclusion which was symbolized in the obscuring character of their outdoor raiment. Among the men of the upper and middle classes who retain their old practice, the ordinary dress consists of cotton drawers, and a cotton or silk shirt with very wide sleeves. Above these are generally worn a waistcoat without sleeves, and a long vest of silk, called kaftan, which has hanging sleeves, and reaches nearly to the ankles. The kaftan is confined by the girdle, which is a silk scarf, or cashmere or other woollen shawl. Over all is worn a long cloth robe, the gibbeh (or jibbeh) somewhat resembling the kaftan in shape, but having shorter sleeves, and being open in front. The dress of the lower orders is the shirt and drawers, and waistcoat, with an outer shirt of blue cotton or brown woollen stuff; some wear a kaftan. The head-dress is the red cloth fez or tarbush round which a turban is usually worn. Men who have otherwise adopted European costume retain the tarbush. The fellahin wear nothing but drawers and a long blue gown of linen or cotton, with a belt, and in cold weather a coarse brown cloak over all. Many professions and religions, etc., are distinguished by the shape and colour of the turban, and various classes, and particularly servants, are marked by the form and colour of their shoes; but the poor go usually barefoot. An increasing number of ladies of the upper classes now dress in European style, with certain modifications, such as the head-veil, though its use is now being largely abandoned in the cities. Those who retain native costume wear a very full pair of silk trousers, bright coloured stockings (usually pink), and a close-fitting vest with hanging sleeves and skirts, open down the front and at the sides, and long enough to turn up and fasten into the girdle, which is generally a cashmere shawl; a cloth jacket, richly embroidered with gold, and having short sleeves, is commonly worn over the vest. The women of the lower orders have trousers of printed or dyed cotton, and a close waistcoat. All wear the long and elegant head-veil. This is a simple "breadth" of muslin, which passes over the head and hangs down behind, one side being drawn forward over the face in the presence of a man. A lady's veil is of white muslin, embroidered at the ends in gold and colours; that of a person of the lower class is simply dyed blue. It is intended to conceal all the features save the eyes. Ladies use slippers of yellow morocco, and abroad, inner boots of the same material, above which they wear, in either case, thick shoes, having only toes. The poor wear red shoes, very like those of the men. The women, especially in Upper Egypt, not infrequently wear nose-rings.

The principal meals are breakfast, about an hour after sunrise; dinner, or the mid-day meal, at noon; and supper, which is the

chief meal of the day, a little after sunset. Pastry, sweetmeats and fruit are highly esteemed. Coffee is taken at all hours, and is, with a pipe, presented at least once to each guest. Tobacco is the great luxury of the men of all classes in Egypt, who begin and end the day with it, and generally smoke all day with little intermission. Many women, also, especially among the rich, adopt the habit.

In social intercourse the Egyptians observe many forms of salutation and much etiquette; they are very affable, and readily enter into conversation with strangers. Their courtesy and dignity of manner are striking, and are combined with ease and a fluency of discourse. They have a remarkable quickness of apprehension, a ready wit and a retentive memory. They are fatalists, and bear calamities with surprising resignation. Filial piety, respect for the aged, benevolence and charity are conspicuous in their character. Humanity to animals is another virtue, and cruelty is openly discountenanced in the streets. Their cheerfulness and hospitality are remarkable, as well as frugality and temperance in food and drink, and honesty in the payment of debt. Their cupidity is mitigated by generosity; their natural indolence by the necessity, especially among the peasantry, to work hard to gain a livelihood.

The amusements of the people are generally not of a violent kind, being in keeping with their sedentary habits and the heat of the climate. The bath is a favourite resort of both sexes and all classes. Notwithstanding its condemnation by Mohammed, music is the most favourite recreation of the people; the songs of the boatmen, the religious chants, and the cries in the streets are all musical. There are male and female musical performers; the former are both instrumental and vocal, the latter (called *'Almeh*, pl. *'Awālim*) generally vocal. The 'Awālim are, as their name ("learned") implies, generally accomplished women, and should not be confounded with the Ghawāzi, or dancing-girls. There are many kinds of musical instruments. The music, vocal and instrumental, is generally of little compass, and in the minor key; it is therefore plaintive, and strikes a European ear as somewhat monotonous, though often possessing a simple beauty, and the charm of antiquity, for there is little doubt that the favourite airs have been handed down from remote ages. Many of the dancing-girls of Cairo to-day are neither 'Awālim nor Ghawāzi, but women of the very lowest class whose performances are both ungraceful and indecent. A most objectionable class of male dancers also exists, who imitate the dances of the Ghawāzi, and dress in a kind of nondescript female attire. Not the least curious of the public performances are those of the serpent-charmers, who are generally Rifā'iā (Saadīa) dervishes. Their power over serpents has been doubted, yet their performances remain unexplained; they, however, always extract the fangs of venomous serpents. Jugglers, rope-dancers and farce-players must also be mentioned. In the principal coffee-shops of Cairo are to be found reciters of romances, surrounded by interested audiences.

The first ten days of the Mohammedan year are held to be blessed, and especially the tenth. On the tenth day, being the anniversary of the martyrdom of Hosain, the son of Ali and grandson of the Prophet, the mosque of the Hasanen at Cairo is thronged to excess, mostly by women. In the evening a procession goes to the mosque, the principal figure being a white horse with white trappings, upon which is seated a small boy, the horse and the lad, who represents Hosain, being smeared with blood. From the mosque the procession goes to a private house, where a mullah recites the story of the martyrdom. Following the order of the lunar year, the next festival is that of the Return of the Pilgrims, which is the occasion of great rejoicing, many having friends or relatives in the caravan. The Mahmal, a kind of covered litter, first originated by Queen Sheger-ed-Dur, is brought into the city in procession, though not with as much pomp as when it leaves with the pilgrims. The Birth of the Prophet (Molid en-Nebi), which is celebrated in the beginning of the third month, is the greatest festival of the whole year. For nine days and nights Cairo has more the aspect of a fair than of a city keeping a religious festival. The chief ceremonies take place in some large open spot round which are erected the tents of the khedive, of great State officials, and of the dervishes. Next in time, and also in importance, is the Molid El-Hasanen, commemorative of the birth of Hosain, and lasting 15 days and nights; and at the same time is kept the Molid of al-Ṣaliḥ Ayyub, the last sovereign but two of the Ayyubite dynasty. In the seventh month occur the Molid of the sayyida Zenab, and the commemoration of the Miarag, or the Prophet's miraculous journey to heaven. Early in the eighth month (Sha'ban), the Molid of the imam Shafi'i is observed; and the night of the middle of that month has its peculiar customs, being held by the Mohammedans to be that on which the fate of all living is decided for the ensuing year. Then follows Ramadan, the month of abstinence, a severe trial to the faithful; and the Lesser Festival (Al-'id aṣ-ṣaghir), which commences the new month of Shawwal, is hailed by them with delight. A few days after, the Kiswa, or new covering for the Ka'ba at Mecca, is taken in procession from the citadel, where it is always manufactured, to the mosque of the Hasanen to be completed; and, later, the caravan of pilgrims departs, when the grand procession of the Mahmal takes place. On the tenth day of the last month of the year the Great Festival (Al-'id al-kabir), or that of the Sacrifice (commemorating the willingness of Ibrahim to slay his son Ismail), closes the calendar. The Lesser and Great Festivals are those known in Turkish as the Bairam (*q.v.*).

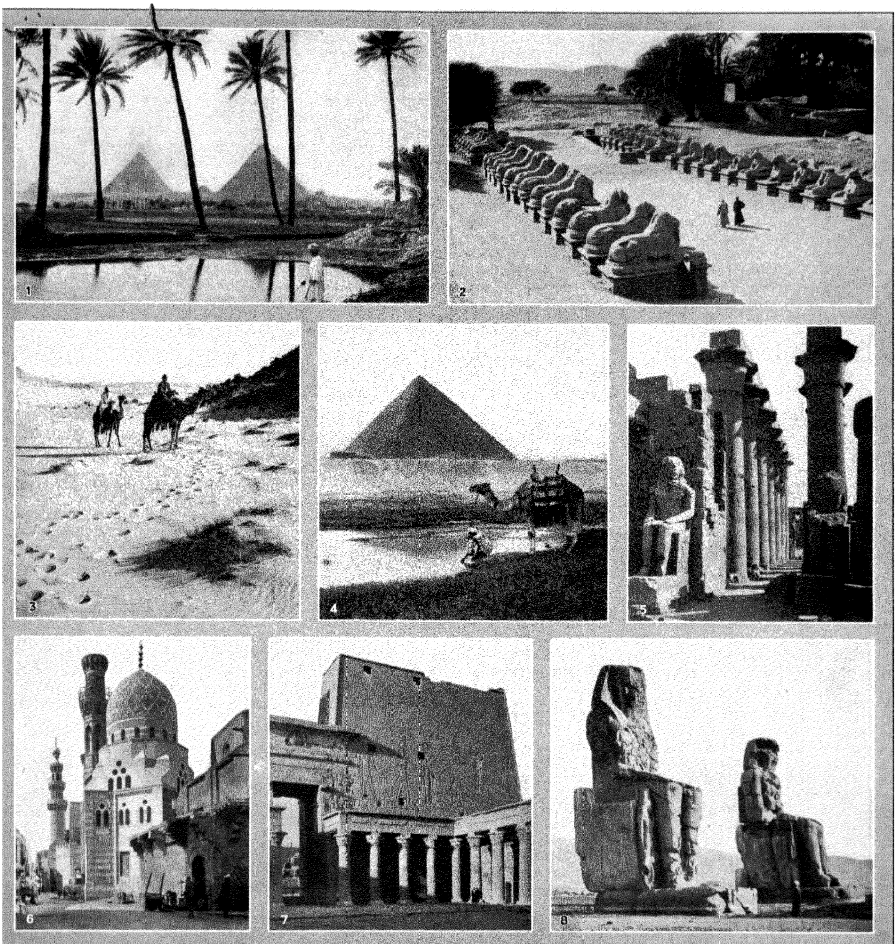
The rise of the Nile is naturally the occasion of annual customs, some of which are doubtless relics of antiquity; these are observed according to the Coptic calendar. The commencement of the rise is commemorated on the night of the 11th of Baūna, June 17, called that of the Drop (Lelet-en-Nukta), because a miraculous drop is then supposed to fall and cause the swelling of the river. The real rise begins at Cairo about the summer solstice, or a few days later, and early in July a crier in each district of the city begins to go his daily rounds, announcing, in a quaint chant, the increase of water in the nilometer of the island of Roda. When the river has risen 20 or 21 ft., he proclaims the Wefa en-Nil, "Completion" or "Abundance of the Nile." The crier continues his daily rounds, with his former chant, excepting on the Coptic New Year's Day, when the cry of the Wefa is repeated, until the Salib, or Discovery of the Cross, Sept. 26 or 27, at which period, the river having attained its greatest height, he concludes his annual employment with another chant, and presents to each house some limes and other fruit, and dry lumps of Nile mud.

Tombs of saints abound, one or more being found in every town and village; and no traveller up the Nile can fail to remark how every prominent hill has the sepulchre of its patron saint. The great saints of Egypt are the imam Ash-Shafi'i, founder of the persuasion called after him, the sayyid Aḥmad al-Baiḍawi, and the sayyid Ibrahim ed-Desuki, both of whom were founders of orders of dervishes. Egypt holds also the graves of several members of the Prophet's family, the tomb of the sayyida Zeyneb, daughter of 'Ali, that of the sayyida Sekeina, daughter of Hosain, and that of the sayyida Nefisa, great-granddaughter of Hasan, all of which are held in high veneration. The mosque of the Hasanen (or that of the "two Hasans") is the most reverenced shrine in the country, and is believed to contain the head of Hosain. Many orders of Dervishes live in Egypt, all presided over by a direct descendant of the caliph Abu Bekr, called the Sheikh el-Bekri. The Saadīa are famous for charming and eating live serpents, etc., and the 'Ilwania for eating fire, glass, etc. The Egyptians firmly believe in the efficacy of charms, a belief associated with that in an omnipresent and over-ruling providence. Thus the doors of houses are inscribed with sentences from the Koran, or the like, to preserve from the evil eye, or avert the dangers of an unlucky threshold; similar inscriptions may be observed over most shops, while almost every one carries some charm about his person. The so-called sciences of magic, astrology and alchemy still flourish.

GOVERNMENT

The national flag of Egypt is green, and has a white crescent enclosing three five-pointed white stars between its horns.

Constitution and Administration.—Egypt, until the World War, was nominally a tributary State of the Turkish empire, ruled by a khedive appointed by the sultan. The steps by which it passed



BY COURTESY OF (3) REALISTIC TRAVELS, LONDON; PHOTOGRAPHS, (1, 2, 4, 5, 6, 7, 8) DONALD MCLEISH

ANCIENT AND MODERN EGYPT

1. The Pyramids of Gizeh, near Cairo, the largest and among the oldest of architectural monuments. The surrounding district is flooded periodically by the Nile barrages, for purposes of irrigation
2. Avenue of Sphinxes leading to the great temple of Ammon at Karnak, near ancient Thebes, on the left bank of the Nile
3. The Libyan desert, west of Lake Moeris, Fayum
4. The Great Pyramid of Cheops, the largest of the pyramids at Gizeh
5. The Colonnade of the Temple at Luxor, built about 1400 B.C. The vastness of its proportions (each of the fourteen pillars is 52 feet high) makes this temple one of the most impressive relics of ancient Egypt
6. Cairo. The Mosque of Kierbeh in the middle distance, and behind it that of Agha, popularly known as the Blue Mosque
7. Outer court and one of the west pylons of the Temple of Horus at Edfu, dating in its final form from the Ptolemaic period (1st century B.C.). It is one of the last as well as the best preserved of the temples characteristic of the ancient Egyptian style
8. Colossi of Memnon, Thebes. That to the left was called the "Singing Memnon," from the belief that in Roman times it gave forth a musical note at sunrise

into an independent State, under a hereditary monarch with the title of king (now Fuad I.), are shown in detail under the section *History*. The exact measure of Egypt's independence remains unsettled so long as no agreement is reached on the points reserved in the unilateral declaration by which Great Britain recognized Egypt as a sovereign State. Equally unsettled is the distribution of constitutional power within the country. In theory, the central administration is carried on by a cabinet of ministers appointed by the king, and supplemented for consultative purposes by two British advisers in matters of finance and justice. By the Constitution of 1923 legislative power is exercised by the king in concurrence with the parliament: but in 1928 the king by edict dissolved parliament and forbade it from assembling again for three years; the former system of legislation by royal rescript being thus reverted to. The parliament, when it functions, consists of two houses, a senate, of which two-fifths of the members are nominated, and a chamber of deputies, elected on the basis of one member for every 60,000 inhabitants.

For purposes of local government the chief towns constitute governorships (*moafzas*), the rest of the country being divided into *mudirias* or provinces. The governors and *mudirs* (heads of provinces) are responsible to the ministry of the interior. The provinces are further divided into districts, each of which is under a *mamur*, who in his turn supervises and controls the *omda*, mayor or head-man, of each village in his district.

The governorships are: Cairo; Alexandria, which includes an area of 70 sq.m.; Suez canal, including Port Said and Ismailia; Suez and El-Arish; the Western desert; the Southern desert; Sinai; and the Red sea coast. Lower Egypt is divided into the provinces of: Behera, Gharbia, Menufia, Dakahlia, Kaliubia, Sharkia. The oasis of Siwa and the country to the Tripolitan frontier are dependent on the province of Behera. The provinces of Upper Egypt are: Giza, Beni Suef, Fayum, Minia, Assiut, Girga, Kena, Aswan. The peninsula of Sinai is administered by the War Office.

Justice.—There are four judicial systems in Egypt: two applicable to Egyptian subjects only, one applicable to foreigners only, and one applicable to foreigners and, to a certain extent, Egyptians, also. This multiplicity of tribunals arises from the fact that, owing to the Capitulations, which apply to Egypt as having belonged to the Turkish empire, foreigners are almost entirely exempt from the jurisdiction of the native courts. It will be convenient to state first the law under the old régime as regards foreigners, and secondly the law which concerns Egyptians; though it will be understood that the position regarding the Capitulations is in a state of flux, with the movement of Egypt towards independence. Criminal jurisdiction over foreigners is exercised by the consuls of those Powers possessing such right by treaty, according to the law of the country of the offender. These consular courts also judge civil cases between foreigners of the same nationality.

Jurisdiction in civil matters between Egyptians and foreigners and between foreigners of different nationalities is no longer exercised by the consular courts. The grave abuse to which the consular system was subject led to the establishment, in Feb. 1876, at the instance of Nubar Pasha and after eight years of negotiation, of International or "Mixed" Tribunals to supersede consular jurisdiction to the extent indicated. The Mixed Tribunals, composed of both foreign and Egyptian judges, employ a code based on the *Code Napoléon* with such additions from Mohammedan law as are applicable. In certain designated matters they enjoy criminal jurisdiction, including, since 1900, offences against the bankruptcy laws. Cases have to be conducted in Arabic, French, Italian or English. Besides their judicial duties, the courts practically exercise legislative functions, as no important law can be made applicable to Europeans without the consent of the powers, and the powers are mainly guided by the opinions of the judges of the Mixed Courts.

The judicial systems applicable solely to Egyptians are supervised by the Ministry of Justice, to which has been attached since 1890 a British judicial adviser. Two systems of laws are administered:—(1) the *Mehkemehs*, (2) the Native Tribunals. The *mehkemehs*, or courts of the cadis, judge in all matters of personal status, such as marriage, inheritance and guardianship, and are guided in their decisions by the code of laws founded on the Koran. The grand cadi, who must belong to the sect of the *Hanifis*, sits at Cairo, and is aided by a council of *Ulema* or learned men. This council consists of the sheikh or religious chief of each of the four orthodox sects, the sheikh of the mosque of Azhar, who is of the sect of the *Shafi'is*, the chief (*nakib*) of the *Sherifs*, or descendants of Mohammed, and others. The cadis are chosen from among the students at the Azhar university. (In the same manner, in matters of personal law, Copts and other non-Mohammedan Egyptians are, in general, subject to the jurisdiction of their own religious chiefs.)

For other than the purposes indicated, the old indigenous judicial system, both civil and criminal, was superseded in 1884 by tribunals administering a jurisprudence modelled on that of the French code. The system was, on the advice of an Anglo-Indian official (Sir John Scott), modified and simplified in 1891, but its essential character remained unaltered. In 1904, however, more important modifications were introduced. Save on points of law, the right of appeal in criminal cases was abolished, and assize courts, whose judgments were final, established. At the same time the penal code was thoroughly revised, so that the Egyptian judges were "for the first time provided with a sound working code." There are courts of summary jurisdiction presided over by one judge, central tribunals (or courts of first instance) with three judges, and a court of appeal at Cairo. A committee of judicial surveillance watches the working of the courts of first instance and the summary courts, and endeavours, by letters and discussions, to maintain purity and sound law. There is a *procureur-général*, who, with other duties, is entrusted with criminal prosecutions. His representatives are attached to each tribunal, and form the *parquet* under whose orders the police act in bringing criminals to justice. In the *markaz* (district) tribunals, created in 1904 and presided over by magistrates with jurisdiction in cases of misdemeanour, the prosecution is, however, conducted directly by the police. Special children's courts have been established for the trial of juvenile offenders.

The police service is under the orders of the Ministry of the Interior, though the provincial police are largely under the direction of the local authorities, the *mudirs* or governors of provinces, and the *mamurs* or district officials; to the *omdas*, or village headmen, who are responsible for the good order of the villages, a limited criminal jurisdiction has been entrusted.

SOCIAL SERVICES

Education.—Two different systems of education exist, one founded on indigenous lines, the other European in character. Both systems are more or less fully controlled by the ministry of public instruction. The Government has primary, secondary and technical schools, training colleges for teachers, and colleges of commerce, education, agriculture, engineering, law, medicine and veterinary science. The Government system, which dates back to a period before the British occupation, is designed to provide, in the main, a European education. In the primary schools Arabic is the medium of instruction, the use of English for that purpose being confined to lessons in that language itself. The school of law is divided into English and French sections according to the language in which the students study law. Besides the Government primary and secondary schools, there are many other schools in the large towns owned by the Mohammedans, Copts, Hebrews, and by various missionary societies, and in which the education is on the same lines. A movement initiated among the leading Mohammedans led in 1908 to the establishment as a private enterprise of a national Egyptian university devoted to scientific, literary and philosophical studies.

The indigenous system of education culminates in the university mosque of el-Azhar, the largest and most important of seven well-endowed Mohammedan institutions which provide instruction on traditional religious lines. El-Azhar is regarded as the chief centre of learning in the Mohammedan world. Its subjects of study are mainly the theology of Islam and the complete science of

religious, moral, civil and criminal law as founded on the Koran and the traditions of the Prophet and his successors; but they also include Arabic literature and grammar, rhetoric, logic, versification, and a certain amount of mathematics and physical science. Attempts to reform the direction and curriculum have been uniformly defeated: and of late the el-Azhar has declared itself an organ of advanced nationalism. Its students come from all parts of the Mohammedan world; they pay no fees, and the professors receive no salaries, subsisting mainly by private teaching, the copying of manuscripts and the reciting of the Koran.

All over the country are scattered mosque-schools or *kuttabs* conducted on similar lines. Their pupils are taught to recite portions of the Koran, and most of them learn to read and write Arabic, with a little simple arithmetic. Numbers of the *kuttabs* have been taken under Government control, and now provide a good elementary secular education as well as a knowledge of the Koran. Other qualified schools of a similar type receive grants-in-aid, provided Arabic is taught. The number of pupils in private schools under Government inspection was, in 1898, the first year of the grant-in-aid system, 7,536; in 20 years time it had grown to over 300,000. The Copts have over 1,000 primary schools, in which the teaching of Coptic is compulsory, a few industrial schools, and a college for higher education. There are also special schools for the teaching of Mohammedan religious law and the instruction of sheikhs.

As elsewhere, the competing demands upon the taxpayer have restricted the funds available for purposes of national education. Until the change in 1922 of the status of the country the Government's policy may be described as a general concentration upon the development and encouragement of mosque schools, and primary education and the maintenance of a few secondary schools in Cairo and Alexandria, intended to serve as nuclei and models for the conduct of secondary education by the local educational authorities (provincial councils), Mohammedan educational trusts and private enterprise. Since the school year 1922–23 there has been a definite move towards taking over secondary schools and direct assumption of the development of secondary education by the State.

The provision of higher and general professional education has throughout been left to the State and effected in a series of separate schools under various Ministries. Some of these schools, notably the School of Medicine at Qasr el Aini, have acquired more than a local reputation; but the local demand for higher education is great, and many Egyptian students go to Europe and America to obtain it.

The desirability of uniting the above institutions as faculties of a modern Egyptian university has long been under consideration, and was reported on favourably in detail by a special commission in 1921. Owing, however, largely to difficulties in securing suitable accommodation and to differences in regard to means of government and methods of teaching, the realization of the project has been continuously delayed. Although these difficulties have only been partially overcome, the formal and administrative incorporation of the specified higher schools to constitute a university was enacted by royal decree in March 1925.

Public Health.—All the capital towns of the *mudirias* (provinces) have now been furnished with up-to-date water supplies, either of filtered or of deep well-water, besides many other of the larger towns. As efficient water supplies were installed, water-carriage drainage followed, and it was found that main drainage systems had to be undertaken in order to prevent the land becoming sewage-logged. Drainage systems have now been installed in Cairo, Alexandria, Port Said, Suez and several other of the larger towns. Establishments coming under the law dealing with "établissements insalubres, incommodes et dangereux," which corresponds roughly to the British Factory Acts, are now registered and are visited by special inspectors. A new "milk law," controlling the collection, distribution and sale of milk, and laying down standards for the fat-content, etc., has been drawn up, as well as a "pure food law."

Very great progress has been made in the prevention and control of epidemic disease. Plague, both bubonic and pneumonic, has been reduced to practically negligible proportions. The whole organization for the prevention and combating of cholera epidemics has been remodelled and, although infection has frequently been brought into the country from infected areas, cholera has been prevented from developing into epidemic form, partly owing to an excellent system of port control. Typhus and relapsing fever have been combated on modern lines, and by means of careful delousing of patients and contacts the number of cases in the country have been enormously reduced. Systematic vaccination with revaccination in infected areas has now reduced smallpox to an almost negligible quantity.

In 1918 an Anti-Malaria Commission was instituted, on which the irrigation and main drainage and public health departments are represented, and a great deal of work in draining and filling in swamping areas has already been completed in districts known to be malarial. Active campaigns have now been started against ankylostomiasis and bilharzia, and travelling hospitals and dispensaries are at work throughout the country treating the infected peasants.

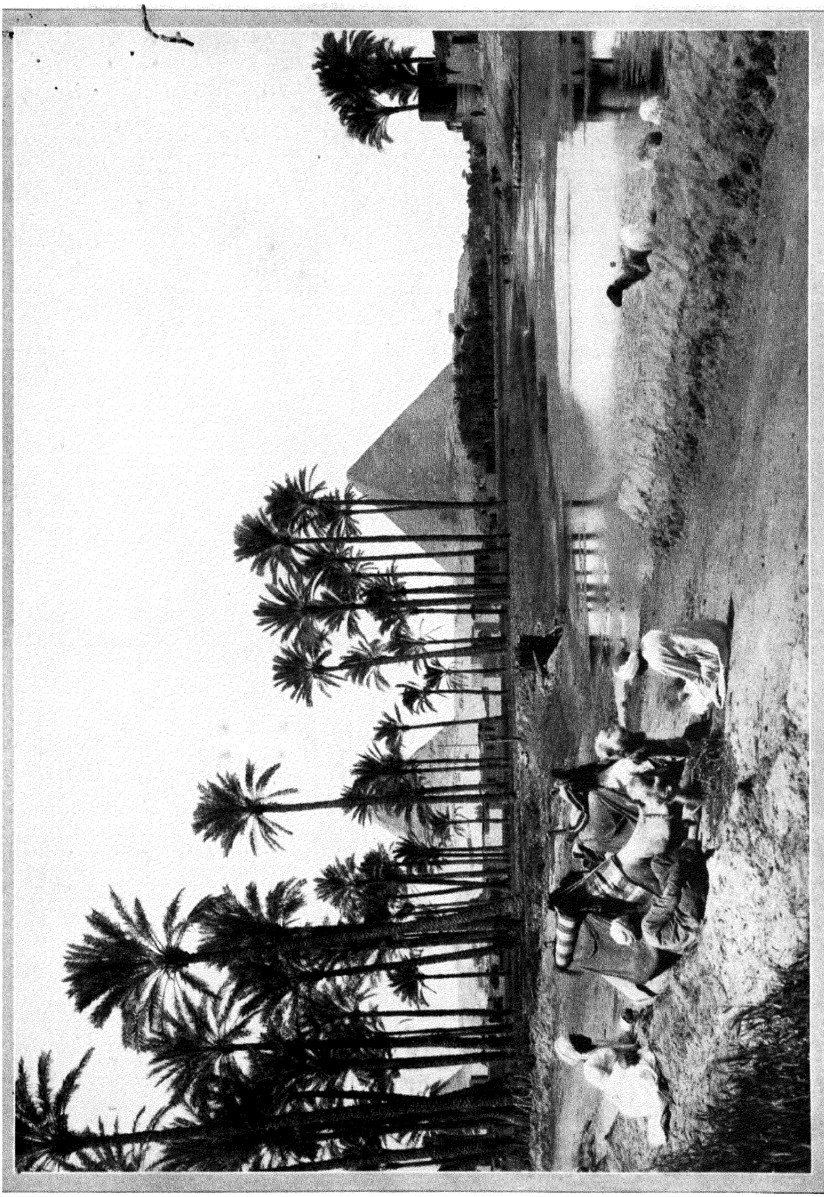
A large number of ophthalmic hospitals have been built and opened throughout the country, and there is now a permanent ophthalmic hospital in every provincial capital. The Imperial War Graves Commission have built an ophthalmic research laboratory as a memorial to the men of the Egyptian Labour Corps and Camel Transport Corps who gave their lives in the World War. A new general hospital of modern design has been opened at Damietta. Dispensaries now exist in all the *markaz* towns and free medical treatment is given to the poor. A new pharmacy law has been promulgated, as also a law controlling the importation and sale of stupefacient drugs. Under the new law, firms importing cocaine operate under licence, and are to all intents and purposes rationed.

A number of children's dispensaries (welfare centres) and maternity homes for the poor have been opened all over the country, though the infantile mortality is still high. Housing and town-planning are receiving increased attention and an interesting experiment in laying out a model industrial settlement may now be seen at Port Fuad, immediately opposite Port Said.

ARCHAEOLOGY AND ART

1. Archaeology and Excavation.—In Egypt archaeology has won its greatest triumphs and has developed into a science that has imparted its rules and methods of work to the archaeologists in the older fields. The reason is the preservative climate of Egypt, the absence of damp, and the certainty of fine weather, that keeps things intact which would perish elsewhere, and enables the excavator to count upon absolute security of work uninterrupted by bad climatic conditions. It is through excavation in Egypt that archaeology has developed as it has during the last fifty years. There was no real excavation in Egypt, other than the opening of tombs, till the 'fifties and 'sixties of the 19th century, when the names of Rhind and of Mariette mark the beginnings. Modern archaeological investigation begins in Egypt with Naville and Petrie when the Egypt Exploration Society began to work, in the early eighties. And it is to Petrie in succession to Rhind that the "codification" of the art of Egyptian digging, so to speak, and its assumption of a scientific character, is due. Petrie was the first, after Rhind, to insist on accurate record of all finds, however insignificant they might appear to be, for who knows what thing, apparently insignificant now, might not be regarded as enormously significant by archaeologists of the future? His systematic style of work has since been adopted in various forms by numberless disciples, imitators, adapters and critics, some of whom are much more meticulously "scientific" than their model, while others think that they can take what is good from his work while dropping what they consider unnecessary labour in recording things already known almost *ad nauseam*, especially if they possess no virtue other than that of being ancient. Others would strictly confine the business of recording finds to the European observers, leaving nothing even to a trained native.

In the 45 years that have elapsed since the first work was done for the Egypt Exploration Fund in the Delta, the original excavators have seen grow up a great *corpus* of archaeological knowledge of ancient Egyptian civilization and history that depends



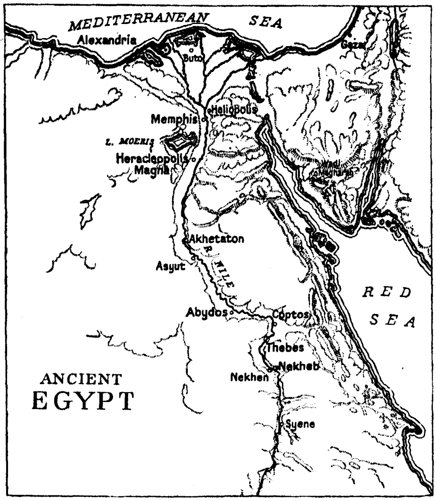
BY COURTESY OF THE CANADIAN PACIFIC STEAMSHIPS

AN OASIS IN THE DESERT, GIZEH, EGYPT

Oasis with a small village, facing the plateau of the three great pyramids

almost entirely on scientific excavation.

Britain, America, France, Germany and Italy have all contributed to the list of actual excavators, while Russia, Holland, Belgium and the Scandinavian countries have also added a number of scientific students of Egyptology. And the methods and aims of Egyptian archaeology have been passed on first to the Greek and international workers in Greece (with especial brilliance of results under Evans in Crete), then to Italy and the West, later to Mesopotamia and lastly to India. China still awaits scientific excavation, although Chinese Turkestan has already known it with magnificent results at the hands of Sir Aurel Stein and Dr. von Lecoq. And in Chinese Turkestan we obtain results most analogous to those gained in Egypt, owing to the resemblance of the climate of the two countries; though one is hot and the other cold, both are phenomenally dry. The methods in use in Egypt have, with necessary modifications owing to varying local conditions been adopted everywhere. They are the methods of common sense, of accuracy in record and in fact of the scientific conscience, without which antiquarians are still mere dilettanti. The scientific man wishes to know accurately what was; he should have no preconceived ideas of what ought to have been; he should have none but an ordered enthusiasm for truth, and should have a metaphorical jug of cold water ready for all undisciplined and illiterate enthusiasms. Irrational theories about Egypt, whether dealing with the Great Pyramid, an Unlucky Mummy or "Mummy Wheat" are unhappily very popular, and the scientific archaeologist often has to deal very patiently with believers in ideas of this kind, connected with prophecies, ghosts and other pseudo-religious or "occult" phenomena, with which science, which is never muzzy, "occult" or obscurantist, makes no muddles, and dignifies them as "mysteries," as hard and clear as the Greek day, has nothing to do.



MAP OF ANCIENT EGYPT, SHOWING THE LEADING CITIES

We have, in fact, to investigate ancient Egypt rather with the Greek spirit of clarity and naked truth than with the Semitic spirit of enthusiastic belief in veiled mysteries, or the ancient Egyptian spirit of muddleheadedness which makes such an appeal nowadays.

While it is to Egyptian excavation that archaeology owes its scientific system, it is of course not the fact that Egyptian archaeological science owes all its knowledge to the art of excavation. We always had the evidence of the classical writers in Egypt, chief of them of course Herodotus, whose account of Egypt is read by none with greater pleasure and instruction than by a modern archaeologist. It is not always accurate, it is often superficial, but as a contemporary witness it is incomparable. We had the epitomes of the work of the Egyptian priest Manetho on the dynasties of Egypt; his scheme of dynasties, garbled as the royal names have been by copyists, has survived all archaeological discovery, has proved to fit the facts, is retained by all modern historians of ancient Egypt. We have the references of many classical writers to the mysteries of Egyptian religion. They may have thought that they were explaining that marvellous welter of conflicting beliefs satisfactorily to their contemporaries; modern writers have thought they were doing the same thing. But anybody can find in the Egyptian religion whatever he wants to find in it. To the scientific observer it seems so confused and self-contradictory as to deter him from wasting his time in trying to clear up the muddle; he would be ploughing the sands. Only description is possible (*see* below).

Then in modern times the decipherment of the hieroglyphs begun by Young and Champollion in 1821, and put on the basis of firm knowledge by the latter, enabled the *savants* swiftly to gain a more accurate knowledge of the religion and, with the dynastic skeleton of Manetho to help make acquaintance with the flesh and blood of history derived from the monuments of the Egyptians themselves. Wilkinson and Lepsius, and after them Birch and Brugsch, are the greatest names associated with the early historical work, and Lepsius, as the result of his labour with the royal Prussian expedition to Egypt in the 'forties, was the greatest of these. Gliddon was the first to talk about the new discoveries in America in the 'thirties, and Wilkinson was the first to make the new knowledge really accessible to the educated public of Britain and the United States by his famous "Manners and Customs of the Ancient Egyptians" (first published in 1837 and re-edited by Birch in 1878), a book which has probably made not only Egyptian archaeology, but archaeology generally, familiar to many who otherwise would never have realized its enthralling interest. Though he never excavated in the modern manner, but only probed for and dug out tombs in the Theban hillside, and probably did not observe or record with anything like the care that is considered necessary nowadays, Wilkinson may be considered the father of Egyptian archaeology, as Champollion was the father of Egyptian philology. And the Egyptologists proper, the philologists, were hard at work deciphering the hieroglyphed monuments and the hieratic papyri; Birch, Goodwin, Brugsch, de Rouge, Chabas are the greatest names. We knew a great deal before the days of scientific excavation, from the monuments above ground, in Egypt and in our museums, and the relics discovered in Theban tombs. Bonaparte's great expedition in 1798 with his attendant *savants* and the resultant publication of the great "Description de l'Egypte" had directed the attention of the world to ancient Egypt, and initiated the work that culminated in Champollion's discovery, after which a real furore set in for the collection of Egyptian monuments, the bigger the better, for European Museums. Men like Salt, Belzoni and Drovetti collected indiscriminately, with the result that, for instance, the British Museum has been saddled with dozens of figures of the lioness-headed goddess Sekhmet (many of them in quite bad repair) from Thebes, whereas two or three good ones would have sufficed. Then the era of scientific investigation and collection begins with the expedition of the French and Tuscan Governments, under Champollion and Rosellini in 1827, and then came the famous Prussian expedition of Lepsius (1842) which brought back objects chosen with discrimination and studied them on the spot, and in the great *Denkmäler* (1851)—still one of our chief sources of inscriptional material—produced the first scientific work on ancient Egypt on the grand scale. Meanwhile, Wilkinson had lived and dug his tombs at Thebes, where Rhind followed him. Then came the new régime of Mariette in 1858. Egypt ceased to be a happy hunting ground of collectors; a Museum of Antiquities was founded and established first at Būlāq, a suburb of Cairo, and everything found had to go there.

This exclusive policy in the 'sixties and 'seventies and the strict confinement of excavation to Mariette and the Būlāq museum, filled the galleries of the new museum with a wonderful collection of antiquities, especially of the Old Kingdom. But the return to a more liberal system after Mariette's death in 1881 and the British occupation in 1882 and the concession of the right to excavate to properly accredited museums and learned societies, such as the Egypt Exploration Fund, during the almost fifty years of its existence, has actively fostered the contemporary growth of archaeological science, has enriched museums with scientifically recorded material (hardly known before), and has proved in no way prejudicial to the national museum of Egypt, which under the two régimes of Maspero, that of de Morgan and others, has probably trebled its collections as they were left by Mariette. From Būlāq the Museum had to move to Gizeh and then to the great new building at Kasr-el-Nīl. It has only gained by the introduction of international co-operation and the equitable division of finds, one half to the museum, the other to the excavator. Return to a less liberal system, by which the museum may take what it likes, all if it likes, of what an European or American expedition finds, will inevitably react unfavourably both on the museum's progress and on archaeological progress generally. It is an elementary consideration that the subscribers to archaeological expeditions will cease to subscribe if they see no return for their money in their own museums.

During the last fifty years the "surface" knowledge, good as it was, the result of decades of work by great scholars, has been reinforced and completed by the knowledge derived from scientifically-directed excavations, with the result that we now know far more of the archaeology of Ancient Egypt than of any other country, not excepting Greece and Italy. For the damper climates of Greece and Italy have not been able to preserve for us all the actual objects, even things of filmy linen, textiles, everything that men used in those remote days, the furniture and the rest, made of wood, that elsewhere perishes, the last food placed for the dead in the tomb by the mourners. Egypt preserves all intact. Where else could one find a Tutankhamun tomb? It is said that once when a tomb was opened the modern intruders saw, imprinted on the sand covering the floor, the imprints of the feet of the men who had borne the mummy to its tomb four thousand years before.

It is of course not every day that a tomb so inviolate is found. Even that of Tutankhamun seems as a matter of fact, to have been entered by robbers who did not penetrate far into it. The tombs of all the other kings of Thebes were violated long ago, long before Greek times by the Egyptians themselves, who were as consummate hereditary tomb-robbers four thousand years ago as they are now. The tomb of Queen Hetepheres at Gizeh, discovered recently by Reisner, is a case in point. A hieratic papyrus of the 20th Dynasty (1100 B.C.) records the trial of ancient Thebans for the robbery of royal tombs even then. One can only guess the lost magnificence of a tomb of a great king like Seti I. from that which we have from the tomb of an insignificant one like Tutankhamun, and that of the plundered private tombs from the contents of these, found intact by Schiaparelli a few years ago, which are in the Museum of Turin.

The Egyptians were not always buried in stately rock-cut tombs. Excavation has revealed one thing unknown to the older archaeologists—the whole prehistoric or pre-dynastic period, with its weapons of flint, and its crouched bodies in shallow graves. Similar groups were used long after in crowded necropoles, such as Abydos, which are much confused and difficult to dig.

Excavation by no means confines itself to tombs and graves. Temples and town-ruins are more usual subjects for excavation nowadays, and the latter especially provide much more difficult problems in excavation than tombs, or even superimposed and confused graves. The problem of stratification presents itself, and often demands the utmost skill and careful observation on the part of the excavator to unravel. This is, above all, one of the major tasks of the new archaeologist. It presents itself in greater complexity in Greece and in Syria than in Egypt, where superimposed town-strata of succeeding periods in a *tell* or mound are not so common.

2. Development of Egyptian Civilization As Revealed by Archaeology: the Palaeolithic Period.—The most ancient relics of antiquity in Egypt are the palaeolithic tools of flint and chert found on the lower desert plateaux at the head of the wadis that debouch into the Nile-valley throughout its length in Egypt. These are sometimes found in their *ateliers* where they were originally knapped from the flint boulders that are common in the desert. The most usual form is that of the Acheulian *coup-de-poing* or hand-axe. These ancient tools are often deeply patinated by the wind and sun of the ages that have elapsed since they were made. The people who used them evidently lived on the desert margin of the valley, where there was as yet no cultivation, but probably an endless marsh, inundated yearly without check by the rising Nile-flood. We have little proof of much difference in climate from that of to-day. It is not probable that the desert was then covered with humus in which grew trees favoured by a rainier climate; the fossil trees found in the desert belong to an older time when no doubt the climate was in reality different.

The Neolithic Age.—How far these palaeoliths of Egypt were contemporary with those of Northern Europe we do not know. At any rate it does not look as if there was a definite break between the palaeolithic and the neolithic people, who as late as the fifth millennium B.C. lived in the valley. They still used flint and chert, very rarely obsidian. The art of flint-knapping has developed greatly, and in a way peculiar to the Niletes, whose flint and chert weapons are often quite different from those of the rest of the ancient world. They are often chipped with the most extraordinary care, and some knives have a serrated edge so minute as hardly to be visible to the naked eye. They are among the most beautiful of the products of the flint-knapper. The people who made them were not merely hunters, as the palaeolithic folk probably were. They were also pastoralists and, to some extent, agriculturalists. The regulation of the Nile flood and the reclamation of the valley had begun in all probability. Indigenous civilization began slowly to develop. The makers of the flint knives also made stone vessels with the aid of emery (which must have come from abroad, as none is known in Egypt), crude pottery and basket work. The pottery developed, on indigenous lines, like the flint-working, and we have innumerable examples of it, all made without the wheel, in the red and black polished ware, and the less common red ware with white decoration; then later the buff ware with red painted decoration representing ships with oars (rarely sails), men and women and animals, which have been recovered from the shallow graves in which the neolithic people were buried. The bodies were usually wrapped in mats and were placed in a crouching position. They were not mummified in any way, their preservation being due to the dryness of the soil in Upper Egypt; though it is possible that they may sometimes have been smoked. This indigenous culture has been shown by the work of the *Archaeological Survey of Nubia* to have existed in Nubia also where a local form of it persisted so late as the time of the 12th Dynasty. We do not know how long it was before copper made its first appearance in Egypt. We have no absolute chronology of the pre-dynastic period, the age to which the neolithic remains of course belong, and the post-neolithic antiquities up to the time of the union of the kingdom under the First Dynasty, about 3400–3200 B.C. (*see* CHRONOLOGY). But on purely archaeological evidence Prof. Sir Flinders Petrie has devised a scheme of "sequence dating" (*q.v.*) of pre-dynastic antiquities which can be used as a sort of "chronologimeter." So great a number of pre-dynastic necropoles have been excavated that we can trace in them the coming into vogue of various types of flints, pots, stone vases, etc., their period of use, and their gradual disuse, and we can say with comparative certainty that that type of flint and that of vase were in use together, and no other. So at Sequence-date (S.D.) 50 we can say that such-and-such things were in use, and none other. And as we take 1–100 as our gamut, and leave say 1–30 at the beginning for unknown beginnings and say 80–100 at the end of the period for the transition to dynastic styles, we see that S.D. 50 is about the middle of the dynastic period. What actual date S.D. 50 corresponds to of course we do

not know. We think that the first Dynasty began not before 3400 and not much later than 3200 B.C. Prof. Sir Flinders Petrie thinks it began 1460 years earlier (*see* CHRONOLOGY), but he stands alone in this belief, as also does Dr. Borchardt in his unusual date (about 4000 B.C.). A recent writer, Dr. Scharff, would bring the date down to about 3000 B.C. And it must be admitted that his arguments are good, and that at any rate it is more probable that the date of the First Dynasty is later than 3400 B.C. than earlier (*see* CHRONOLOGY). The most generally accepted date is *c.* 3200 B.C. (Meyer). We may guess that S.D. 50 may represent anything round about 4000 B.C. Now copper is first found at S.D. 38, and a fine copper dagger from Nagada dates between S.D. 55 and 60. The Egyptians therefore ceased to be purely neolithic probably before 4000 B.C. More we cannot say.

The Chalcolithic Age.—It must not be supposed that with the introduction of metal, stone weapons and tools suddenly went out of use. During the whole of the chalcolithic age, from the middle of the pre-dynastic period to the time of the 13th Dynasty, roughly two thousand years, stone was used for commoner purposes, side by side with copper; butcher's knives, for instance, were still made of flint under the 12th Dynasty, and arrow-heads of flint were naturally still used, since it was senseless to waste metal on a weapon that could not be retrieved.

The introduction of metal meant a rapid advance in civilization, and by the end of the pre-dynastic period Egypt had developed from a land inhabited by barbarian tribes into a civilized nation with a complicated polity and a culture to which art and even luxury were not unknown. The brain of the nation developed with great speed, and we find that long before the beginning of the 1st Dynasty an astronomical calendar had appeared and must have been first used (*see* CALENDAR) in 4241–4238 B.C., unless with Scharff we suppose that it was first invented a Sothic period later, about 2781–2778 B.C., and in the reign of Zoser of the 3rd Dynasty, whose date he brings down to later than this (*see* CHRONOLOGY). There is no doubt that the impulse to this development, and probably the introduction of metal itself, was due to influences from Syria, and it is probable that already in the middle of the pre-dynastic period the infiltration of non-Nilotic broad-headed foreigners from the North had begun which ended in the domination of the nation by a royal and aristocratic tribe of Asiatics of much higher cranial capacity than the indigenes, who gradually mingled with the Nilotic natives and founded the historical civilization of Egypt. Both elements (and also a third, the Libyan from the West, akin to the Nilote) made their contribution to the common culture; to the indigenous Nilotes belong probably the more distinctly Nilotic and Africa.. characteristics, the animal gods for instance, and their representation on what have incorrectly been called "totem-poles" and perches (we find similar insignia borne in the boats painted on the prehistoric pottery), and the earlier method of burial; to the northern invaders the gods in human form (we find the two elements side by side later when a human-headed god has his animal incarnation beside him), especially the god Osiris who certainly came with more highly developed agriculture from Syria (he was primarily a corn-god, and only connected with the dead by identification with the old indigenous deity of the necropoles [*see* CHRONOLOGY]) and the political institutions of the kingdom; while the Libyans contributed peculiar elements of their own. By the time of the foundation of the kingdom the fusion of the two chief races had progressed far, and it was probably to a royal house of the invading stock long settled in Upper Egypt that the conquest of the North was due which laid the foundation of the united kingdom of the North and South which persisted in spite of periodical fallings apart, until the end (see *History*).

In all probability the coming of the northerners modified the language (which seems to be a mixture of "Semitic" and Nilotic elements) and they probably introduced a primitive picture-writing of their own (equally the original of the Sumerian script from which in Mesopotamia cuneiform developed), which started the development of the Egyptian hieroglyphic system. This also certainly included a large Nilotic element derived from the natives.

The Archaic Period.—The true position of the pre-dynastic culture is exemplified at Naqada and Ballas in Upper Egypt, as revealed by the acumen of Jacques de Morgan and recent finds by Petrie and Miss Caton Thompson at Badari and in the Fayyum have revealed its earliest phase and a peculiar form of it. The transition period from the pre-dynastic period to the 1st Dynasty has been specially illuminated by the work of Reisner at Nag 'ed-Dair, north of Abydos and of Junker at Turra near Cairo. The civilization of the 1st Dynasty was revealed to us largely by the discoveries at Abydos in the south and Tarkhan in the north, and at Hierakonpolis in the south, due chiefly to Petrie and to Quibell and Green. It is an archaic form of the historic Egyptian culture; its art was still in an archaic stage. Then suddenly at the time of the 3rd Dynasty, under the kings Kha'sekhemui and Zoser, civilization took a sudden upward spring, probably due to a genius, Yemhatpe or Imhotep, the king's minister (*see* below). To this man seems to be due the sudden rise of Egyptian architecture at this time, when we see at Sakkara Firth's fine discovery of the funerary temple of Zoser set around the first Egyptian pyramid, the Step Pyramid of Sakkara. And from this building (*c.* 3000 B.C.) in less than two centuries developed first the pyramid of Snefru at Meidum and then the wonderful Great Pyramid of Gizeh, the grave of king Khufu or Cheops of the 4th Dynasty, itself. The brain-power to which the Great Pyramid testifies is as great as that of any modern man. Under the 5th Dynasty at Abusir the fixed conventions of Egyptian art in temple-decoration first appear. Henceforward for nearly three thousand years these conventions remain the same. A Roman emperor in his guise as Pharaoh appears before the gods in much the same costume as a king of the 5th Dynasty. And the gods never altered. This was the time when the final choice was made of the historic characteristics of Egyptian culture and art, when certain archaic ideas and motives were thrown out and never reappear.

Later Development.—Henceforward in spite of minor differences and alterations, chiefly due to foreign invasion or influence, things Egyptian remained on the whole the same: there is less difference between the civilization of the 5th and 6th Dynasties and that of the 18th than there is between it and that of the 1st. It is a mistake, however, to regard Egyptian externals as absolutely unalterable. Costume changed, for instance, from age to age, though less, probably, than in many other lands. But whereas the costume of kings and gods under the 5th Dynasty is what was actually worn then, the Roman Pharaoh wears this 5th Dynasty costume which no Egyptian king had really worn, except perhaps at religious festivals, since the time of the 12th Dynasty. The bewigged and beskirted and be-earringed noble of the 19th Dynasty is very different from his simpler forbear of the 12th. And though the Saite noble of the 26th represented himself, by an archaistic fashion, as wearing 5th or 12th Dynasty costume, he certainly never did, any more than our grandees of the 17th and 18th centuries ever donned the Roman armour they are depicted wearing in their statues. And the small things altered continually, the ornaments, the pottery, the stone vases. But this alteration was only unchecked in things with which religion had nothing to do. And these were comparatively few. For in few countries has religion more dominated the art and handicraft of a country than in Egypt. And religious things could not alter. So that the numberless religious objects that entered into the art-repertory of Egypt, the god-figures, the sacred animals, the amulets, etc., maintained a conservative unity in art motives throughout her pagan history, on which the changes were rung in an endless succession. Only one man tried to break the spell, Ikhnaton, the heretic, and he failed. To a resuscitated man of the 5th Dynasty the art of the 19th Dynasty, florid, baroque though it was, and filled with foreign ideas from the Semitic East, would still, in spite of differences, have seemed to be the Egyptian art of his own time, of his own contemporaries. He would have found the hieroglyphic writing of the 19th Dynasty, and specially its hieratic, very different, and hard to understand. That is true, but though the combinations were different from that of the Old Kingdom, and many new signs and words had appeared, yet all the old signs were there; it was still the same system. (*See* LANGUAGE and HIEROGLYPHS.)

Foreign Influence.—Under the 18th Dynasty we find the first real differences from the classical civilization of the Old and Middle Kingdoms, owing to the conquest of the country by Semitic foreigners, the Hyksos, and the conquest of Hither Asia by the Egyptians that followed their expulsion. This event modified Egyptian culture profoundly, and sowed the seeds of its degeneration. The foreign influences, Asiatic, Cretan, Libyan, grew ever more potent to affect the externals of Egyptian culture, though the religion (except during the ephemeral revolution of Ikhnaton), and the writing maintained their characteristic form, and preserved the individual nationality of the people.

Archaism, the Last Phase.—Under the Saites, mental revolt against the foreign elements, and against Asiatic contamination generally, combined with antiquarian interest in their own most ancient monuments at Memphis and its neighbourhood, brought about the archaistic movement that sought to imitate the old classical period, and more especially its earlier phase, that of the pyramid-builders. There was a definite archaistic revival in art, but its neo-classicism hardly deceives us. It is always an inaccurate imitation; the scientific archaeologist of to-day was yet unknown. Still, the effect is often beautiful, and is eminently characteristic. And the archaism went much further than the realm of art. It did not, however, save Egypt, which went down before the Persian; and when the Macedonians established a new Egyptian empire in Asia, a new imperialist archaism set in, which strove to imitate the works of the Thutmosids and the Ramessides, the imperial style of the 18th and 19th Dynasties, but with less success than the Saite archaizers. The spirit of Egypt was going; she was dying. The Egyptian culture of the Roman epoch was but a miserable parody.

Modern Critical Study.—So archaeological study has taught us to distinguish the characteristics of the successive ages of Egyptian history, to trace its development from age to age. Although Egyptological knowledge without archaeological study, based on excavation, could enable us to possess a superficial knowledge of the process, it is only within the last thirty years that, thanks to modern archaeology, we have been able to pursue our study into minute details. The comparison of the numberless records of scientific observation in excavation has now enabled us to do this, and we can now date objects of Egyptian culture to their proper periods without any royal inscription to help us. It is cumulative evidence that has told. And in the case of Egypt we can do so with more certainty than in the case of any other ancient people, the Greeks not excluded. With one characteristic exception, the figures of the gods. Here we can rarely tell the date of, say, a bronze Osiris, unless he is inscribed or we know with what objects he was found. The gods did not alter. And the dress of the kings was in early days nearly as immutable. But under the 18th Dynasty they had begun to wear a headdress unknown before, and under the 19th Dynasty they begin to be represented in the clothes they really wore, as well as in their hieratic 5th Dynasty costume. But to tell the date of an uninscribed royal figure of the "classical" time is difficult, unless we are well versed in niceties of artistic criticism, which in the case of Egypt has nowadays made great strides, so that the critic can argue that an Egyptian statue must or cannot be of the 12th Dynasty on grounds of style alone, and often with success and accuracy.

3. History of Egyptian Art: the Pre-dynastic Period.—The beginnings of Egyptian art antedate the arrival of the "Dynastic Egyptians" from the north. We see them in the curious painted pottery figures of mourning women, standing or seated on the ground with their arms raised, and with their bodies decorated apparently with tattoo-marks, which are found in early pre-dynastic graves (a fine collection is in the British museum), in tusks of ivory with carved heads of long-bearded men, in a few crude scratched representations of animals on the early red and black pottery, and in the geometric and (rarely) animal-figure designs in thick white slip-paint on red ware. Combs of ivory with male heads, and figures of animals follow, and slate palettes in the form of animals, such as hippopotami, hyenas, bats, tortoises, fish and cuttle-fish, on which face-paint was ground for use. Then come the pictures of men, women, goats, cattle and boats in thin red paint on the buff ware. These figures are not in outline and cross-hatched, as in the earlier white and red ware, but are solid. Male figures are rarer than female. The men are naked. The representations of boats are very curious, and with one or two exceptions are extremely unlike boats, so much so that they were formerly often taken to be pictures of stockaded village-settlements, the oars being the stockade, the cabins the houses, while the "totem-poles" with figures of animals would be appropriate to both conceptions. It seems, however, that we must regard them as boats. Then come the first wall-paintings with very similar scenes, as at al-Kab, in which we find the men wearing now the characteristic Egyptian waist-clout of white linen. The colours used are red, white and black. To this time probably belong the rude gigantic figures of the god Min from Keptos, in the Ashmolean museum, with their reliefs of goats on hills.

As the conquest by the people of the North continues we find the level of art rising swiftly. The flint weapons are at their finest, the technique of stone-vase making rapidly improves, gold decoration begins to be used, as for instance on the handle of the famous flint knife from al-'Araq. But pottery deteriorates. It would look as if the improvement in stone vessels meant less interest in the finer kinds of pottery. Stone and gold-work attract most attention. Stone sculpture begins in rude flat relief figures on limestone grave stelae. A parallel with contemporary Sumerian art is found in the sculpture of processions of animals, generally sheep, goats or cattle; no doubt these were intended to ensure continuance of riches in flocks and herds in the next world. The slate paint-palettes develop into large objects with a circular ring-depression for the paint, and are decorated with most lively scenes in low relief of hunters, armed with bows and arrows and throwsticks pursuing lions, and of the corpses of the dead in battle being cast out to be devoured by vultures (British museum, Louvre). Other such fragments show ostriches (Brit. mus.), giraffes with a palm tree (Ashmolean); on another (Brit. mus.) is the earliest hieroglyph known, the symbol of the god Min, while on the British museum fragment of the large "hunt-palette" is the hieroglyph of a chest, the sign of "burial."

The Archaic Period.—These works herald the beginning of the Dynastic Period, when we find a strongly marked upswing of artistic capacity. Progress is specially marked during the first five reigns, of Narmerza and 'Ahai (who with the pre-dynastic Southern king and first conqueror of the North were probably together the originals of the legendary "Menes"), of Zer, Za and Den. We know the work of this time well from the discoveries at Abydos, Hierakonpolis, Tarkhan and Turra. A typical example of this progress is seen in the one instance of the figure of the hawk, typifying the king, above the *serekh* or "proclaimer" banner containing the name of the king, now written in genuine hieroglyphics which we can interpret. This hawk-figure develops in a most interesting way, till after the end of the reign of Den it takes on its characteristic form, which it has finally assumed by the end of the dynasty. And in order to appreciate not only the advance that was made during the early dynasties, but also the remarkable strength of conception and power of design in the work of the beginning of the 1st Dynasty we may compare reliefs of the 3rd and 4th Dynasties with the *chef-d'oeuvre* of the archaic period, the remarkable slate "palette" of Narmerza from Hierakonpolis (Cairo museum; casts in British museum and at the Ashmolean), on which we see in relief "Menes" attended by his sandal-bearer, inspecting the bodies of his slain Northern enemies, while the hawk of his Upper Egyptian tribal god Horus seizes a strange half-human figure emblematic of the North: above, the queer fetish-heads of the cow-goddess Hathor, which we already know in the pre-dynastic period, seem to typify the union of the two races that was producing Egyptian civilization. The great ceremonial mace-heads of the Scorpion and Narmerza, also from Hierakonpolis (in the Ashmolean), commemorating the Scorpion's conquest of the North and the Jubilee festival of Narmerza also show very interesting reliefs. "One is struck by the naive energy of this commemorative art, which has preserved

for us a contemporary record of the founding of the Egyptian kingdom." In ivory we have (Brit. mus.) the extraordinarily lifelike little figure of a king (No. 37,996) wearing the crown of Upper Egypt and a long and very foreign-looking patterned robe of a kind that we never see a king wearing later, which was found by Petrie at Abydos. It is probably the most precious relic of the archaic period.

Den-Semti was the first to bear the afterwards time-honoured title of "Insibya" or king of Upper and Lower Egypt, and in his time the first moment of crystallization in the development of art and culture occurred. After his time the *tempo* slows down; originality becomes rarer, crudities begin to be thrown aside. At the same time luxury increases noticeably. From the relics found in his tomb, or cenotaph, at Abydos we see already a rich and picturesque civilization, energetic and full of new ideas, both artistic and of a more practical character. Gold and ivory and valuable wood were lavishly used for small objects of art, fine vases of stone were made, and the wine of the grape (*irp*) was kept in great pottery vases stored in magazines like those of the pithoi at Knossos. The art of making the blue glaze "fayence," that typically Egyptian art, which had already been invented in pre-dynastic times, developed very much at this time. The king's jewellers made wonderful bracelets of gold and carnelian, sceptres of sard and of gold, and so forth. The king's carpenters "could make furniture of elaborate type; the well-known bull's hoof *motif* for chair-legs already appears." And they could make the interesting little labels of ivory and wood on which were inscribed the events of the king's reign, with incised representations of him smiting his enemies (Brit. mus.). Wood was imported for large and small work, for beams or for year-labels, into woodless Egypt from Syria already, no doubt by sea. It was used considerably in building in conjunction with brick, for the art of stone building had not developed much yet; that progress was reserved for the next age. Pottery had deteriorated badly since the pre-dynastic age. It is a curious fact that elsewhere, in Babylonia and in Crete, for instance, the pottery also degenerated at the opening of the age of metal. It was still built up, made without the wheel, which had not yet reached Egypt from Babylonia.

Possible Babylonian Influence.—The question of Babylonian influence on the nascent Egyptian culture and art is interesting and important. We see undoubted traces of it in many things, chief among them the style of building brick walls, which are simple reproduction of the Sumerian style, with its recessed panels, in everything but the shape of the brick, which in Egypt is always rectangular and long, never either plano-convex or a flat square, as often in Babylonia. It looks as if the crude brick had been invented independently in Egypt, as it naturally might be in a land of mud, but that the panelled style of building with bricks came from Babylonia. Again, the use of stone (and wood) seal-cylinders at this time in Egypt, and also of the peculiar conical macehead, points to Babylonian influence. A reverse influence, of Egypt on Babylonia, is improbable, because in Babylonia at least the first of these things were at home, and were there to stay, whereas in Egypt they were not destined to last, the use of the seal-cylinder indeed being comparatively ephemeral there. Then there are the Babylonish-looking monsters on slate palettes, which disappeared from Egypt with the 1st Dynasty, the similar processions of animals in both arts at this time (already mentioned), and the identical early representation of the lion with open grinning jaws and round muzzle in both countries; already by the time of the 3rd Dynasty the Egyptian had dropped him and evolved his own dignified lion with closed mouth, whereas the Babylonian retained his own furious lion to the end of the chapter of his art. These things, and others, are important to note, especially now that we seem to be compelled by the latest discoveries at Ur to recognize the superior antiquity of Sumerian art. If Babylonia was the senior we could understand that she contributed something to the feverishly accumulating make-up of the young Egyptian culture, some of which was afterwards dropped. But there is the question whether the communication was direct, or whether the fact was that both Egypt and Babylonia received certain similar elements of culture from a common source, which must have been in Syria. We do not yet know. The "dynastic Egyptian" who came from Syria probably brought certain elements of culture thence; besides developed agriculture and the connected Osiris-Isis worship, also probably the knowledge of copper, and probably the conical macehead, and possibly the panelled style of building. But other foreign elements seem later, and to be contemporary with the union of the kingdom; and it must be remembered not only that more or less direct communication with Babylonia through the Hauran and so across the desert was then possible as later, but that in all probability direct sea-communication existed between such ports as Qusair, at the sea-end of the Wadi Hamamat, and the ports of Southern Babylonia. The evidence of the al-'Araq knife with its gold-beaten handle-reliefs of foreign ships and a Babylonish-looking god is evidence of this even in the pre-dynastic period; and we know that in all probability the Māgan, "the place to which one goes in ships," from which the Sumerians derived some of their hard stone (unobtainable in their own country) was the Eastern Desert of Egypt and possibly Sinai.

However this may be, the two cultures very soon took each its own line of development, and Babylonia, at least, was never influenced in the smallest degree by Egypt except possibly at one single period, that of the Sargonide kings of Akkad (*c.* 2700 B.C.) when a peculiar style of sculpture was in use that recalls the work of the early Egyptian dynasties more than anything else in technique, though the subjects show no sign of Egyptian influence.

The Epoch of Imhotep.—Under the long 2nd Dynasty we have little to record; a static period succeeded the dynamic 1st Dynasty. But with the advent of the short-lived 3rd, a new dynamic period set in suddenly with a political explosion. A new king from the South Kha'sekhem, dispossessed the successors of Menes, who had taken up their abode in the conquered North, and as king of both countries called himself Kha'sekhemui ("Appearance of the two Powers" instead of "Appearance of the Power"). His statue in the Ashmolean Museum, from Hierakonpolis, tells us that he took 47,209 Northerners captive, and on its base we see, summarily cut in outline, variously contorted figures of the slain. Evidently the twisted attitudes of their bodies were admired and sketched at the time, and were reproduced by the king's sculpture on his statue-base. "It was an age of cheerful savage energy, like most times when kingdoms and peoples are in the making." The statue of the new Menes however did not mark a very great advance on former work, though it was bigger; the lifesize figure was to come in the next reign, which marked a climacteric in the history of Egyptian art and science. His son Zoser (Tosorthros) was probably one of the greatest of the early pharaohs; at any rate he was served by one of the greatest of Egyptian ministers, the wise Yemhatpe or Imhotep, who was later deified under his own name (in Ptolemaic days pronounced Imouth, the Imouthes of the Greeks), as the god of knowledge and especially of medical science the Egyptian Asklepios. He is depicted as a priestly man, seated, reading a scroll open on his knees. Imhotep was not only a physician, he was also an architect, and it is more than probable that the extraordinary architectural development that marks the reign of Zoser was due to his inspiration and teaching. He was certainly not deified for nothing, and when we find that it was in the reign of the king whose minister he, the divine patron of science, was, that a sudden and unparalleled advance in art and architecture was made, we can hardly err in attributing this advance to him. It was always recorded that it was in the reign of Tosorthros that "the first stone house was built," as we read in Manetho; and the most ancient Egyptian pyramid, the "Step-Pyramid" at Sakkarah, was built by Zoser. No such great stone building was known before. And now Mr. Firth has revealed at Sakkarah the original 3rd Dynasty funerary temple of the king, with the *serdab*, or recess, in which his lifesize statue (the oldest) was placed at his death and found by Mr. Firth; and it is more than likely that the royal tomb itself may be reached. And the most extraordinary thing about this temple is its architecture. It has panelled walls of fine limestone, and lotus-columns of the same beautiful oolite stone, long corridors of them; the work is the first

of the developed Egyptian style which we know henceforth till the end. It has been said that such "style" means a long previous development through stages unknown to us. But yet there seems to be no time for any such development. In the work of the 1st Dynasty there was nothing like this. The conclusion seems unavoidable that this was a sudden development due to a single brain, that of the wise Imhotep, or to two brains, if Zoser is to be given a share of the credit. And such sudden developments do occur from time to time in history; such powerful brains do sometimes appear, and bend things to their superior will. We have later instances in the history of Egypt itself, notably that of Ikhnaton, though his work was impermanent. We are too apt to assume "long periods of development." Nature does not do things *per saltum* but man does. He sometimes creates specially, as Imhotep seems to have done. At any rate, in the absence of any evidence of any such previous development, we seem justified in assuming so.

It was not only in architecture that the creative genius, whom we have supposed to have been Imhotep, showed his hand. In relief sculpture also the style that had already appeared in the memorials of the 1st and 2nd Dynasty kings on the rocks of Sinai now developed into the first examples of the historic Egyptian style, with the king depicted in the manner in which we see him henceforward; though it was not stereotyped till the time of the 5th Dynasty. Sculpture in the round remains more archaic in type, with curious human faces reminding us of certain extraordinary sculptured heads hitherto usually attributed either to the Hyksos or to the 9th Dynasty (at Cairo), which may however themselves be of the 3rd. The portrait-statue of Zoser is somewhat of this type, and the figure is distinctly archaic still. Sculpture in the round was not to take its final form till the next dynasty, the age of the great pyramid-builders.

The Pyramid-builders.—The impulse given to architectural development in Zoser's reign pushed on swiftly in less than a century after his death to the achievement of the most colossal buildings in Egyptian, if not in all human history, the Great and Second Pyramids of Gizeh, the tombs of the kings Khufu (Cheops) and Khafre' (Chephren) of the 4th Dynasty. The wonderful height attained in the sphere of mathematics and engineering, as well as design, which is attested by these two great buildings, has always struck the imagination of mankind.

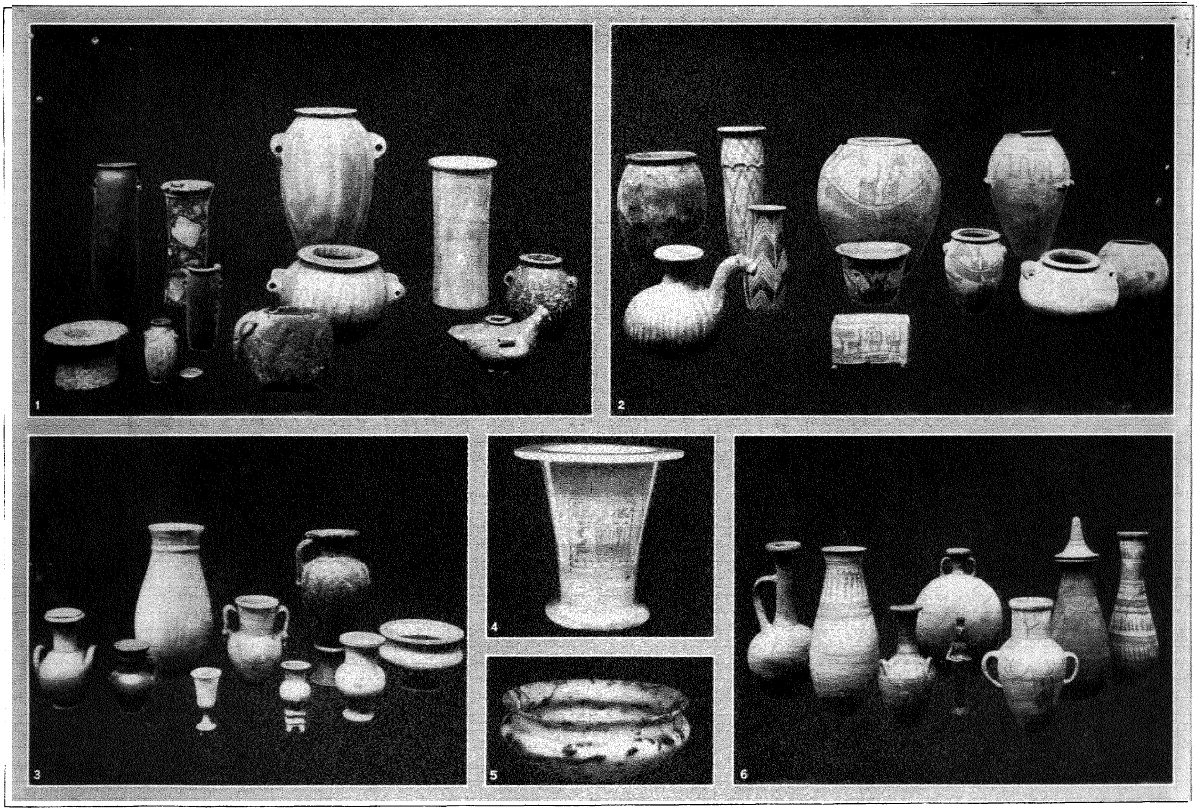
At this time begins the long series of private tombs decorated with reliefs representing the dead owner amid his daily surroundings, with his wife and family, hunting or overseeing his estates, and with his fellahin engaged in their daily avocations. The royal tombs themselves are not yet decorated in any way: but their funerary temples, close by, were, chiefly with religious scenes. At the same time sculpture in the round assumes its final form in the statues of the kings Khafre' and Menkaure', the latter with his queen and with the goddesses of the "nomes" or provinces of Egypt, which are among the greatest treasures of the Cairo museum. We now see in the faces of the kings the first examples of the Egyptian genius for personal portraiture which later became one of the chief and most valuable characteristics of Egyptian art. Another portrait-figure of the time is the well-known "Skeikh al-balad." And in the famous statues of the Prince Ra'hotep and his wife Nefert (also at Cairo), with the amazing lifelike effect of their eyes, produced by the means of a pin of copper representing the iris inserted into a crystal eyeball, we have a startling combination of accurate portraiture and appearance of life. This technique of eye-representation was often repeated in Egypt later on, in glass or obsidian, as well as crystal. It was paralleled contemporaneously in Babylonia, by means of shell for the white of the eye and jasper for the cornea, but not so successfully. Wood-carving is exemplified in the beautiful reliefs of the panels of Hesire' at Cairo. Pottery improves, a fine bright red polished ware coming into use, that continued till the time of the 7th Dynasty.

Under the 6th Dynasty the pyramids deteriorate, and are largely composed of rubble with an outer facing of limestone, whereas the great pyramids of the preceding dynasty had been made of the finest limestone blocks throughout. The actual tomb-chamber of the king now begins to be decorated with religious texts, the "Pyramid-Texts," spells relating to life in the next world calculated to secure the safety of the dead monarch there; precursors of the chapters from the "Book of the Dead" of a later epoch (see *Religion*). The funerary temples on the other hand are magnificent, built with great papyrus-columns of red granite and decorated with fine reliefs in which the official religious style is now fixed. Tomb-reliefs and portrait-statues continue excellent. Stone vases have become smaller and more delicate; under the 5th and 6th Dynasties beautiful unguent pots of alabaster (calcite) were often placed in the tombs.

Under the 6th Dynasty we have the magnificent statues from Hierakonpolis of king Pepi I. and his small son in copper (not bronze, as used to be thought owing to a mistaken analysis), at Cairo. The copper was apparently beaten, not cast, though this is not quite certain in the case of the head of the prince. Here we have a technique that first comes to our knowledge now, though it was probably older, since we have a record of a copper statue having been made of king Kha'sekhemui under the 3rd Dynasty. It is probable that this art came to Egypt from Babylonia, where we find it in the case of the great copper reliefs and figures of animals found at al-'Ubaid, near Ur, which date to about 3100 B.C., and are presumably contemporary with the 3rd Dynasty owing to the usual computation, but before the 1st if we adopt that of Scharff.

The Middle Kingdom: 9th to 12th Dynasty.—At the end of the dynasty, art, which had been slowly deteriorating for some time, temporarily disappeared in a welter of civil war and possibly foreign invasion, both of Semites from the North and Nubians from the South. Under the Herakleopolite kings of the 9th Dynasty it reappears, but under the first Thebans of the 11th is still of a rude and clumsy character, especially in its reliefs, until in the settled and prosperous reign of king Mentuhotep III., who reunified the distracted country, a sculptor seems to have arisen, named Mertisen, to whom is probably due the artistic renascence of the Middle Kingdom. His work is to be seen in the sculptures of the king's funerary temple, Ikh-isut, at Dair al-bahri, discovered by Naville and Hall in 1903 (Brit. mus.). These reliefs and figures are still a little crude, but give ample promise of the fine art to come. In the reign of Amenemhet I., the first king of the 12th Dynasty, we find a very delicate style of relief. Under Senusret I. sunk relief (*cavo rilievo*) is used at Koptos, in that of Senusret III. (Sesostris) splendid vigour of portraiture in the grey granite royal statues from Dair al-bahri and the red granite head from Abydos (Brit. mus.), which becomes magnificence in the famous portraits of Amenemhet III., especially in the small obsidian head, formerly in the Macgregor collection, which is probably he, and is a marvel of style and workmanship in so intractable a material as well as, evidently, a faithful portrait of the original. Another small portrait, in serpentine, which is certainly Amenemhet, was in the Grenfell collection, and now belongs to Mr. Oscar Raphael. The small statue of him as a young man, at Leningrad, is also well known (casts of all three in the Brit. mus.). Amal sphinx in the British museum, recently presented by the National Art Collections Fund, magnificently carved, shows us the hitherto unknown features of his son Amenemhet IV. The treatment of the mane of this sphinx, in short lion's locks, is precisely similar to that of the manes of the so-called Hyksos sphinxes from Tanis at Cairo which are, on this new authority, definitely to be dated to this period and no doubt present portraits of Amenemhet III. Tomb reliefs now are uncommon, and the wall decoration is usually simply painted in tempera.

The small arts of ivory carving, of fayence-making, of gold and electrum work, and of *cloisonné* inlay in beautiful stones such as carnelian, lapis, turquoise and blue felspar, of scarab-making in glazed steatite, obsidian, crystal and amethyst, are all now at their apogee. Nothing so tasteful, so well proportioned, so graceful, so delicate was made later. The figures of the royal princesses from Dashur and Lisht are of beautiful workmanship. Scarabs at this time came into general vogue. They had been used at the end of the Old Kingdom and made of blue glaze, without inscription, but with the labyrinthine designs common at the time on small seals, especially on a class known as "button-seals," probably of foreign origin, and usually made of ivory or steatite, which is



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STONE AND POTTERY VASES: PRE-DYNASTIC PERIOD TO XIX. DYNASTY

1. Pre-dynastic stone vases. Before 3200 B.C.
2. Pottery of the pre-dynastic period
3. Stone vases: 18th–19th dynasties. About 1580–1350 B.C.
4. Alabaster vase of the 6th dynasty. About 2600 B.C.
5. Diorite bowl of the 4th dynasty. About 2900 B.C.
6. Pottery of the 18th dynasty

closely paralleled in early Minoan Crete. From the 9th to the 12th Dynasty the scarab develops with characteristic spiral designs of Aegean (and possibly ultimately Central-European) origin, and under the 12th inscriptions are added; it begins to be used as a seal. When inscribed its material was usually of glazed steatite; scarabs of the harder stones were generally not themselves inscribed, but often bore an inscription on a gold, electrum or silver plate cemented to the base. Twelfth Dynasty scarabs are among the finest known, both for design and beauty of glaze (*see* also SCARAB).

A quaint, often crude, but also often finely executed art of the period from the 6th to the 12th Dynasty, is the making of the little model figures of people at work in the fields or the granaries, ploughing, winnowing, etc., also of boats with their rowers, conveying the funeral cortege across the Nile, which were placed in the tombs at this time. (See *Religion.*)

Ivory carving was a specialty of this dynasty, very characteristic being small seated male figures, like the wooden ones, often with inscriptions or spiral designs on the base. Small figures of this kind were characteristic of the time also in other materials, especially blue fayence; and magnificent small examples of figures of animals in this material, especially of hippopotami, with the water plants amid which they lived, painted in manganese black on their sides, are in the chief museums. The fayence has now largely abandoned the original pale blue colour of the Old Kingdom for a splendid deep blue. Ordinary pottery has now deteriorated again, the fine polished red ware of the Old Kingdom disappearing. Stone vases continue to be fine, especially those of alabaster and of a peculiar blue marble very popular at this time for unguent-vases or *alabastra.*

Thirteenth Dynasty Art and Hyksos.—Under the 13th Dynasty deterioration again set in. The great school of sculptors cannot keep up the standard of Amenemhet III.'s time. Royal statues become curiously lanky and attenuated; faces and necks get long, heads disproportionately small, as in the Sebekhotep in the Louvre. The finest work of the time (early in the dynasty) is the head long attributed to Amenemhet III. (and formerly to Apepi of Hyksos) from Bubastis in the British museum. From the form of the headdress and other characteristics I would attribute this work to the 13th rather than the 12th Dynasty. The king whose portrait it is is unknown. But things never get so bad as they were between the 6th and 9th–12th Dynasties. The 12th Dynasty taste in small objects continues, though workmanship falls short of the old distinction. A newly developed art is that of coffin-decoration. Until now the dead had been placed in great rectangular chests, at first with little ornament but a bare inscription, then under the 12th Dynasty finely and simply decorated without with bands of inscription, and often within with maps of the underworld to guide the soul, pictured lists of the amulets and sacred unguents buried with him, and funerary spells of power. In this under the 12th Dynasty the mummy was often placed with a human-face cartonnage mask over its head. In the following period the rectangular chest was given up (probably owing to growing difficulties of obtaining suitable wood from Syria) and an outer coffin of poor native wood was substituted with a human head like that of the inner mask, and with body roughly shaped like a swathed mummy. In the case of some of the kings the body of the coffin was painted with the vulture-feathers of the protecting goddess, so that they are known, from the Arabic word, as *rishi* coffins. Henceforward the human-headed coffin was the rule (see *Religion*), and an enormous number of artists (of high and low degree of capacity) must have been employed at all times in making, painting and gilding them.

The New Kingdom: 18th Dynasty.—Under the 18th Dynasty a new renascence begins, with a new note of a hitherto unknown tone. A wave of Asiatic conquest had overflowed Egypt, and had retreated, but it had left its marks. The art of the first two reigns of the new dynasty of "Liberators" bears strong traces of close relationship to that of the 12th–13th Dynasties, but in the reign of Thutmosis I., the first to carry the Egyptian arms into Syria to avenge the Hyksos conquest, the new element appears, which is certainly due to foreign Syrian influence. Such things as the chariot (*see* below) were directly adopted from Asia with the advent of the horse and weapons add to their number such a purely Asiatic form as the curved scimitar or *Khepesh,* previously unknown, and certainly adopted, like the chariot, from the Hyksos. In the reign of the conqueror Thutmosis III. we are in the full tide of the great civilization and art of the 18th Dynasty, and we see in it unequivocal traces of the foreign influence, which increases as time goes on. In the reign of Amenhotep III. it is specially strong, but at the same time in no way dominant or able in reality to denationalize Egyptian culture and art at all. The old Egyptian traits, especially in the all-embracing domain of religion, are as strong as ever. But where religion could not penetrate, the loss of character due to foreign connections is evident. The new art, like the new culture, is beautiful, but it is lavish, its taste is not so good as was that of the 12th Dynasty, it is rococo.

In architecture we do not see any very great development of previous ideas. We know very little of the temple-buildings of the 12th Dynasty, as they were mostly rebuilt in later days, but it is probable that the 18th Dynasty introduced few new improvements on them. Even so original a building as Queen Hatshepsut's terrace-temple at Dair al-bahri is now known to be merely an enlarged adaptation of the older temple of the 11th Dynasty at the side of which it was built. The old tradition of adorning them with the statues of the kings who built them is carried on, with the same care of portraiture, and with a greatly developed tendency to gigantism, which began under the 13th Dynasty when the first colossi were produced. The colossal head of Amenhotep III. in the British museum is one of the finest Egyptian portraits existing. The extremely unbeautiful, but probably lifelike, colossal heads of Ikhnaton, lately discovered, are evidence that the colossus-convention was retained by him. Among smaller royal portraits the young Thutmosis III. at Cairo is one of the finest known; it is unusually unconventional in treatment for the time, and no doubt a good likeness. A more conventional head, probably of the same king (but by some considered to be more probably his sister Hatshepsut) in the British museum, shows how the royal features could be toned down and regularized for an official portrait. Votive statues of private persons show the same regularized portraits, but very often they are as true as under the 12th Dynasty, as we see from the famous figures of the sage minister, Amenhotep son of Hapu, at Cairo. The groups in white limestone of a man and his wife seated, side by side, which were either placed in the round in tombs or sculptured in high relief in the rock at the end of the tomb-corridor, are very characteristic, and show the costume of the new age with careful accuracy. For costume had now altered and developed in a way unknown since the beginning of the Old Kingdom, though the change was in no way so radical as those known in Europe. There was, however, now an added note of grace in men's as well as women's costume, that contrasts greatly with the stiffness of the dress of the older dynasties (see *Dress*). Tomb-decoration for private persons of distinction consists chiefly of wall-portraits in distemper depicting the same scenes of daily life as before, to which great men add pictorial records of the honours they have received from the king, or of events of their time redounding to the honour and glory of their royal master, such as the reception of foreign ambassadors and tribute-bearers from Asia and from Greece. The tomb of Sennemut, the architect of Queen Hatshepsut, of Rekhmire', the vizier of Thutmosis III., and of Menkheperre'senb, another great man of his time, are cases in point. In them we see pictures of the reception of Minoan ambassadors from Crete which are among the most important historical records of their time. In the reign of Amenhotep III. relief decoration comes into fashion again for tombs, as it had always been used in the temples. The delicate colour reliefs of the temple at Dair al-bahri, depicting Queen Hatshepsut's expedition to the land of Punt (Somaliland) are among the finest earlier works of the dynasty. Later on we have such fine work as that in the tombs of Khaemhe't and Ra'mose at Thebes. The royal tombs do not yet show the elaborate painted decoration, representing scenes in the next world, so characteristic of the 19th

and 20th Dynasties, and do not yet approach the extensive plan of those of the later time. Amenhotep II.'s is the finest, and is decorated with restraint. Tutankhamun's tomb is but a sepulchre, with little wall-decoration and that unfinished.

The actual objects buried with the king are of unparalleled magnificence. In his case not only specifically funerary objects were buried with him but also, apparently, most of the things that he had actually used in life, his chairs, clothes, boxes, lamps, chariots, sticks, weapons, rings, amulets, necklaces, etc., and it is probable that much the same thing was done in the case of every deceased monarch. But only Tutankhamun's has ever been found intact, though we have previously found objects, fewer in number, but of almost equal magnificence and interest, in the tomb of Iuya and Tuyu, the grandparents of King Ikhnaton whose successor Tutankhamun was. These things enable us to form a picture of court life in the fourteenth century B.C. in Egypt more complete than that which we possess in the case of any other ancient civilization. Archaeological excavation has told us more of ancient Egyptian life than that of any other ancient nation. For details of the various wonders of ancient art that Tutankhamun's tomb has revealed the published accounts of this find must be consulted. But little has been revealed by it that was actually unknown before. The forms, the motives, the types of decoration were all known. But we often find them in new and unprecedented combinations, especially in the royal jewellery, which shows how sumptuously the old 12th Dynasty tradition of gold and semi-precious stone inlay was carried on. The taste, however, is now not so good. The newer art is sometimes rather garish and vulgar, as seen in many other objects from Tutankhamun's tomb such as, more especially, the great alabaster or calcite vases represented as on imitation wooden stands of alabaster and combined with the twining papyrus and lily-stems emblematic of South and North; the conception is forced and ugly. Calcite vases with coloured lions on their lids look as if they were made of sugar and were intended to be eaten. Bad taste is beginning to creep in. But on the other hand we also see the characteristics of the new free conception of art introduced by Amenhotep III. and Ikhnaton in the representations of the young king with his consort on the back of a chair, or the almost Persian miniature picture of a lion-hunt on a box. Foreign influence we see too in such work as that of the king's iron and gold daggers, with their non-Egyptian type of hilt and gold filigree decoration.

The Amarna Period.—In the reign of Amenhotep III. a new impulse towards freedom in art was given, in conjunction with the movement towards new thought in religious matters, which culminated in the monotheistic cult of the *Aton* or sun-disc, proclaimed by his son Ikhnaton (see *Religion*). For a time Egyptian art seemed to be about to cast off its age-long shackles, and, had the religion of the Aton endured, this would have happened. The removal of the religious bonds would have led, probably, to an extraordinary development of art, and at the same time have altered the whole course of Egyptian civilization. But this was not to be; and after only a few years, in the reign of Tutankhamun, in fact, king and people returned to polytheistic orthodoxy, and history resumed its course on the old lines. It was in fact impossible to alter the religion of the whole nation, and we see that in spite of all his efforts, Ikhnaton was unable to deflect the Egyptian mind more than a very little out of its accustomed ways. In the art of his time, of which we have recovered so many magnificent examples from the ruins of his city of palaces at al-'Amarna, the old motives of religious origin still persisted. There is nothing radically new in the most daring innovations of the disc worshippers; only the representation of the sun-god himself, as a disc with rays terminating in hands holding the symbol of life, is entirely new. The old *clichés* go on in use, and after all they were beautiful, extraordinarily decorative. They were preserved. In sculpture in the round we see the new striving after truth in such a wonderful portrait as the coloured stone head of Queen Nefertiti at Berlin, in which all ancient convention seems to have been dropped: even the eyes are painted naturalistically, with none of that curious antique convention of representation that had persisted since the days of the 1st Dynasty and was to reassert itself very soon. Of the sculptor's desire for truth we have a proof in the extraordinary series of plaster masks, taken from living and dead faces, and from statues, found with the Nefertiti head in the "House of the Sculptor" at Amarna. They were part of his stock-in-trade to be used for portrait-figures. We see new ideas in the representation of the home-life of the royal family, shown with a freedom unprecedented; for the first time Egyptian royalties are human. Ikhnaton offers his wife a flower; Amenhotep III. leans forward heavily and lazily, arm over knees, as he sits on his throne, even in a formal sculpture; Tutankhamun and his wife are shown affectionately conversing. But the setting remains the same and the technique cannot alter, and above all Ikhnaton cannot change the hieroglyphic writing, in which the whole ancient history of Egypt's religion and art are enshrined. The protest could not last; and when the priests of Amon gained the upper hand, after the king's death, it was not long before all the ephemeral beauty of Ikhnaton's art disappeared. Tutankhamun's tomb had a few things of his style; after all, he had only been a few years dead. But after the long reign of the conservative reactionary Horemheb nothing remained of the beauty that Amenhotep III. had envisaged and Ikhnaton had for a moment carried into effect, than a certain delicacy of workmanship in the reliefs of Seti I. at Abydos and the swan-song of fine Egyptian art—the beautiful statue of Rameses II. at Turin.

Small art shows the old characteristic of freedom in all things non-religious. Alabaster vases are specially beautiful; the jug-shape, previously unknown, comes into use, and the globular-bodied, high-lipped vase on a high foot. Scarabs alter very much in type, green glaze comes into vogue, fayence becomes a favourite material, and in the first half of the 15th century the blue fayence is extraordinarily beautiful. Later on, under Amenhotep III., polychrome glazes are introduced, and all sorts of vivid shades of blue, violet, yellow, chocolate, apple-green are used, which are characteristic of the Amarna period. This polychromy arose from the new polychromy of glass. Under the 12th Dynasty real glass, as opposed to glaze, appeared for the first time. It was at first plain blue; but about the time of Thutmosis III. the art was discovered of making the wonderful opaque polychrome glass vases that are among the most beautiful and most valuable contents of our Egyptian museums. The first produced were somewhat heavy and coarse, but very soon a remarkable lightness of handling was obtained. A particularly beautiful pale blue is characteristic, and an imitation of obsidian or black glass is excessively rare. Combination of all these materials with gold is common. Gold is lavishly used. "Gold is as dust in thy land, my brother," writes the king of Babylonia to Amenhotep III. Tutankhamun had a solid gold coffin. And no doubt other kings had solid gold coffins also. Gold is used very freely in conjunction with wood, especially in furniture and in chariots. The arts connected with chariot-wheel making and horse-trappings generally are new in Egypt at this time, as the chariot and horses were not introduced from Asia till the time of the Hyksos, about 1800 B.C.; previously the Egyptians had not employed wheeled vehicles at all, but sledges, and asses for draught. Bronze is now in regular use for weapons, and iron comes into more general use but is still precious and worthy of kings.

The Ramessides and the Decadence.—Under the kings of the 19th Dynasty the degeneration sets in. Gold is too much to the fore and is becoming vulgar. Growing vulgarity is the note of the age. The long reign of Rameses II. saw a progressive decline of the arts. We find a grandiose conception of Tutankhamun's architects at Luxor imitated by Seti I. in a still more grandiose conception, the great Hypostyle hall at Karnak. But it is too big; too gigantic. It is coarse and clumsy. And this coarseness is seen in all the arts after the death of Seti. There is only one good statue of Rameses, that at Turin. The rest are either abominable, or else are not really his but are stolen from former kings. The great rock-cut temple of Abu-Simbel is an atrocity, with its great lumpish clumsy figures, everything out of proportion, everything all wrong. The huge royal tombs are imposing, with their pictured halls showing the adventures of the soul in

the underworld. But their painting is often coarsely executed. Relief is now, after Seti's low-relief work at Abydos, generally sunk, *cavo-rilievo*, an old Egyptian idea not much in favour under the 18th Dynasty. Now we find it employed for the amazing scenes of royal wars that covered the outer walls and pylons of the temples in which the king, of an enormous size, slays hordes of foreign enemies. He had done this before, on a smaller scale, in art as far back as the time of the 1st Dynasty, but now he did it on the heroic scale. And the style is almost barbaric. Private tombs, excavated as before in the hillsides, show a progressive degeneration of the 18th Dynasty decoration.

In small art vulgarity progresses, but not so blatantly. Many beautiful small things of art were made under the 19th Dynasty, of faience, of alabaster and other stones. The fine alabaster vases of the 18th Dynasty continue, often with handles in the form of animals; but forms deteriorate. The blue faience is not quite so good; polychromy continues in duller, dirtier tints. Red stones come into use, such as jasper, sard and carnelian to the exclusion of blue, though stones of Asiatic origin, like lapis or chalcedony, were rather favoured. Asiatic influence becomes more and more marked; Semitic gods, Semitic names and Semitic ideas appear upon the monuments.

Under the 20th Dynasty the pace of the deterioration increases, especially after the reign of Rameses III. Temples become hideous rows of sausage-pillars with hieroglyphs a yard high, miracles of bad taste. Gold becomes gilding, and it is everywhere; vulgar display hides growing poverty of idea. There is nothing new, there is nothing distinguished now. Tomb reliefs are stereotyped; even the old power of portraiture has gone. Under the 21st there is a short Indian summer of art at Thebes; almost a pathetic attempt at a revival of lost beauty. The blue faience is startlingly deep in colour; something had been recaptured here. But it is too harsh a blue, and the modelling it covers is worthless. The art of coffin-making which had developed in the direction of complexity of religious ornament from the simple inscription bands of the 18th Dynasty is now very elaborate. The yellow-varnished coffin of the time with their relief decorations and inscriptions in gesso, are well known. We have an interesting relic of the time in the embroidered "funeral tent" of Queen Isemkheb, which has been eclipsed as an example of an Egyptian luxury-textile by the robe (?) of woven linen tapestry of Amenhotep II., found in the tomb of his son Thutmosis IV. We know that the Egyptians used embroidered linen in great variety (though little of it has come down to us) from the paintings. The national art of linen-making is of course characteristic of all periods from the pre-dynastic, when it first appears, though it may have been at its finest under the 11th and 12th Dynasties.

The Archaistic Renascence Under the Saites.—With the 22nd Dynasty everything becomes bad, poor and dull; it is the nadir of Egyptian art. Under the 25th however in the North a new spirit arose in the 8th century. The monuments of the pyramid-builders in the vicinity of Memphis attracted the attention of the artists, and a new school of sculptors arose at Memphis characterized by a curious archaism. The style of the ancient statues and reliefs was adopted, often directly imitated. Notables of the new time were shown wearing, not their real clothes, but the plain loin-cloths of the 5th Dynasty, combined with the round wigs they usually wore; just as in the 17th and 18th centuries our worthies were often represented in Roman armour with wigs. Sometimes, as in a statue at the British museum, the archaism extends to the wig, so that but for the inscription it would hardly be possible to tell that the statue was not of the 5th Dynasty. The writing could not be archaized very much, though attempts were made in that direction. At Thebes something of the old imperial art-tradition remained, and there we see a neo-Theban school, with a touch of the Memphite archaism in it, which produced some remarkable work in the 7th century, notably the portrait heads of the princes Nsiptah and Montenhe't and the unknown old man in the British museum (No. 37,883). Here the native genius for portraiture again shines forth after its eclipse since the 20th Dynasty, and throughout the 26th Dynasty it persists, and later, till it again dies out under the Ptolemies. The Saite archaism was eclectic, and we can often diagnose it by its mixture of the characteristics of historically different periods, such as the Pyramid-time and the 12th Dynasty. It appealed to the Egyptians of the seventh century as appropriate to the new course in national history which was now entered on after the emancipation from Assyrian conquest under the Saites. The old imperial order constituted with such splendour under the 18th Dynasty was dead, and men turned for new inspiration to the ancient days of the pyramid-builders, before Asia, taken captive, had corrupted her conquerors and planted in them the seeds of decay. The result in the domain of art, as in other things, was the creation of an artificial simplicity and juvenility which, however, was by no means without beauty. The Saite sculptors were wonderful workers of the hardest stones, and their work in basalt and granite, combining the simplicity of old days with the delicacy and style that was wholly new, is characteristic of their period. In small art we see a conscious return to ancient ideas in the abandonment of the dark blue fayence for an imitation—a most delicate and beautiful imitation—of the pale blue of the Old Kingdom. This pale blue faience, well exemplified in the *ushabti*-figures of the time, so well known in our collections, is characteristic of the time. Scarabs and scaraboids were beautifully made of fine stones; the Saite engraver was a master. But it was not only in small things that the Saite artist excelled. He made very big things too, such as the huge monolithic shrines in the temples, equally characteristic of the period. Tombs were now built very often with a certain archaism, in the form of huge brick buildings above the actual chambers of the dead hollowed out of the rock below; this was in some sort a return to the *mastaba* of the Old Kingdom, and a rejection of the hillside chamber-tombs of the 12th and 18th–20th Dynasties. Tomb reliefs imitate those of the 5th Dynasty, with a difference that does not escape the modern critical eye. And as time goes on we see this difference accentuating itself in a way that we cannot mistake; it is being influenced by the renascent Greek art of the 6th and 5th centuries. Already under Apries and Amasis we see Egyptian figures adopting a curious simpering smile, which we can hardly fail to attribute to the influence of Greek archaic art, communicated through the medium of Naukratis, of Daphnae and of Cyprus. This "archaic smile" which was natural to the young Greek art, was unnatural and artificial in Egypt, and was adopted there merely as a preciosity. It continued all through the Ptolemaic period in Egypt, and became characteristic of the work of that age. Conversely, Egyptian archaistic figures influenced the early Greek sculptors in their figures of Apollos or winners in the games. In the 5th and 4th centuries Egyptian tomb-reliefs and vase-decorations show definite imitations of the new mature Greek art grafted on to the archaistic Saite style. The age of the last native kings is still in its art Saite, but of a curiously delicate refined character to be carefully distinguished from the larger style of the 26th Dynasty.

Ptolemaic Art.—Under the Ptolemies there is another change. Foreign conquest again became familiar under the successors of Alexander, and from a finikin imitation of Old Kingdom models men turned to gross and wooden imitations of the imperial style again in temple reliefs and in statuary. All art became gradually worse; the Saite delicacy was soon entirely lost, what there was of grace and beauty in the first Ptolemaic century disappeared at the end of the period. The roughness of the sculpture in coarser soft sandstone shows an incredible decadence, which was only emphasized under the Romans. The small arts degenerate conformably, but more slowly. The pale blue glaze continues under the Ptolemies to be very beautiful, and was often used by Greek artists to fashion purely Greek objects of art, as had already been done at Naukratis under the Saites. But a coarser, sugary glaze, often of darker colour, has also come into use and under the Romans gains the mastery. Only in metal-work, especially in gold and silversmithery, do we still find good work under the Ptolemies, and in the old Ramesside style, which had never died out; for in this domain of art archaism had never found a place, the reason being probably that there was no goldsmith's work of the Old Kingdom known to the Saites which they could imitate. We, with our knowledge dervied from archaeological excavation

which enables us to survey the whole course of Egyptian art-history from beginning to end, know far more of these things than the ancient Egyptians of any one period knew themselves.

The Roman Period: the End.—Of Egyptian art under the Romans one can only speak as a dead thing. The only thing worth looking at is the faience, with its characteristic semi-transparent dark blue glaze, often laid on over yellow to give the effect of green. A fine hard black glaze was also used, as well as an apple-green. The sculpture is dry and dull; half-Romanized portraits of classical and Egyptian style are produced, of horrific tastelessness. The temple reliefs are abominable, barbarous, and as bad as anything that the Nubian imitators of Egyptian art at Napata and Meroe had produced. Egyptian art could not exist any longer by the side of Graeco-Roman art; it was not only provincial, it was definitely barbarous, the childish performance of "natives," which could only cause amusement to the citizen of the modern world-empire of Rome. So old Egypt expired, "a driveller and a show." She left a few motives, of religious origin, to the "Coptic" art of the Christian period, which otherwise was Syro-Roman in style. The ancient symbol of "life," ☥, easily became the Christian cross.

ARCHAEOLOGY: DETAIL

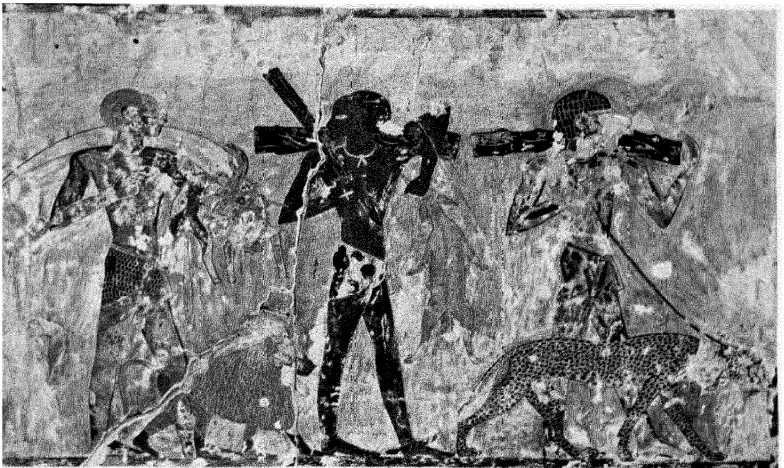
Agriculture.—As now, Egypt's staple industry was her agriculture. She early became a granary for the surrounding world, and her corn was no doubt exported to the Aegean or to Syria in ancient days almost as largely as it was to Rome later on. Ancient pictures of the fellahin at work in the fields have much the same appearance as modern representations of the same scenes. The crops were much the same as to-day. Wheat and spelt were used for making bread, of which many ancient specimens have been preserved in the tombs to our own day. There is no possible truth in modern tales, constantly repeated, of ancient mummy-wheat being planted nowadays and producing a crop; the germ cannot live so long, and the grain in question is always certainly modern. Barley was used for making beer. The vine was cultivated and wine made in Egypt, especially in the Oases and the Mareotic district of the delta; nowadays the climate is considered too dry and hot for the production of good wine. The date-palm was as important as it is now. Bee-keeping was a very ancient industry. The title of the king as king of Upper and Lower Egypt meant "Bee-man" (byati) 𓆤.

Honey was much eaten; cane-sugar of course being unknown. Land was usually held by the farmers from a landlord, either the king, a feudal chief, temple-chapter, local squire (a farmer himself) or in late times a wealthy townsman. The king was the nominal owner of all land, but in practice, even at the height of the royal power, he could not claim to own directly the lands of the priests, and if he dared to confiscate any he gained a very bad reputation thereby.

Animals.—The oldest domestic animals of the Egyptians were asses, oxen, sheep, goats, pigs, dogs, cats, geese and ducks. The pig is not often represented, as it was considered unclean. A peculiar breed of sheep, with long twisted horizontal horns, died out as early as the 18th Dynasty, but its peculiar type continued to be represented in the ram-headed god Khnum (confused with the goat of Mendes). The ordinary breed with helically-twisted horns was the animal of the god Amon. The dog was domesticated very early, as the hound and the turnspit were differentiated as early as the Middle Kingdom. The cat was probably not so domesticated as it is to-day, but as the animal of the goddess Bastet was held in high honour. The horse was not introduced from the East till the time of the Hyksos, with the chariot; the domestic fowl not till that of the 18th Dynasty, when its phenomenal powers of laying were regarded with wonder ("the bird that brings forth eggs every day"). Neither horse nor fowl ever were regarded as sacred, or gave heads to Egyptian therianthropic gods, although in very late Roman times a cock-headed Gnostic demon evolved, probably through some confusion with the hawk-headed Horus. The Egyptian breed of horses became famous in later times, as we see from a well-known biblical reference (1 Kings, x., 28); and in the 8th century king Pi'ankhi in an expedition from Nubia extends his clemency to those princes who treated their horses well, and censures one for neglecting his. The horse was not ridden till Saite times. The donkey and the pig dispute the honour of giving a head to the god Set. The camel was never used in the Nile valley, being confined to the Arabian desert, and is never represented till the latest period. The baboon and other species of apes can hardly be regarded as domesticated, but were well-known from early days, especially the dog-headed baboon, the animal of Thoth, the god of learning. The elephant was not generally domesticated, or used in war till Ptolemaic days. It was however well known from predynastic days, and later often brought as tribute from Asia, where it still lived in North Mesopotamia and Syria. The lion, also brought from inner Africa and Mesopotamia (where it still existed till the middle of the 19th century in the Euphrates marshes) was trained to accompany the king (under the 18th and 19th Dynasties) in war.

The tiger, of course, was unknown to the Egyptians, but the hyena, wolf and jackal were indigenous, the two latter animals being held in high religious honour, the jackal being thus placated in very early days in order to persuade him not to ravage the graves of the dead in the desert (see *Religion*). The giraffe was brought from Kordofa, as tribute from the negroes, with the baboon. The hippopotamus and crocodile were among the commonest denizens of the Nile; the former persisted in the Delta till the beginning of the 19th century, while the latter was only quite recently retired from Upper Egypt and Nubia to the region south of the Second Cataract. Both gave heads to Egyptian deities. Of other non-domesticated animals the ibis is the best known: also sacred to Thoth (see *Religion*).

Architecture (see also *Art*).—There is a model in the British museum of a pre-dynastic house, a box of pottery with a lid, in the shape of a long hut with a door with beam-architrave. The well-known Egyptian splay and torus moulding is certainly of pre-dynastic origin, being an imitation of the splaying tops of the rows of reeds of which a reed hut was built, bound together by a roll of cord along the length of the roof. Details of stone shrines in later days which are evidently modelled on wooden originals (at Dair al-bahri under the 11th Dynasty, the carved limestone is painted to imitate the grain of wood) show strong and well-designed carpenter's work in early building. Although brick may be an Egyptian invention independent of Babylonia, wall-details were either borrowed from Babylonia, or by both Egypt and Babylonia from a common source. The sudden development of stone building under the 3rd and 4th Dynasties has been described, and the stereotypes of temple-details under the 5th. Of Middle Kingdom buildings we have the 11th Dynasty funerary building at Dair al-bahri and that of the 12th at Lisht, besides the pyramids of the kings at Dashur, Lahun and elsewhere. The undecorated walls, built of gigantic stones, of the "Temple of the Sphinx" at Gizeh and the Osireion at Abydos, which have been attributed to this dynasty, are certainly in the case of the Osireion much later, belonging to 19th, while the view that the Gizeh building may be of the Pyramid epoch is not disproved. Both are subterranean buildings built for certain funerary purposes connected with Osiris in the underworld. The temple developed its full magnificence under the 18th and 19th Dynasties. While the gods were housed in halls of granite and sandstone, the kings continued to live in palaces of mud-brick, decorated however with beautiful wall-paintings; stone being confined to pillar-bases and thresholds, sometimes also doorjambs, architraves and beams being of wood. Large halls were often built of this construction. The systematic excavation of the ruins of Akhetaten, the town of Ikhnaton at Amarna by the Egypt Exploration Society, following the work of the German Orient-Gesellschaft, is teaching us much regarding Egyptian domestic architecture. Streets were broad at Akhetaten, and suitable for chariots abreast, but the town was a new foundation, and we cannot doubt that the alleys of an old city were as tortuous and noisome as they are to-day. Housebuilding has really altered very little in Egypt or in 'Iraq, and the ways of the people are the same as in ancient days; in few countries is the complete continuity of modern civilization with that of four thou-



BY COURTESY OF MRS. N. DE GARIS DAVIES AND (1) THE TRUSTEES OF THE BRITISH MUSEUM, (2) THE EGYPT EXPLORATION SOCIETY

WALL PAINTINGS OF THE 18TH DYNASTY

1. Wall painting in the tomb at Thebes of Rekhmire, Vizier of Thutmosis III., depicting negroes bringing tribute of ebony, ivory, pelts, a leopard and a monkey. About 1450 B.C., 18th dynasty

2. Two of the seven daughters of King Ikhnatun (Akhenaton) from a fresco at Tel-el-Amarna, the king's city of palaces Amarna period, about 1370 B.C., 18th dynasty

sand years ago so evident as in Egypt. Foreign ideas appeared from time to time, sometimes owing to a royal whim, as in the famous case of the outer gate of the temple of Rameses III. at Medinet Habu, which is an imitation in sandstone of a Syrian *migdol* or fortified tower. In later days the temple-architecture becomes coarse and ugly, until revived and refined to some extent by Saite archaism. The Ptolemaic age has left us at Dendera, Edfu, and elsewhere the only completely roofed and well-preserved temple-buildings we have; Edfu indeed is practically perfect and gives a magnificent idea of what an older temple was like, for though the Ptolemaic sculptors could only design wall-reliefs childishly, the architects were well able to reproduce the buildings of the past. Even the Roman age at Esneh has left no inconsiderable monument. Details of course altered in time, became misunderstood, debased or vulgarized, but the main appearance of a temple was the same as it had been under the Old Kingdom—the style was the same. There were no religious buildings in Egypt of clashing styles. The pillar capitals of the lily and papyrus orders established by the time of the 5th Dynasty (the closed lily-bud capital dates from the 3rd at Sakkara) continued to the end. The bud-capital was very popular under the 18th and 19th Dynasties, and under the 20th became a terrible caricature. The inverted flower, often used for wooden canopy pillars, was used once only in temple-architecture, by Thutmosis III. at Karnak and was not approved. By Ptolemaic and Roman times capitals became very elaborate and rococo. The art of building an Egyptian temple was simple, being merely that of the child who builds with a box of wooden bricks. It is the mass and weight of the "bricks" that are astonishing. There is no doubt that though the Egyptians possessed in early days a primitive kind of crane (probably) and a sort of rocker which could transfer heavy stones from a lower to a high position, much of their building was achieved by sheer man-hauling up mounds of earth. The Egyptian is an adept at throwing-up earth embankments speedily, on account of their necessity in the scheme of irrigation; and he built his temples by hauling the stones with ropes and levers up an earth-slope to the height demanded. An architrave was placed across two pillars in this simple way, which has been used in modern days for the restoration of Karnak. Such levers, ropes, mallets, etc., are often found in excavations of temples. Implements such as squares, plumb-lines, etc., were used. The mason's square  was a very lucky amulet.

Arms and Armour.—The first copper weapons discovered in Egypt appeared about the middle of the pre-dynastic period in the shape of triangular daggers. Axe-heads of copper, of simple rounded shape, were common under the earlier dynasties. Under the 12th Dynasty the usual Egyptian hatchet-shape was introduced, sometimes for weapons of parade with decoration of groups of animals in open-work, sometimes with scenes in inlaid metal work, as in the case of the famous dagger of Queen A'aḥḥotep in the Cairo museum. Decoration of this kind, showing pictures of fighting and hunting in variously coloured metals, was probably of Aegean origin, introduced into Egypt. The finest known examples are the inlaid daggers from the shaft-graves at Mycenae (*c.* 1600 B.C.). Spearheads, tanged, first appear in the early Middle Kingdom. The pear-shaped stone macehead, common as a weapon under the early dynasties, went out of use about the same time. The dagger, often with spiral inlay (also Aegean) on the blade, was hilted with a peculiarly-shaped handle of ivory. Bronze now came into use for the finer weapons. Under the Hyksos the Syrian scimitar or *Khepesh* was introduced from Asia, and became a characteristic Egyptian weapon. The axehead under the 18th Dynasty continued as before, and was still stuck through the haft and secured by leather bands; the invention of the socket, well-known in Babylonia nearly 2,000 years before, not yet having been adopted in Egypt for the axe: socketed spearheads appeared however. Long swords were of foreign make and only used by foreign mercenary troops from South-East Anatolia (Shardina and Kahak); an example is in the British Museum. A heavy bill, with a peculiar blade weighted by a round ball, which took the place of the old mace, was also probably of foreign origin. The peculiar ivory round-tipped dagger-hilt of the Middle Kingdom and early 18th Dynasty was given up in favour of a hilt of foreign type, probably Aegean, made of fine stone such as crystal or chalcedony. The gold and iron daggers from Tutankhamun's tomb have hilts of this type, decorated with gold granulated chevron patterns. Bows and arrows were known from the beginning, but the Egyptian bow was not a very powerful weapon, although it was said that no man could bend the bow of king Amenhotep II. Iron, known for weapon making as early as the Hyksos period (a spear of that time was found in a Nubian grave), came first into general use in the 14th and 13th centuries B.C., and by the time of the Saites was universally used in Egypt as elsewhere, bronze surviving only for weapons of parade and for arrowheads, just as stone had survived for arrowheads well into the bronze age, the commoner and cheaper material being used at all times for weapons that could not be retrieved. The Egyptian flint arrowhead was usually of a peculiar flat-edged, not pointed type, like a front tooth. For hunting plain hard wood points were generally employed. Arrows were carried in quivers, suspended at the side of the chariot. Body-armour was never in great favour in Egypt, no doubt owing to the heat. It does not appear at all till the late New Empire, when helmets, often plumed, of a laminated construction (probably, again, of Aegean origin) began to be worn occasionally, though they were never common, and armour of slats or scales of metal or bone sewn on to a leather or linen hauberk; laminated armour, apparently introduced by the Anatolian mercenaries of the time, like the big broadswords already mentioned. This "linen" armour, sometimes made with crocodile skin, was still used under the Saites, when Greek metal armour was introduced, but was used probably only by princes.

Boats and Shipping.—Oared boats were known in the pre-dynastic period, and carried insignia (so-called "totem-poles"), the sacred animals or symbols of tribes (later the names) on poles. A masted and sailed boat occurs on a vase of the middle pre-dynastic period in the British museum; the sail is square. Square-sailed boats were common under the Old Kingdom and thenceforward. Great boats were used in the Mediterranean to fetch wood from Phoenicia (the Lebanon) at least as early as the 3rd Dynasty. Ships had navigated the Red sea as early as the pre-dynastic age, and are represented on the handle of the al-'Araq knife, and we find them regularly mentioned as sailing to Punt (Somaliland) at least as early as the 11th Dynasty. A tale of the Middle Kingdom tells us of the strange adventures of a ship-wrecked sailor in the Red sea, and voyages to Gebal (Byblos) in Phoenicia were common. Under Hatshepsut (18th) we have representations of great sailed and oared galleys going to Punt. Whether Egyptian ships ever got so far as Babylonia or India we do not yet know, but Babylonian vessels seem to have come up the Red sea to the Sinaitic peninsula in search of stone at a very early period. In the Mediterranean, the ubiquity of the Cretan and Phoenician sailors no doubt prevented any great development of Egyptian shipping: under the 18th Dynasty we see a Phoenician ship depicted unloading at a quayside at Thebes. The anarchy in the Mediterranean after the fall of the Minoan civilization probably put an end to Egyptian maritime enterprise in the North. When an ambassador of the 20th Dynasty goes to Phoenicia he sets sail in a Phoenician ship. Under the Saites, however, we see a revival of Egyptian enterprise on the water; very large vessels were built for war service on the Nile, and Egyptian sailors fought well in the service of Persia at Artemision and at Salamis. Egyptian ships were always known by individual names, such as "Appearing in Memphis" (early 18th Dynasty), "The sun-disk lightens," (late 18th Dynasty) "The Ship of Amon," and "The Great Ship of Sais" (26th Dynasty). Sailors and shipmen, especially those of the royal barges, are often mentioned on the monuments. *Canopic Jars, Coffins, etc.* (see *Religion.*)

Ceramics.—Egypt affords us the most striking instance of the development of the potter's art. As in other countries pottery was made even in Neolithic times, for the Nile mud forms a fine plastic clay and sand is of course abundant. With these materials, various kinds of pottery, often extremely well made and of good form, have been continuously produced for common domestic

requirements, but such pottery was never glazed.

The wonderful glazes of the Egyptians were applied to a special preparation which can hardly be called pottery at all, it contained so little clay. Yet as early as the 1st Dynasty the Egyptians had learnt to shape little objects in this tender material and cover them with their wonderful blue glazes. We have therefore to study the development of two independent things: (1) the ordinary pottery of common clay left without glaze; (2) the brilliant glazed faience which appears to be special to Egypt, though it may have been the groundwork for the technique of the slip-faced painted and glazed pottery of the nearer East. We probably possess specimens of the most primitive Neolithic pottery in that of "Badarian" type recently found by Sir Flinders Petrie at al-Badari in Upper Egypt. The black and red ware of Ballas and Nagada is later. This ware is very hard and compact and the face is highly burnished. The red colour was produced by a wash of fine red clay; the black is an oxide of iron obtained by limiting the access of air in the process of baking, which was done, Prof. Sir Flinders Petrie suggests, by placing the pot's mouth down in the kiln, and leaving the ashes over the part which was to be burnt black. Both red and black colour go right through in every case. All-red and all-black vases are occasionally found, the red with geometrical decorations in white slip colour, and the black with incised decoration. The forms are usually very simple, but at the same time graceful, and the grace of form is more remarkable when it is remembered that none of this early pottery was made on the wheel.

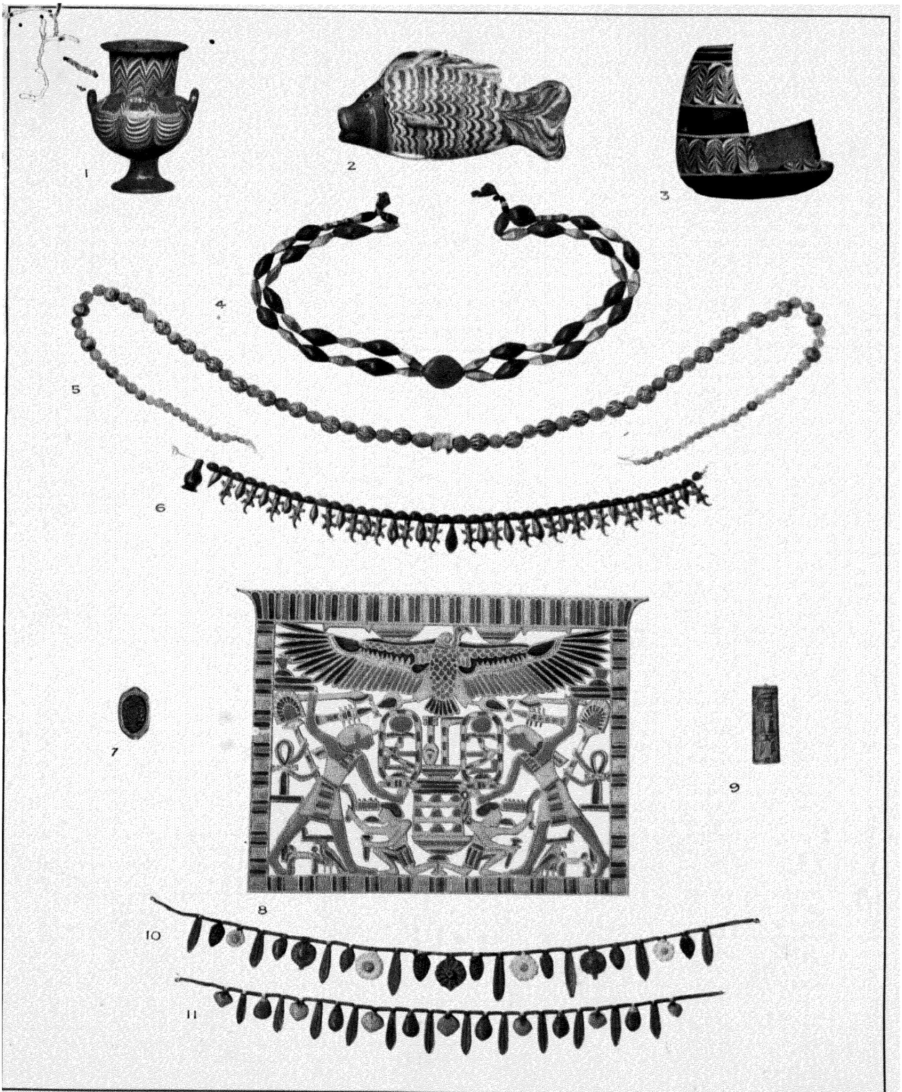
A very similar red and black ware, usually of thinner and harder make, and often with a brighter surface, was introduced into Egypt at a later date (12th Dynasty), probably by Nubian immigrants who were descended from relatives of the Neolithic Egyptians. From their characteristic graves these people are called the Pan-Grave people, and their pottery is known by the same name.

Later in date than the early red and black wares, the second characteristic type of primeval Egyptian pottery is a ware of buff colour with surface decorations in red. These decorations are varied in character, including ships, birds and human figures; wavy lines and geometrical designs commonly occur (see *Art*). They are the most ancient handiwork of the Egyptian painter, and mark the first stage in the development of pictorial art on the banks of the Nile. Some other types of pottery, in colour chiefly buff or brown, were also in use at this period; the most noticeable form is a cylindrical vase with a wavy or rope band round it just below the lip, which developed out of a necked vase with a wavy handle on either side. This cylindrical type, which is probably of Syrian origin, outlived the red and black and the red and buff decorated styles (which are purely pre-dynastic) and continued in use in the early dynastic period, well into the copper age. The other unglazed pottery of the first three dynasties is not very remarkable for beauty of form or colour, and is indeed of the roughest description, but under the 4th Dynasty we find beautiful wheel-made bowls, vases and vase-stands of a fine red polished ware. Under the 12th Dynasty, and during the Middle Kingdom generally, a coarser unpolished red ware was in use. The forms of this period are very characteristic; the vases are usually footless and have a peculiar globular or drop-like shape—some small ones seem almost spherical.

The art of making a pottery consisting of a siliceous sandy body coated with vitreous copper glaze seems to have been known unexpectedly early, possibly even as early as the period immediately preceding the 1st Dynasty (4000 B.C.). The oldest Egyptian glazed ware is found usually in the shape of beads, plaques, etc.—rarely in the form of pottery vessels. We find tiles made of it at Sakkara under the 3rd Dynasty, and under the 6th and 12th Dynasties pottery made of this characteristic Egyptian faience came into general use and continued in use down to the days of the Romans, and is the ancestor of the glazed ware of the Arabs and their modern successors. The colour is usually a light blue, which may turn either white or green; but beads of the grey-black manganese colour are found, and on the light blue vases of King Aha (who is probably one of the historical originals of the legendary "Mena" or Menes) in the Brit. mus. (No. 38,010), we have the king's name traced in the manganese glaze on (or rather in) the blue-white glaze of the vase itself, for the second glaze is inlaid. This style of decoration in manganese black or purple on copper-blue continued till the end of the "New Empire" shortly before the 26th (Saite) Dynasty. It was not usual actually to inlay the decoration before the time of the 18th Dynasty. The light blue glaze was used under the 12th Dynasty (Brit. mus., No. 36,346), but was then displaced by a new tint, a brilliant turquoise blue on which the black decoration shows up in sharper contrast than before. This blue, and a somewhat duller greyer or greener tint was used at the time for small figures, beads and vases, as well as for the glaze of scarabs, which, however, were usually of steaschist or steatite—not faience. The characteristically Egyptian technique of glazed stone begins about this period, and not only steatite or schist was employed (on account of its softness) but a remarkably brilliant effect was obtained by glazing hard shining white quartzite with the wonderfully delicate 12th Dynasty blue. A fragment of a statuette plinth of this beautiful material was obtained during the excavation of the 11th Dynasty temple at Deir el-Bahri in 1904 (Brit. mus., No. 40,948). Vessels of diorite and other hard stones are also found coated with the blue glaze. A good specimen of the finest 12th Dynasty blue-glazed faience is the small vase of King Senwosri I. (2400 B.C.) in the Cairo museum (No. 3,666). The blue-glazed hippopotami of this period, with the reeds and water-plants in purplish black upon their bodies to indicate their habitat, are well known (Pl. VII., figs. 1 and 2). Fine specimens of these were in the collection of the Rev. Wm. MacGregor at Tamworth.

The blue glaze of the 12th Dynasty deepened in colour under the 13th to which the fine blue bowls with designs (in the manganese black) of fish and lotus plants belong (Pl. VII., fig. 9) (Brit. mus., Nos. 4,790, etc.). The finest specimens of 18th Dynasty blue ware have come from Deir el-Bahri, in the neighbourhood of which place there may have been a factory for the manufacture of votive bowls, cups, beads, etc., of this fine faience for dedication by pilgrims in the temple of Hathor (good collection in Brit. mus.). Towards the end of this dynasty polychrome glazes came into fashion; white, light and dark blue, violet, purple, red, bright yellow, apple-green and other tints were used, not only for smaller objects of faience, such as rings, scarabs, kohl-pots, etc., but also for vases, *e.g.*, No. 3,965 of the Cairo museum (Amenophis III., wine-bottle), the ground colour of which is white with a decoration of flower wreaths in blue, yellow and red, with an inscription in delicate blue. An unglazed but finely polished red ware was in use at this time that may be of Syrian origin. Vases of the same ware in the shape of men and animals are not uncommon. Another ware of this period has a highly polished yellow face, sometimes becoming ruddy and passing off into a pinkish red; in this ware "pilgrim bottles" are common. An unpolished, brittle and thin yellow ware was also used largely for wine-vases. The rougher, commoner red and brown ware at this period became decorated with designs chiefly of lily wreaths, etc., in paint of various colours, usually with a chalky blue ground. Marbling, in imitation of stone, was also employed. This new development hid the ugly colour of the common pottery and was a cheaply obtained imitation of the expensive polychrome glazed ware of the period (Pl. VI., figs. 1 and 3). This painted pottery continued in use until about the time of the 22nd Dynasty. From this time onwards, till the Ptolemaic period, the commonest pottery was a red ware, usually covered with a white slip. Under the 26th Dynasty a finer homogeneous white ware occurs, usually for vases, with a rude representation of the face of the god Bes on their bodies.

The 26th Dynasty marks a new period of development in the history of Egyptian faience. The old deep blue colour had gradually deteriorated into an ugly green (Brit. mus., No. 8,962), which was replaced by the Saite potters with a new light blue of very delicate tint, imitated in accordance with the archaistic spirit of the time, from the old light blue of the earliest Dynasties. The glaze itself is very thin. The old decoration of the blue with designs and inscriptions in manganese-black is aban-



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GLASS, JEWELLERY AND FAIENCE FROM THE XII. TO THE XVIII. DYNASTY (2000–1350 B.C.)

1–3. Vases of polychrome glaze. 18th dynasty, c. 1400 B.C. 4–6. Necklaces of carnelian, gold, amethyst and jasper (4 and 5, c. 2000 B.C.; 6, c. 1450 B.C.). 7. Faience scarab in gold mounting. 12th dynasty c. 2000 B.C. 8. Inlaid pectoral of gold, carnelian, lapis lazuli, and felspar, representing King Amenemhet III. slaying his enemies, beneath the protecting wings of the vulture goddess Nekhebet-Dahshur. 12th dynasty, c. 2000 B.C. 9. Glazed steatite cylinder-seal of Queen Sebeknofru. 12th dynasty, c. 2000 B.C. 10–11. Necklaces of polychrome faience, with pendants in form of flowers. 18th dynasty, c. 1400 B.C.

uoned; on the *ushabtis* the inscriptions are now incised. Side by side with this light blue glaze was used an unglazed faience, a sort of composition paste with the colour going right through which had already appeared on pale blue under the 18th Dynasty. (Some of these figures appear to have been made with a mixture of sand, clay and coloured glass which produced a real glassy porcelain—the earliest porcelain of which we have any record.) It has more variety of colour than the glazed faience, light green and a dark indigo blue being found as well as the Saite light blue. Sometimes it is of a very soft, almost chalky consistency. It was used for vases, but more generally for small figures and scarabs. The commonest vase-form of this period is the pilgrim bottle, now made with the neck in the form of a lily flower, and with inscriptions on the sides wishing good luck in the New Year to the possessor. These flasks appear to have been common New Year gifts.

Under the Sebennytite kings of the 30th Dynasty a further new development of glaze began, of a more radical character than ever before (see *Art*). The colour deepened and the glaze itself became much more glassy, and was thickly laid on. The new glaze was partly translucent, and differed very greatly from the old opaque glaze. It first appeared on *ushabtis* at the end of the Saite period. A curious effect was obtained by glazing the head-dress, the inscription, etc., of the *ushabtis* in dark blue, and then covering the whole with translucent light-blue glaze. This method was regularly used during the succeeding Ptolemaic and Roman periods, when the new style of glaze came into general use. A yellowish green effect was obtained by glazing parts of the body of the vases in yellow and covering this with the translucent blue glaze. This method was used to touch up the salient portions of the designs in relief, imitated from foreign originals, a style which now became usual on vases. The usual decoration is mixed Egyptian and classical, the latter generally predominating. A large range of colours was employed; purple, dark blue, blue-green, grass-green and yellow glazes all being found. The glaze is very thickly laid on, and also is often "crazed." A remarkable instance of this Romano-Egyptian faience is the head of the god Bes in the British museum (No. 35,028). A hard, light blue, opaque glaze like that of the 26th Dynasty is occasionally, but rarely, met with in the case of vases (Brit. mus., Nos. 37,407, 37,408).

We know something of the common wares in use during this period from the study of the *ostraka,* fragments of pottery on which dated tax-receipts, notes and so forth were written. From the *ostraka* we see that during the Ptolemaic period the commonest pottery was made of red ware covered with white slip which has already been mentioned. At the beginning of the Roman period we find at Elephantine a peculiar light pink ware with a brownish pink face, and elsewhere a smooth dark brown ware. About the 3rd century A.D. horizontally ribbed or fluted pots, usually of a coarse brown ware, came into general use. These were often large-sized *amphorae,* which had very attenuated necks and long handles. During the Byzantine (Coptic) period most of the pottery in use was ribbed and usually pitched inside to hold water, as the ware was loose in texture and porous.

During the Coptic period, a lighter ware was also in use, decorated with designs of various kinds in white, brown or red paint on the dull red or buff body. In Nubia a peculiar development of this ware is characteristic of the later period (Brit. mus., No. 30,712).

A polished red ware of Roman origin (imitation Arretine or "Samian") was commonly used as well.

The heavily glazed blue faience continued in use until replaced in the early Arab period by the well-known yellow and brown lead-glazed pottery, of which fragments are found in the mounds of Fostat (old Cairo).

Chariots, used both for war and peace, were introduced into Egypt from the East in the time of the Hyksos, about 1800 B.C. They came with the horse. They were of very light construction, and of very broad gauge, suitable for use in rocky land and for swift movement. The wheels usually had four spokes and thick leather tyres. But the wheels are of the same type, especially as regards the pole and method of securing the reins to it, as the oldest chariots known in Babylonia, where the chariot was invented by the Sumerians before 3000 B.C. The Sumerian wheels were originally made of three pieces of wood, an elliptical piece between two demilunes, secured by two cross-buttons, one above, the other below the hub. Spokes were invented later. The Sumerians invented the chariot before the horse was known to them; originally they harnessed asses to it. From Babylonia the invention of the wheel and the car spread to Anatolia and to Greece probably before it reached Egypt. Although usable in Egypt only in the desert, the horse and chariot must have contributed materially to the success of the Hyksos invasion. The Egyptians took up the invention literally "with a vengeance," and the Egyptian chariotry became the most famous in the world. Cavalry were never used by the Egyptians.

Costume: see *Dress.*

Excavations: see *Archaeology* and *Art.*

Furniture.—Wood was early used for the making of furniture, which under the earliest dynasties was already becoming elaborate. Our finest examples are of the 18th Dynasty. A characteristic form was a stool with folding legs, of exactly the modern form; the legs were habitually made in the form of goose-heads. Lion-claws were used for larger chairs, which often had backs, and are of very modern appearance. The Egyptians sat on chairs, and never reclined at meals, as the Greeks and Romans did. Cushions were usual. Long beds, boxes of various kinds, etc., were made, often of rare inlaid woods and combined with thick gold overlay.

Government.—The king was a god in human form, and was so regarded, at any rate conventionally and by courtesy, even in the later days after the 18th Dynasty, when Egypt came into contact with other kings who claimed no such dignity. But the government was no theocracy. The "good god" was usually a very human person, and except when dressed up for religious festivals, had very little of the priest about him. Queens regnant in their own right were not really "constitutional," and were not recognized "in law;" we have records of only two, Skemiophris of the 12th Dynasty, and Hatshepsut of the 18th. Hatshepsut masqueraded as a man. Probably Skemiophris, of whom we know next to nothing, did not. The Herodotean queen Nitókris of the 6th Dynasty never existed; the Nitagri of that time was a king. The king exercised his power through ministers at all periods and through feudal chiefs: in times of royal weakness the latter were practically independent. The later kings of the 12th Dynasty suppressed the local dynasts, and by the time of the 18th Dynasty a bureaucracy presided over by royal sheriffs had taken their place. The chief minister, or vizier, was the *Zate,* "the Man," as opposed to "the God," *i.e.,* the king. This was no doubt a very ancient title. It is often mistranslated "mayor," but the *Zate* was a much more important person than a mere mayor of Thebes, although he bore the title of "Zate of the city," *i.e.,* Thebes, as capital of the South. A Northern vizier was also appointed under Thutmosis III., with his seat at Memphis. Nubia was governed by "the King's Son of Kush," not necessarily, or usually, a royal prince, however. The Asiatic conquests were looked after by travelling commissioners, so far as can be ascertained, when the government was not military. There seems, however, to have been a viceroy in Phoenicia. The vizierate might descend from father to son, but a strong king would never allow a dynasty of viziers to grow up who might soon become "mayors of the palace" and kings themselves. At the installation of the vizier the king delivered to him a charge, detailing his duties, copies of which exist in three tombs of viziers under the 18th Dynasty. In practice the power of the vizier was checked by the complete independence of the financial power under the king's treasurer and by the existence of officials called the king's eyes and ears, who watched both vizier and treasurer. The vizier was also chief justice, and presided over the Great Qenbet (see *Law*). The king was his own war-lord, foreign minister and colonial administrator, and he represented his people before the gods, offering sacrifices, and presiding over festivals. But his relations with the priesthood were by no means always friendly, especially in the case of

Ikhnaton and probably of his father, Amenhotep III. Under the weak kings of the 20th Dynasty the wealthy chapter of Amon at Thebes grew so powerful that the high-priest eventually himself became king. (See *History*.)

He had his own immediate court officials, who accompanied him to war. The country was divided up into *nomes*, divisions of great antiquity, which persisted with various local modifications and readjustments, till the end. Normally there were 42 nomes, 22 in Upper and 20 in Lower Egypt. The ancient distinction of Lower Egypt (the Delta) from Upper Egypt was always recognized, and in times of weak government the country was always liable to fall apart into its two chief components, Memphis belonging always to Lower Egypt. In Ptolemaic times a Heptanomis of seven nomes was formed in Middle Egypt. In Upper Egypt the Thebaid (*Ptashenno,* "the city-march") had from the time of the 18th Dynasty taken a rather peculiar position as the metropolitan province, which it continued to occupy even after the practical destruction of Thebes by the Assyrians in B.C. 663. Between the Thebaid and Syene (Aswan) the valley south of Ombos was sometimes regarded as belonging to Upper Egypt, sometimes to Nubia. South of Syene again the Nubian valley as far as Hierasykaminos (Mahárraka) was regarded in Roman times, under the name of *Bodekaschoinos,* as Egyptian territory, all south of it being left to the Meroitic kings. Local government of the nomes was exercised in various ways, through royal officials known as heralds (uōhemu), or through local magnates, who were all responsible to the vizier as the king's lieutenant. The whole country was known generally as Kēmet, "the black land," from the colour of its soil; poetically also by other names, such as *Tomera.* The Hebrew name, *Mitsraim,* and the Greek Ἄιγυπτος, are both of unknown origin: the former is still used as the modern appellation of the country in Arabic, *Misr.* The Hebrew name for Upper Egypt specially, Pathros, is the Egyptian *Ptores,* "the South-Land."

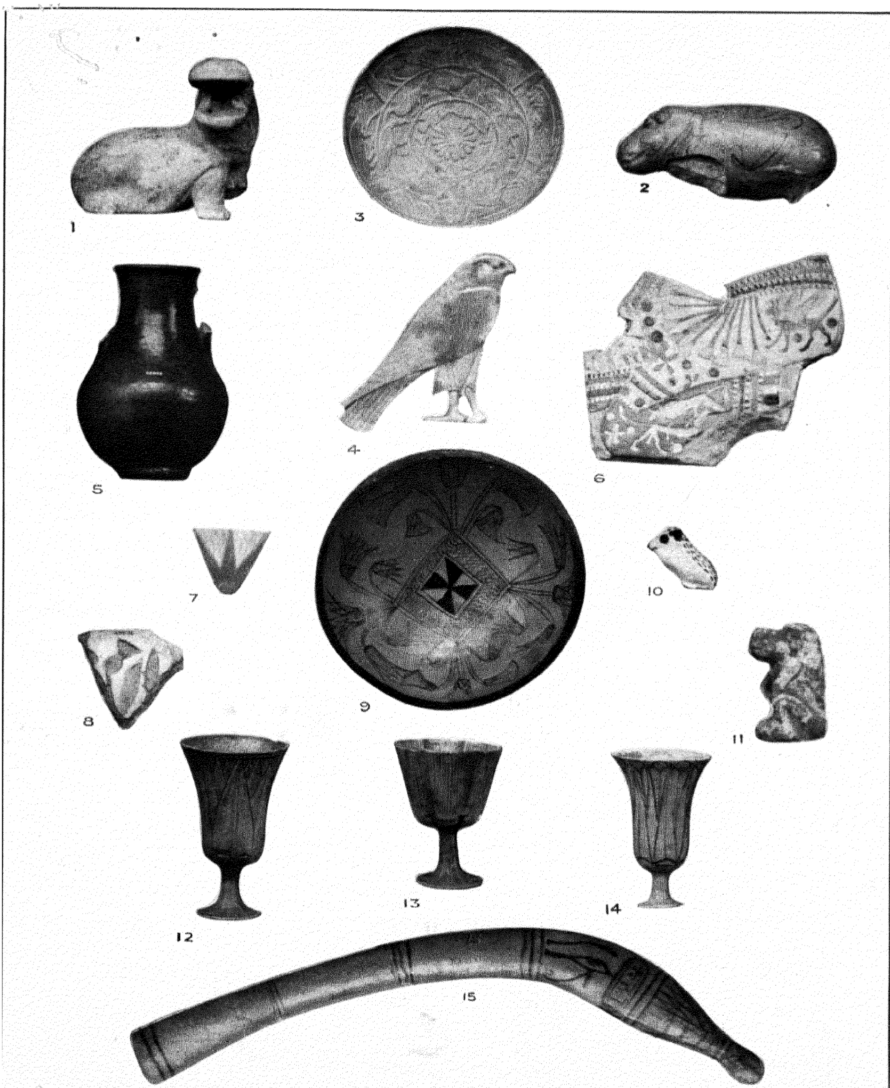
Hunting, Fishing, etc.—The Egyptians were great hunters of wild animals of all kinds on the desert-margin of the valley and in the Asiatic countries subject to their sway, especially of wild oxen, antelopes and the larger cats. The hunters used not only the bow and arrow, but also a throwstick, the latter specially for wild fowl in the marshes, which were hunted from boats, as also the hippopotamus. In the desert the chariot was commonly used for hunting. Fish were chiefly netted.

Law.—No code is known; we have nothing like the laws of Hammurabi in Babylonia. There was however by Ptolemaic times a great body of law that had grown up through the centuries, based no doubt on royal enactment, like the decree of Horemheb at Karnak, the only ancient one we know, which prescribes penalties against oppression of peasants by landlords. This body of law was known to Ptolemaic and Roman Egypt as "native law," and was quoted side by side with Greek (Athenian and Ptolemaic) and Roman law. There were courts in early times, composed of royal and feudal officials; the "vizier's court" and the "great qenbet" or board of judges (assize) are mentioned. We have records of a civil trial of the reign of Horemheb in the papyrus of Mes. Special commissions were set up by the king to try special causes, *e.g.,* the cases of tomb-robbing under the 20th Dynasty at Thebes (Abbott papyrus). A single commissioner enquired into a delicate matter in the royal harem under the 6th Dynasty (Inscr. of Uni). Penalties of death, nose-cutting, banishment to the mines, the bastinado, etc., were inflicted, death usually being inflicted by beheading. Written legal instruments and documents existed at all times, but actual extant examples date chiefly from the later period. They are quite modern in character and phraseology. Inheritance passed largely through the mother. Matriarchal ideas were very prevalent in Egypt, where marriage was, we should consider, rather promiscuous. Brother-and-sister marriage was not uncommon, and seems to have been usual in the royal family. A concubine was as usual as the proper wife (*hēmet*), and was often known by the name of "sister" (*snē-t*).

Metals and Minerals.—Copper, gold and iron were known in middle pre-dynastic times, the latter no doubt only in its aerolithic form, and very rarely. Copper came from Sinai and further afield in Asia (also no doubt from Cyprus), its knowledge probably from Babylonia or Syria. It was not only used for weapons, etc., but also for making the copper frit of which the blue glaze was composed. Gold was early obtainable from Nubia, and later from Asia and Anatolia, whence also came silver, always rarer in Egypt than gold. The electrum mixture was used at least as early as the 12th Dynasty; in Babylonia it had been known before 3000 B.C. Whence tin came for bronze-making (not long before 2000 B.C.) we do not know. Antimony was found nearer home. Lead was known, of course, at the same time as silver. Galena was used for making *kohl* or eye-paint even more commonly than antimony, as early as 2000 B.C. Corundum (emery) must have been brought from the Aegean already in the pre-dynastic period for making stone vases. Iron did not come into use, and then but rarely, for weapon-making till about 1800 B.C., and was a precious metal reserved for royal use, like gold, as late as the 14th century (Tutankhamun's dagger), but soon thereafter comes into common use. Haematite was always well known. Manganese was used for making dark purple glaze. Cobalt was not used till a late period, for colour and glaze.

Metal-work, Plate and Jewellery.—Egyptian gold chiefly came from the Nubian mines in the western desert in the Wadi 'Alāki and the neighbouring valleys. A map of these mines, dating from the time of Rameses II. (1300 B.C.), has been preserved. Silver was not mined in Egypt itself, and came mostly from Asia Minor, even at the earliest period. Then gold was comparatively common, silver a great rarity. Later, gold appears to have been relatively more abundant than silver, and the difference in value between them was very much less than it is now.

In the language of the hieroglyphs silver is called "white gold," a fact which points strongly to the priority of the use of gold, which archaeological discoveries have rendered very probable. Among the treasures of the "royal tombs" at Abydos, dating to the 1st and 2nd Dynasties, much gold was found, but no silver. On the walls of one of the tombs at Beni Hassan there is an interesting representation of a gold- and silver-smith's workshop, showing the various processes employed—weighing, melting or soldering with the blow-pipe, refining the metal and polishing the almost finished bowl or vase. Owing to the Egyptian practice of burying with their dead personal ornaments, the amount of gold jewellery that has been discovered is very large, and shows the highest degree of skill in working the precious metals. Jewellery reached its acme of taste under the 12th Dynasty, to which the beautiful PARURES belong that were found in the tombs of princesses at Dabshar and Lisht (Cairo mus., Met. mus. N.Y.). The inlays of semi-precious stones, such as blue felspar and carnelian, in gold settings that are characteristic of this jewellery, is remarkable for its beauty. Under the 18th Dynasty we have the jewellery of Tut'ankhamun, with a more lavish use of gold, but the same technique of inlay with stone. Enamel inlay begins about this time, and is well represented from Egypt, whose fine goldsmith's work was renowned in the ancient world and is well represented in our museums. Gold signet-rings were a specially Egyptian characteristic, especially under the 26th Dynasty, when they were particularly heavy and of solid workmanship. Under the 18th Dynasty gold scarabs were commonly mounted as swivel-bezels of gold rings (see *Scarabs*). We can form some notion of what the larger works, such as plates and vases in gold and silver, were like from the frequent representations of them in mural sculpture and paintings. In many cases they were extremely elaborate and fanciful in shape, formed with the bodies or heads of griffins, horses and other animals, real or imaginary. Others are simple and graceful in outline, enriched with delicate surface ornament of leaves, wave and guilloche patterns, hieroglyphs or sacred animals. A gold vase of the time of Tethmosis (Thothmes) III. (18th Dynasty, about 1500 B.C.), taken from a wall-painting in one of the tombs at Thebes shows this. The figure on its side is the hieroglyph for "gold." Others appear to have been very large and massive, with human figures in silver or gold supporting a great bowl or crater of the same metal. Vases of this type were, of course, manufactured in Egypt itself, but many of those represented in the Theban tombs were tribute, mostly of Phoenician



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

EGYPTIAN FAIENCE AND GLAZED POTTERY FROM THE I. DYNASTY TO THE ROMAN PERIOD (3200 B.C.–A.D. 150)

1 and 2. Faience hippopotami. 12th dynasty, *c.* 2000 B.C. 3. Faience bowl with embossed animal friezes. 30th dynasty, *c.* 350 B.C. 4. Falcon for inlay. 30th dynasty. 5. Vase *Glazed pottery*, Roman period, A.D. 150. 6. Part of a kneeling figure in inlaid glaze. 20th dynasty, *c.* 1180 B.C. 7 and 8. Faience lily and thistle for inlay. 18th dynasty, *c.* 1370 B.C. 9. Faience bowl. Early 18th dynasty, *c.* 1500 B.C. 10. Mouse, polychrome. 12th dynasty, *c.* 2000 B.C. 11. Ape, blue, discoloured. 1st dynasty, *c.* 3200 B.C. 12–14. Lotus cups, blue glaze. 18th–22nd dynasty, *c.* 1400–800 B.C. 15. Throw-stick from tomb of King Ikhnaton. 18th dynasty, *c.* 1365 B.C.

workmanship. But plate of really foreign type as well as origin was also brought to Egypt at this time by the "Kefti ships" from Kefti, the island of Crete, where the "Minoan" culture of Knossos and Phaestos was now at its apogee. Ambassadors from Kefti also brought gold and silver vases as presents for the Egyptian king, and on the walls of the tomb of Sennemut, Queen Hatshepsut's architect, at Thebes, we see a Keftian carrying a vase of gold and silver which is almost the duplicate of an actual vase discovered at Knossos by Sir Arthur Evans. The art of the "Minoan" and "Mycenaean" goldsmiths exercised considerable influence upon that of the Egyptians; under the 20th Dynasty, about 1150 B.C., we find depicted on the tomb of Rameses III. golden stirrup-vases (*Bügelkannen*) of the well-known Mycenaean type, and in that of Imadua, an officer of Rameses IX., golden vases imitating the ancient Cretan shape of the cups of Vaphio.

The chief existing specimens of Egyptian plate are five silver *phialae* (bowls), found at the ancient Thmuis in the Delta, and now in the Cairo museum (Nos. 482–486 in the catalogue). These are modelled in the form of a lotus blossom, most graceful in design, but are apparently not earlier than the 4th century B.C. Of the splendid toreutic art of a thousand years before, of which we gain an idea from the wall-paintings mentioned above, but few actual specimens have survived. The Louvre possesses a fine gold patera, 6½ in. across, with figures of fishes within a lotus border in *repoussé* work; an inscription on the rim shows it to have belonged to Thutii, an officer of Tethmosis III. (*Mém. soc. ant. de France*, xxiv. 1858).

A splendid bronze bowl, which shows us what some of the finer gold and silver plate was like, was found in the tomb of Hetaai, a dignitary of the 18th Dynasty, at Thebes, a few years ago, and is now in the Cairo museum (No. 3,553 in von Bissing's catalogue). The engraved decoration, representing birds and animals in the papyrus-marshes, is a fine piece of native Egyptian work.

Military Organization.—The armed force of Egypt was early organized from levies of the young men, and we find this levy at least as early as the 6th Dynasty. Under the 18th one of the titles of the great minister Amenhotep, son of Hapu (temp. Amenhotep III.) was what we should call "director of recruiting"; he oversaw the conscription of the young warriors throughout the land. We possess interesting models of an earlier date, 11th Dynasty (at Cairo), of two companies, one of Egyptians, the other of black soldiers, armed with spears. At Dair al-bahri (18th Dynasty) we see a parade of soldiers, led by officers armed with battleaxes, advancing at a swift springy step. Under the 19th we find the army used by Rameses II. against the Hittites organized in legions known by the names of the gods, such as the "Legion of Amon," the "Legion of Ptah," and so on. These were native Egyptian troops. Large numbers of foreign mercenaries, Syrians, Anatolians from Pisidia and Lydia chiefly, and Libyans (Shardina, Kahak, etc.), began to be employed at the end of the 18th Dynasty, and were regularly used by Rameses. They wore their own native armour and weapons, and the Shardina formed the royal guard. Libyan warriors settled in large numbers in Egypt, and after a time formed a standing body of foreign soldiery, gradually mixed more and more with natives through intermarriage. Leaders of this military organization of Libyan-descended families ("the great chiefs of Ma") eventually became so powerful as to impose a dynasty (the 22nd) on Egypt, the first king of which was Sheshenk or Shishak, the conqueror of Jerusalem (*c.* 947 B.C.). Under the Saites Herodotus speaks of a regular class of professional hereditary warriors called "Kalasiries" and "Hermotybies." The first name is the Egyptian *Kal-shere*, "young Syrian," and dates from the time of the Syrian mercenaries; the second is the Egyptian *Rom-debá* ("men of the spear"). At the same time foreign mercenaries, chiefly Jewish, were stationed on the frontiers (*e.g.*, at Aswân), and Greek soldiers of fortune began to be employed. Under the last native kings (4th century B.C.), the army was almost wholly composed of these Greek mercenaries under their own generals, hired for the occasion, like Agesilaos, the aged king of Sparta, and Mentor, the admiral to whose treachery the final destruction of the native kingdom was due. Under the Ptolemies the same system was followed.

Music.—Many ancient Egyptian musical instruments have been recovered from the tombs and are represented on the monuments. The most typically Egyptian of all was the *sistrum*, with its small discs shaken on wires, which has survived as a church instrument in Abyssinia. The true harp, with sounding-board, was greatly developed, and often of great size like the modern harp, which it resembled. Flutes or rather pipes of various kinds were also employed, besides trumpets, cymbals, and no doubt drums. Lyres and citharae were introduced in Ptolemaic times from Greece.

Painting (see *Art*).—Egyptian wall-painting was in distemper, not fresco. Simple colours, a soot-black, an ochre red and yellow, a copper blue and green, were employed. (Inks were red and black; the Egyptians were certainly the inventors of ink made with a solution of gum). The great period of wall-painting was from the 12th to the 19th Dynasty; after this it disappeared, except for a revival of coloured relief under the Saites.

Priesthood (see *Religion*).

Scarabs.—The Egyptian scarab is an image of the sacred dung-beetle, *Scarabaeus* or *Ateuchus sacer*, which was venerated as a type of the sun-god. Probably the ball of dung, which is rolled along by the beetle in order to place its eggs in it, was regarded as an image of the sun in its course across the heavens, which may have been conceived as a mighty ball rolled by a gigantic beetle. The beetle was called *khepr*, the god in beetle-form *khopri*, and the beetle sign was used to spell the word *khōpe* (*r*), "to become," which as a substantive meant "transformation" or "phenomenon." The beetle was mummified. Towards the end of the Old Kingdom amulets of blue faience or ivory in the form of the beetle began to be made, on a flat base with plain markings or meander-patterns. Spiral decorations derived from the Aegean began to be employed, and at the beginning of the 12th Dynasty inscriptions appeared, usually the name of the owner or of the reigning king, as a lucky talisman. Glazed steatite and other stone scarabs were now made, which were hard enough to be employed as seals, the incised inscription leaving its impression in relief on the clay sealing of a document. Obsidian, amethyst, crystal, felspar, etc., were used for seal-scarab making also, and very often the seal was cut on a gold, electrum, or silver plate cemented to the base (see *Art*). This use of the scarab persisted till the end. Scarabs of the 12th and 13th Dynasties have very beautiful spiral and other designs, as well as inscriptions, on their bases. A peculiar, rather barbaric, style of decoration was introduced under the Hyksos, in which designs of lions and bulls, typifying the king, overcoming crocodiles, besides other types, appear. Under the 18th Dynasty the scarab reaches its greatest beauty of cutting and glaze. Characteristic of the end of the dynasty are regular issues of gigantic scarabs with inscriptions commemorating such events as the marriage of the king Amenhotep III. and Queen Tiye, the slaying by the king of lions and wild bulls in the hunt, etc. (examples in the British museum). Under the 19th Dynasty the scarab degenerates, being generally of faience coarsely glazed and cast in a mould, though some fine ones of red stone or lapis with royal inscriptions were still made. Under the Saites fine stone scaraboids, rather than scarabs (the representation of the wing-cases and legs being dispensed with), with delicately cut inscriptions containing lucky sentiments and prayers, were popular. The scarab suddenly disappears at the end of the 26th Dynasty, but Phoenician and Greek imitations of it, generally in sard, continued to be made abroad, the latter with classical *intagli*. Large numbers of Phoenician scarabs have been found at Tharros, in Sardinia. The small seal-scarab was always perforated along its length to be strung with others or with beads; under the 18th Dynasty it is often found so strung, but it was also mounted in the swivel-bezel of a finger-ring. Base-less scarabs, uninscribed, of hard stone, occur in late times. A larger form of scarab, inscribed on the base with the *Heart-chapter* (XXXB) of the *Book of the Dead*, usually of hard green stone, often mounted in gold, as prescribed by the ritual, was placed as the heart of the mummy as early as the Middle Kingdom. This scarab is often human-headed. Chapter lxiv. identified the scarab with the heart. Large winged scarabs were often placed on the breast.

Seals.—As in Babylonia, the inscribed seal was early used in Egypt, at first in the form of an engraved cylinder, which was rolled over the surface of the clay sealing. Seal-cylinders, possibly derived from Babylonia, were used from the end of the pre-dynastic period till the 12th Dynasty, when they were finally supplanted by the scarab-seal (see *Scarab*). The sign for seal, is a picture of the cylinder rolling over the clay. Later on, under the Saites, signet-rings were by a false archaism made in this shape, which was supposed to represent a ring. Signet-rings of gold are known as early as the 12th Dynasty, but were commonest under the 18th and 26th Dynasties. Under the 18th they usually had swivel-bezels containing a scarab or plaque; under the 26th they were solid, made in the shape shown above. Seal-impressions of clay, being the imprint of the scarab on clay, are often found among town remains, being not seldom baked.

Stones.—Egypt is a land of easily available stone, so we find the limestones and sandstones of the desert-hills and the granites, syenites, diorites and dolerites of the Aswân region, Sinai and the Eastern desert, already used at a very early period. The fine white limestone of the Thebaid and the red granite of Aswân are well-known from the Egyptian monuments; a grey granite was also commonly used, a fine diorite in early times, and a hard basalt in Saite days. A fine reddish-yellow quartzite sandstone was also used under the 18th Dynasty, and a beautiful white quartzite under the 12th for medium-sized statues, sarcophagi, etc. Other quartz and silica stones of all kinds, such as rock-crystal, amethyst, blue felspar, garnet, onyx, sard, carnelian, rarely chalcedony, flint and chert were used at all times for small objects. Obsidian, probably both of Abyssinian and Aegean origin at first, later also from Armenia, was also used for small objects. Lapis-lazuli was imported from Persia as early as the 12th Dynasty. Turquoise was always known and commonly used.

Tombs (see *Religion*).

Tools were made from the earliest times of all kinds, much resembling those in use at the present day, and unnecessary to enumerate. Any museum with a good Egyptian collection contains specimens enough to show the chief types. Chisels were of copper till late times. We have no knowledge of any process being used to harden copper. Hard stone vases were hollowed out with copper and chert borers, with the aid of emery. Wooden mallets are among the commonest objects found in temple-excavations. The copper-adze with wood handle was of a characteristic shape as was also the wooden hoe, used as a plough from the earliest times. Oxen were harnessed to large-size ploughs.

Trade and Commerce.—Egyptian trade was in the form of barter. No coinage was known till the time of the last native monarchy (4th century B.C.) when a few gold staters were struck in imitation of the Greek, but with Egyptian devices. It is probable that gold and silver rings, however, took the place of coined money to a great extent as early as the time of the 18th Dynasty, being bartered for their equivalent in other commodities. Weights and measures, of course, were well-known from early times, and marked with their amounts of *kidet* or *hin*. Commerce with abroad was early developed in the direction of Phoenicia and Punt (Somaliland) by sea (*see* BOATS), with the Nubian countries both by Nile and by caravan-routes overland through the oases of Libya (6th Dynasty). Similar routes to Babylonia, across the desert, or through Syria, were used later, but were in the hands of the Syrians and Arabs. Under the 20th Dynasty a great Phoenician merchant is mentioned at Tanis named Barakat-el, who controlled many ships and, probably, caravans. Such merchant-princes who traded with the East were no doubt usually not Egyptians. Commercial documents and papyri are very common from the later periods, in demotic, Egyptian or in Aramaic script. Jews monopolized commerce in Persian days, Greeks later.

Ushabti or shauabti-figures (see *Religion*) first appear under the 12th Dynasty, in stone and wood, and are of rude make, the latter with rough ink-written inscriptions. Under the 18th Dynasty very fine stone ushabtis were made; bronze is very rarely used for them. Towards the end of the dynasty they are first made of faience, usually polychrome. After the 19th Dynasty blue faience is generally employed. The ushabtis of the 21st and of the 26th Dynasty are easily distinguishable by the difference of their characteristic faience (see *Art*). They were rarely made under the Ptolemies. The latest known is one of late Roman period in the British museum, inscribed Σωτηρ ναυτης "Soter, a sailor." At first and till the end of the 6th Dynasty, the chapter of the *Book of the Dead* which deals specially with the activity of the *ushabtiu* as servants of the deceased in the underworld, was inscribed or engraved upon them; but later very often only the name, title and perhaps parentage of the deceased appear, preceded by the words "Illuminate the Osiris (N.H. . . .)." With every complete collection of ushabtis in a tomb are, under the 18th–22nd Dynasties, a number of similar figures carrying a whip, as *reises* or taskmasters, which are usually depicted wearing the ordinary civil dress of the period, the others being in mummy-form. Under the Saites the mummy-form only was employed. Fine royal ushabtis were made, some of the biggest known being made for the Nubian king Tirhakah. Usually they are only a few inches high.

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(H. R. H.)

SCIENCES

In considering whether or to what extent the ancient Egyptians in the field of science deserved the chorus of praise bestowed upon them by the Greek writers, except Plato, who said that, in comparison with his own people, who were of a speculative and philosophical nature, the Egyptians were a nation with a purely practical turn of mind, we find that while some Egyptologists credit the Egyptians with more speculative interest in science, there is no very strong case for this view.

I. **Astronomy.**—The practical nature of the science of the Egyptians is admirably exemplified by their attitude towards astronomy. The celestial world above them stimulated their imagination, and produced a mass of myth and legend neither more nor less crude than that of any other early people. But since the study of the stars had no obvious connection with everyday life it attracted little attention and no real science of astronomy ever developed in Egypt. The positions of the stars were noted and they were arranged into constellations. It is now held, with considerable probability, that the tables of stars depicted, partly for ornamental purposes, on the roofs of the tombs of Rameses VI. and IX. at Thebes were used for measuring the lengths of the hours of night. A map is given for every fortnight of the year. Each map consists of a representation of a seated human figure, and for each hour of the night the position of some conspicuous star relative to that figure is given. The figure doubtless represents one of two observers seated on a temple roof or other flat place, one at each end of a north and south line. One of the two watched the movements of stars above and behind the other and, by reference to his star table, called the hours at the proper moments. This system, however, valuable though it might have been made with the help of an accurate water-clock (the Egyptian water-clocks were incorrect) seems to have given no more reliable results than the shadow-clocks used for measuring the hours of day, and the evidence appears to show that the problem of dividing a period of time into equal lengths remained unsolved.

In all the writings and inscriptions which have come down to us, historical, scientific and literary, there is no evidence of any kind of speculation as to the nature, size or position of any of the heavenly bodies, or as to the causes of their apparent movement: there is no hint that the Egyptians ever suspected that the sun and moon belonged to the same class of phenomena.

The observation of the heavens was not, however, entirely futile. Egyptian buildings were for the most part strictly orientated by the four points of the compass, and this was achieved by taking a bearing on the Pole star of that period, whose immobility

must therefore have been observed, as was also the fact that a group of stars in its neighbourhood never disappeared below the horizon, for they were called "those which are never quenched." The approximate length of the year, too, had been obtained at a very early date, possibly before 4241 B.C., by observation of the heliacal rising of Sirius or Sothis, but such were the limitations of the scientists of that epoch that they failed to observe, or at any rate to allow for, the fact that this rising every fourth year took place after an interval of not 365 but 366 days, and that consequently their year of 365 days was about a quarter of a day short. Hence the disasters of the Egyptian Civil Calendar (*see* article CALENDAR, *Egyptian*).

There is nothing, therefore, to show or even to suggest that the cause of any single movement in the heavens had been discovered or even surmised, or that any celestial event was ever predicted on other evidence than the fact that it had happened before on the same date or in the same circumstances. In other words regularity had been observed, but causation, even if suspected, had not been investigated.

II. **Mathematics.**—In a country where landmarks were liable to be eliminated yearly by the flood, geometry must early have been a civil necessity, and the marvellous accuracy of construction revealed by the earliest pyramids shows us that as early as the Third Dynasty, say 2700 B.C., the Egyptians were masters of measurement in two and in three dimensions. A number of papyri, notably the Rhind, the Moscow and some fragments from El-Lâhûn give us a very clear picture of the powers of the Egyptian mathematician. These papyri contain nothing of the theory of mathematics but are collections of examples worked out, with the occasional intrusion of tables. The mathematical system which they reveal may be shortly described as follows:

The notation was decimal; one stroke stood for 1, two for 2, and so on up to 9. Ten was represented by a sign shaped like an inverted capital U, 20 by two such, and so on up to 90. There were separate signs for 100, 1,000 and each power of 10 up to 1,000,000. The defect of this system, apart from the lack of any positional notation, lay in its clumsiness, for to write 999 no fewer than 27 signs were needed, and even the ink-written script with its shortened forms did not entirely remove this defect.

The Egyptians were experts in the use of fractions, even those with large denominators, but subject to one limitation, namely that the numerator must always be 1. As multiplication was virtually limited to the multiplier 2 the only difficulty that could arise in multiplying fractions was that of dealing with twice an aliquot part (*i.e.*, twice a fraction whose numerator is 1). To meet this, a series of tables was formed in which the double of each odd aliquot part ($\frac{1}{5}$, $\frac{1}{7}$, $\frac{1}{9}$ etc.) was resolved into the sum of two or more aliquot parts, *e.g.*, twice $\frac{1}{7}=\frac{1}{4}+\frac{1}{28}$, twice $\frac{1}{19}=\frac{1}{12}+\frac{1}{76}+\frac{1}{114}$.

The only exception to the rule that fractions must have unity for their numerator is $\frac{2}{3}$, which to the Egyptian mind was oddly enough more fundamental than $\frac{1}{3}$, for this was obtained by first taking two-thirds of the required number and then halving it.

Addition and subtraction are both fundamental processes of counting and the Egyptians found no difficulty with them, even when the numbers involved were very large. Multiplication, however, was a more difficult operation, for the Egyptian learned only the 2-times table and not up to 12-times as we do. In other words, he could only double. Thus to find five times a number he had to double it, double the result, thus getting four times, and then add on the original number. Division was merely the reverse of multiplication. To divide 13 by 4 we start with 4. Doubling it we get 8, and by adding 4 we get 12, showing that 3 times 4 makes 12. This is just 1 short of 13, and since 1 is $\frac{1}{4}$ of 4, the answer is $3\frac{1}{4}$.

Apart from 2 no multiplier was used except 10, multiplication by which was automatic, inasmuch as one had only to change the units-signs to tens-signs, the tens-signs to hundreds-signs, and so on.

With these simple means the Egyptians proved themselves capable of dealing with such problems of every day arithmetic as came up for solution. The papyri give us examples of the division of ten loaves among various numbers of men, of simple exercises in proportion and of the solution by trial of equations of the form $x+\frac{x}{a}=b$. The conceptions of squaring and square root were both known, and technical terms for them existed. The Rhind Papyrus has two problems in arithmetical progression and one in geometrical.

In two dimensional space the determination of the area of the square and the rectangle cannot be regarded as problems, for they involve nothing more than the conception of square measure. But the Egyptian had gone further than this, for he had correctly solved the area of the triangle. His approximation to the area of the circle was a good one, for he squared eight-ninths of its diameter.

In the geometry of three dimensions the volume of the parallelopiped follows at once from the very conception of three dimensional units, and that of the cylinder as the product of the area of the base into the height involves very little more. In determining the latter the error in the value of π was of course repeated. A much more brilliant feat was the correct determination of the volume of a truncated pyramid by the formula $V=\frac{h}{3}(a^2+ab+b^2)$, where h is the height and a and b the sides of the upper and lower squares of section respectively.

Several problems deal with the slope of pyramids. The angle is measured by its cotangent, *i.e.*, the vertical height is divided by half the side of the square base. Here too the practical interest of the mathematician is uppermost, for in the ratio thus found the first term is reduced to one cubit (or "forearm," 20·6 inches) and the other term, let us say 4 handbreadths, is given as a practical instruction to the stone-dresser, who has only to measure a cubit up and 4 handbreadths horizontally to get the correct slope of each block he has to dress.

III. **Medicine.**—Until a few years ago, when the Edwin Smith Papyrus was re-discovered in New York, Egyptian medicine was regarded rather as a department of magic than as a science. This was inevitable, for in the five or six medical papyri then known to us much less importance seemed to be attached to the remedies employed—though some of these doubtless had their efficacy—than to the magic spells and gestures by which the administration of the medicine was to be accompanied. Some of the recipes consisted wholly of spells, and in one papyrus the scribe had not even troubled to insert the quantities of each substance in the prescriptions. The arrangement of the contents of the papyri, too, seemed chaotic and unintelligent, and of the *materia medica* much was manifestly magic in origin, *e.g.*, milk of a woman who has borne a male child, while much was clearly chosen on the principle of "the filthier the more efficacious," *e.g.*, the excrement of flies or the blood of mice.

In the face of this evidence it is useless to deny that there existed a popular science of medicine in Egypt which, while conversant with the beneficial effects of certain drugs (unfortunately not many of the plant names are recognizable to us), was so thickly overlaid by magic as almost to forfeit the name of a science.

That there was something more to be said for Egyptian medicine than this, however, was already suggested by a description in the Ebers Papyrus of a system of "vessels" in the body, leading from the heart to the various organs, conveying air, water, blood and other substances. Their failure to function correctly was one of the causes of disease, and the treatment aimed at cooling, quieting, renewing or checking their activity by means of drugs. The more scientific attitude here observed is also to be found in the new Edwin Smith Papyrus, the full publication of which will undoubtedly raise our opinion of Egyptian medicine. The treatise is arranged in regular order, working from the head downwards, and deals chiefly with the surgery of the bones and outer tissues. It arranges its cases systematically under the headings of name of the complaint, examination, diagnosis and verdict. The explanatory notes which accompany some of the cases show a quite remarkable skill in studying the exact nature of a lesion, and a genuine curiosity as to precisely what has happened to

produce it. Yet observe what is on the back of the same document, written in part by the same hand. Firstly a spell for "driving out the wind of a year of plague" and secondly a book of spells "for transforming an old man into a youth of twenty." What is to be made of so quaint a juxtaposition? It would seem as if, side by side with the traditional popular medicine (old women's remedies) highly tinged by magic, there existed a science practised by men who were not without interest in the nature of disease and injury for its own sake. At the same time it may not be a mere accident that of the medical literature which has come down to us at least four-fifths is of the popular, not the scientific type.

In conclusion, it is clear that in a descriptive article of this kind it is necessary almost completely to ignore chronological perspective. The harm done in this case is the less because everything goes to indicate that Egyptian science attained its full growth in that period which was responsible for nearly every good thing which the country produced, namely the Old Kingdom, roughly 2600 to 2200 B.C. Not only do the medical papyri sometimes claim to give recipes known in the days of some king of that epoch, but the grammar of both medical and mathematical papyri is so archaic as to leave no doubt that some of their contents must have been derived from documents of that age. Egyptian tradition itself recognized the early origin of much of its scientific lore when it made Imhotep, a vizier of King Zoser of the Third Dynasty, the father not only of the art of architecture, but also of the science of medicine.

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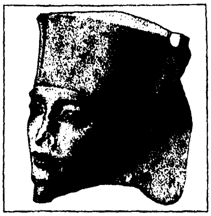
RELIGION

We have now no grounds for holding the opinion that the educated Egyptian priest, far less the man in the street, normally accepted any pious theories of a latent monotheism underlying his blatant polytheism. Abnormally one particular school of priests may have done so for a time—the school of On or Heliopolis—where Ra' the sun-god does seem to have been raised from a henotheistic position to one closely resembling monotheism, until in the reign of Amenhotep III. it probably developed the completely abnormal true monotheism of the worship of the *Aten*, or Sun's disc, the heresy officially established by his son Ikhnaton, but thrown to the winds soon after the death of the latter. So abnormal was this monotheism that the Egyptians would have none of it: Ikhnaton was branded as a "criminal," and the Egyptians, who had, of course, in reality never abandoned it for a moment, returned joyfully to the cheerful polytheism of their ancestors, in which they continued to believe till the coming of Christianity. The educated Egyptian of the best period possessed the conception of "the divine," but not of "the One God"; he could see Godhead as such, but it was manifested in many gods; there was never only "One God" except the Aten, and his glory was but for a day. The nearest approach to monotheism was when one particular god was venerated henotheistically at one time, another at another.

Polytheism was of course the natural ancient belief of the Egyptians. It arose from the complicated fears of the Divine and rituals to propitiate it, and in Egypt more especially bears all the marks, in its complicated cults and rituals, of its savage origin. And naturally the further we go back the more complicated, the more self-contradictory, the more ritualistic and the more barbarous it is, as is the case among all nations. Some simplification was effected by the growth of the national intelligence, which by the time of the 18th dynasty really had evolved religious texts and hymns of a lofty character, that reach their acme under the supremely intelligent but unhappily reckless reform of Ikhnaton. To be so intelligent as he was at that time was to court disaster, even if one was an almighty king. Certainly nobody but a Pharaoh, himself a "god," could have effected such a revolution, nominal as it was. After his failure we go back to the old spells and mumbo-jumbo again, till perhaps in the Saite age comparatively intelligent people again appeared, the reflection of whose thoughts we may perhaps see to some extent in the rationalizings of the classical writers on Egypt. Under the Romans Egyptian religion returned to its original mire, till its death, prolonged by a century of pathetic resistance by the simple blacks of Syene, in the days of Justinian. In religious matters the Egyptians at all periods, except the educated at the end of the 18th dynasty, and probably under the Saites, were in the mental condition of the blacks of the Gold Coast and Niger delta. That was about their level. Marvellous mysteries, occultly harbouring deep truths, are assigned to them by the classical and modern imagination. They had mysteries, of course, like the Ashantis or Ibos. It is a mistake, however, to think that these mysteries enshrined truth, and that there was an occult "faith" behind them. There is no more proof of it than in the case of the Ashantis or the Ibos. They were nearer to Europe, that is all, and we have not always been so critical as we are now. However, educated Romans treated the mysteries of Isis with contempt; only illiterate people believed in them.



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HEAD OF THE GOD AMON, FROM A STATUE ERECTED IN AN EGYPTIAN TEMPLE DURING THE 18TH DYNASTY

The Pantheon and its Chief Deities.—Best known to us of the gods is of course Osiris, with Isis and Horus the child (Harpokrates), the family triad beloved of ordinary people. In later times they seem almost to monopolize worship, and become identified with many other gods. Originally Osiris seems to have been an agricultural deity of Syrian origin, who entered Egypt with the conquering dynastic people, and was chiefly venerated at Mendes, where he seems to have adopted a locally worshipped animal, the goat, if he did not bring him with him. Then in a manner for which various explanations might be given, he later on became identified with two local gods of the dead, the hawk Sokri, and the bull Hapi (Apis) at Memphis, and eventually, under the middle kingdom with another local dead-god, Khentamentiu ("Chief of the Westerners") at Abydos. Thereafter Osiris-Khentamentiu becomes the great god of the dead, ruling the underworld of the tombs in which the dead lived in ghostly fashion, and every Egyptian becomes himself Osiris at his death. Identification with the sun in his nightly progress through the underworld followed. At Memphis a triple Osiris, Ptah-Socharis-Osiris, was confounded with the local deity Ptah, as well as Sokri (Socharis), and the bull Apis was his animal. Under the Ptolemies Osiris-Apis was graecized as Serapis, and because his seat at Sakkarah was also called *Se-n-Hapi,* the Greeks imagined a connection with Sinope in Asia Minor that has not even yet been expelled from the minds of classical scholars.

Presumably Isis came from Syria with Osiris: certainly the well known legend of the finding of his body at Byblos in a cedar-chest by her after his murder by Set points in that direction. She, like him, was human-headed; it might be considered reasonable to suppose that all the human-headed deities were of this extra-Nilotic northern origin, the animal-headed being the gods of the primitive Nilotes. Certainly, Ptah, the human-headed god of Memphis, has a Semitic name, "the Opener." But he is also mummified: and if the primitive people made a human mummy a god he would presumably have a human head. On this showing Osiris, Ptah, Amon, Min, Onhur and other gods would all be extra-Nilotic; Thoth, Hathor, Sobk and others with animal-heads Nilotic. It is unwise to press any such theory, but it is a possibility that though the Nilotes probably had human-headed

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EGYPTIAN HANDICRAFT OF 1580–1200 B.C.

Top: Carnelian plaques, XVIIIth dynasty, from bracelets or armlets, inscribed with name of King Amenhotep III (1411–1375 B.C.) The lower plaques are ornamented with scenes from the king's life. The centre plaque, of dark sard, is ornamented in pierced work with a human-headed sphinx holding before it a cartouche bearing the name of the king. Gold setting is modern. Centre: Turquoise blue glass vase found at Thebes, XVIIIth dynasty; gold statuette of the god Amon, in the likeness of King Thutmose III (1501–1447 B.C.); faience cup in the form of a lotus flower, ornamented in low relief. XIXth–XXth dynasties. Bottom: Wooden coffin painted with hieroglyphics and symbolic figures relating to the soul's journey to the world of the dead

gods of their own, the theriolatry of the nation was their invention, and that they added the "sacred animals" to the paraphernalia of the gods whom the newcomers brought with them.

These "sacred animals" were of course more than this. They were, in the eyes of the people, themselves more or less gods: any ibis or ape *was* Thoth, in a sense, Thoth the god of intelligence walking about and as ibis inquisitively looking for things to find out with his long bill, or as ape weirdly, divinely, parodying, the ways of men and acclaiming the coming of the sun-god at dawn with jubilant cries. Every bull on the contrary was not Apis, who had to have special marks: but a genuine Apis-bull was very much himself the god Ptah-Socharis. Every scarab-beetle was not of course itself the sun in the form Khopri, but as the *type* of Khopri (the roller, shaper, becomer, self-creator) partook of the divine nature of the sun-god and was mummified as much as an Apis. We all know Herodotus's story of the unlucky Greek who killed a cat, and as cats were generally mummified, like Apis-bulls, scarabs and ibises, it is probable that every she-cat, at any rate, was regarded more or less as Bubastis herself. The tale of the furious war between the Ombites and the Tentyrites, because one town had killed the crocodile that the other venerated, was one that always amused the Romans. Such contradictions were of the essence of Egyptian religion. Ombos in Upper Egypt, and one or two other towns in the north had the doubtful honour, in the eyes of other Egyptians, of worshipping Setesh or Set, the evil principle (so the others said), who was represented with the head of an animal that was a cross between those of a donkey and a pig—Set, the murderer of Osiris, whom Horus slew. And here we meet one of the first major inconsistencies of Egyptian religion, for the Horus who slew Set was not really Horus the son of Osiris at all, but quite a different and in reality far older Horus, the hawk-headed sky-god of Upper Egypt, worshipped at Edfu, who was often known as Haroëris, "Horus the Elder," to distinguish him from Harpokrates, "Horus the Child," who was the son of Osiris. Yet no doubt most people believed them to be both the same and different at the same time.

With the elder Horus we reach the group of hawk- or falcon-headed deities who are naturally, gods of the sky, of the sun too, and of the moon. Hawk-headed is Raʻ or Riʻ the sun-god, in early days the most venerated god, especially under the 5th and 6th dynasties. And he is never human-headed, whereas Horus (no doubt by confusion with the other Horus) sometimes is. But another sun-god, Itum, venerated at Heliopolis, and generally regarded as the setting sun, is always human-headed. Perhaps he was a Syrian and the hawk Raʻ, identified with him under the old kingdom, the old Nilotic sun-god. He was so closely identified with Raʻ that the latter alone was often regarded as the Heliopolitan god. The rising sun was another form of the sky-god Horus, hawk-headed, and combined with Raʻ as Raʻ-Horakhti ("Raʻ on the two horizons"), Ra-Harmachis. There was properly speaking no female of Raʻ (as a Raʻt, occurring in later times, was a pure invention in imitation of Isis), nor was there of Horus, unless the cow-headed Hathor ("House of Horus") can be so regarded: at any rate she was clearly connected with Horus in Upper Egypt as her name shows. She was the goddess of the deserts, and at Thebes a form of her, the snake Mersegret, protected the desert tombs. Sekhmet ("Power"), the lioness-headed, might be regarded as a female Raʻ, but she is always described as the consort of Ptah: Bastet or Bubastis, the cat-goddess was a northern Hathor, and like her also by some twist of thought was the patroness of love, of matters feminine and of fashion. Like her she has no official consort, as Sekhmet has. To Ptah and Sekhmet are later given, when somebody tried desperately to introduce logic into the "system," a deified human being, a historical personage turned god, Imhotep the sage, prime minister of King Zoser of the 3rd dynasty, who was naturally venerated at Memphis, the city of Ptah. Another late-deified prime minister, Amenhotep, son of Hapu (Amenothes, son of Paapis), was not so assigned, but in revenge he seems in Roman days to have been confused with Amen, the king of the gods, himself!

Under the Theban 12th dynasty the local god of Thebes, Amon ("the hidden one"), a form of the ancient local god Min, and like him human-headed but unlike him not ithyphallic, came to the front, and with the establishment of the imperial power of the 18th dynasty at Thebes he took place as Amon-Raʻ *Suntĕru* (Amonra-sonthĕr), "the king of the gods." This place he held nominally till the end, but was not much venerated outside Thebes after the close of the imperial period. In late times he seems often to have been confused with Osiris. He had a wife and son, like Osiris, Mut ("Mother") a local goddess of Thebes, and Khons a local moon-god, who rarely appears at all till the 20th dynasty, and then much resembles Harpokrates, with whom in later days he was often confused. He was hawk-headed at first, like Munt, the war-god of Hermonthis, a little further south, a form of Haroëris (?). But later Khons was boy-headed, with the sidelock of youth, like Harpokrates. At Thebes was also venerated the well known hippopotamus-goddess Opet, called often Tauëret (Thouĕris, "the great one"), whose yearly festival was the greatest in the year at Thebes. Mut's animal was the vulture, Amon's the ram with curved horns. Further south, at Elephantine, was venerated Khnum the potter, ram-headed with twisted horns, a great god even till the very latest days. Onhur (Onouris), a human-headed war-god, was also Upper Egyptian. The ithyphallic Min, already mentioned, was the local god of Koptos, and was the deity of fertility.

The great god Dhuti or Thoth, never human-headed (and never ape-headed with a human body, when he is always ibis-headed), the patron of learning letters and intelligence, was one of the major deities, and was worshipped universally, but locally was the god of Hermopolis (Ekhmunu, Ashmunain). The Greeks called him Hermes as the *psychopompos*, since, by association with the Osirian cult, he ushers the dead into the presence of Osiris to be justified, naturally as he was the god who knew how to write and could record their names on his scroll. Even more closely associated with Osiris at Abydos is Anubis, the jackal-headed, originally the same as the local dead-god, Khentamentiu, and deriving his head from the desire to placate the jackals that ravaged the necropolis in the desert: wherefore the jackal was worshipped. In later days Anubis is called a son of Osiris, and is often confused with the very similar Ophois (Upuaut), the wolf-god of Siut (Lykopolis). A foreign importation (from Babylonia early in the middle kingdom) is Bes, the grotesque bearded man who became a patron of jollity and of luxury and fashion; ending as the *Silen* or satyr of the Greeks. Other (later) foreign importations are such purely Semitic deities (all of course human-headed) as Reshpu (Resheph), Baal and Anaita or Kedeshet, or Nubians like Maahes (lion-headed). Baal was often confused or identified with Bes.

Other deities to be mentioned are Hapimōū, the Nile-god, Neith, the war-goddess of Sais in the Delta, very prominent naturally in Saite days, Harshafit (Arsaphes), a ram-headed war-god worshipped at Herakleopolis Magna (Ahnas), among local gods; Shu the wind-god, Nut a sky-goddess and Geb the earth-god among purely cosmogonic deities (who received little or no worship); Ernutet (Thermouthis) the goddess of child-birth and of crops, Nepri the corn-god, and Tait the goddess of the funerary vestments, among miscellaneous minor deities; and deifications of qualities or forces (rather in the Roman fashion), like Ma'at the goddess of law and right (well known with her ostrich-feather, the symbol of justice), and Shai or destiny.

The Sun-disc or Aten was not represented by the Atenist heretics in human or animal forms but simply as the solar disc from which spread to the earth below rays ending in human hands holding the ☥ or symbol of life (*ʻankh*), thus symbolizing the sun's gift of life to the world. This worship of the physical sun (or perhaps of a god behind the sun) as the giver of life was an eminently simple and rational one, but far too much so for the Egyptians, who, like other people, preferred irrational "mysteries" to such rational simplicity.

Lower than deities were various genii or demons like the Four Sons of Horus;—the human-headed Mesti, the hawk-headed

Qebhsnēuf ("Pleaser of his brethren"), the jackal-headed Duamutef ("Praiser of his mother") and the ape-headed Hapi, whose heads are found as lids on the four "canopic" jars in which the viscera of the dead were placed in the tomb. Here also hawks, jackals and apes are given the post of honour among divine beasts. Elephants, deer, antelopes, owls and many other animals have no divine attributes, even the lion is rare as a divine head, and is always very late (Horus) and provincial (Nubian: the god Maahes). There existed, however, some rather holy beasts, like the crane or "phoenix" (*bennu*) venerated at Heliopolis. The imaginary sphinx or human-headed lion was divine in so far as it was an image typifying the king as Horus. It should be noted that the Egyptian sphinx (including of course the great sphinx at Gizeh) is male; there were no female sphinxes in Egypt till Greek times. *See* SPHINX.

These deities were worshipped in their temples throughout the land: contemplar gods were common. Of rites and ceremonies we have a considerable idea. Lustrations of water were common, sacrifices consisted in simple offerings of meat, honey, oils, fruit and flowers: burnt-offerings were un-Egyptian. Incense was an universal offering and a most ancient one, as its name (*snutri*, "that which makes divine"), shows. The use of incense probably came to Egypt from Asia in very early days. The censer was fixed at the end of a long arm which was waved in the air, the swinging censer being unknown till Christian times. Musical instruments such as trumpets, and above all the sistrum (see *Music*) were employed in the ritual, also singing by the priestesses.

Priests did not really form a totally distinct caste, as Herodotus said, but they were an important and influential body from the time of the 18th dynasty, when the priesthood of Amen-Ra' at Thebes, to whom the conquered lands of Asia were largely assigned in fee, became enormously wealthy and powerful. In early days they were not so distinguished from the rest of the better class. We know the titles of the various orders of priests and their functions. High-priests often bore ancient titles, such as the "Great Chief of the Artificers" (*Uer-kherp-hemtiu*), the high-priest of Ptah at Memphis or the "Great Seer" (*Uer-maa*) at Heliopolis. Of the subordinate ranks of the "Pure Ones" (*uēbu*), there were *iotu-neter* or "divine fathers," *hemu-neter* ("prophets of the god"), "hour-priests" and the *khrihabiu* or "cantors" and the *Inmutf* and *Sem* who were connected with the service of the dead, and were often not regular priests but relatives of the deceased who assumed priestly functions for the occasion, in order to carry out the ceremonies at the tomb. Lay "tertiaries" connected with the services for the dead were called "hearers of the cry" (*sedjem-'ash*) in the Necropolis. The priestesses were generally known as "singers" (*shem'a*): they also shook the sistrum, which was a woman's instrument, in processions and dances. Magic dances were usual, and we have ivory wands which were used on them, on which are engraved the figures of various demons of the underworld. Magic was of course not separated from the religion, which was after all basically magical. There were no doubt degrees of magic. The word for magic or incantations, sorcery, etc., was *heka* or *hike*, which is not impossibly the origin of the name of the Greek demon goddess Hekaté.

Such things as scriptures and service-books we know little of. As has been said fine hymns were chanted to the sun-god under the 18th dynasty, and Ikhnaton's hymn to the Aten is famous for its resemblance to the 141st psalm (see *Literature*). But most of the religious writings were confined to the unintelligible spells of the so-called *Book of the Dead*, or "Book of Coming Forth by Day" (as the Egyptians called it), and such more sensible later developments of it as the *Book of the Underworld*, the *Book of the Gates*, and the *Book of Breathings*. All these were, so to speak, guide books to the next world for the use of the soul, devised to warn him of the dangers he might expect to meet and to provide him with powerful spells to guarantee his safety. These spells are most barbarous and least intelligible when we first meet them, in the "Pyramid texts" inscribed in the pyramids of the kings of the 5th and 6th dynasties. They seem to have been devised first for the protection of the king alone, afterwards being extended in use to the nobles and the mass of the nation. As time went on such magical care for the welfare of the dead, originally in all probability reserved for the ruler and his entourage only, became available for all, as the worship of Osiris spread, and almost the humblest came to be regarded in death as much Osiris as the king himself.

The preservation of the body was also no doubt originally a royal prerogative. This custom spread to the subjects with the other devices to ensure safety to the dead man. Originally the bodies of the dead no doubt dried fortuitously in their graves in the desert sand: some may have been smoked. It was seen to be possible in Egypt to preserve the dead from dissolution, and gradually the practice of mummification grew up, that was not really fully developed till the time of the 18th dynasty. (*See* MUMMY.) Middle Kingdom mummies are very lightly dried and often nothing remains but the skeleton. But they were swathed in bandages and elaborately buried in great rectangular wooden coffins with models of ships, labourers at work, etc. The course of mummification from the 18th dynasty to the 26th followed a regular course of development: it is possible to tell the dynasty to which a mummy belongs by the style of bandaging and embalming even when the name and titles have disappeared from the coffin. Human-headed coffins are characteristic of this period, in which the *Ushabtis* and *Canopic Jars* appear commonly. (See *Archaeology*.) Under the Saites Herodotus gives us his well known description of the three methods of embalming in use in his time, which it is unnecessary to repeat. The chief process was the steeping in natron or soda. He adds the interesting detail that the incision in the abdomen, through which the entrails were removed, was made by a special priestly official, the *paraschistes*, who made the cut with "an Ethiopian stone," and then fled away, pursued by (ceremonial) stones thrown at him. The "Ethiopian stone" was evidently a flint knife. Stone sarcophagi first appear under the 18th dynasty, and are specially heavy under the 26th, when two or three inner coffins of wood fitted one inside another, were usual for great people. Sacred animals, like the rams of Khnum and the Apis-bulls, were similarly embalmed and buried, the sarcophagi of the bulls in the Serapeum at Sakkarah being of enormous size and weight.

Tombs develop from the plain desert graves of the pre-dynastic period into brick structures in the case of the kings at the beginning of the 1st dynasty, which by the 3rd have developed into the *Mastaba*—or "bench" type—with chambers above ground and its deep pit, at the bottom of which is the actual tomb-chamber. These upper chambers are ornamented under the 4th with reliefs (see *Art*): the royal tombs have developed into the Pyramids (*q.v.*). Under the 6th dynasty another form of tomb appears in the south: chamber-tombs with a pit cut in the face of a cliff. This type is common under the Middle Kingdom. Owing to the steep shape of the Egyptian hills there is not much in the way of a dromos, which alone was marked by the pyramid-crowned chapel outside. Under the 18th dynasty we have at Thebes the characteristic tombs of Shaikh 'Abd al-Kūrna, with their pillared and painted galleries, and their stelae and statues of the deceased, while the kings have their sepulchres in the valley of the Bibān al-Mulūk, cunningly concealed, with long tunnels of approach cut in the hill, with all sorts of (necessary) precautions against tomb-robbers, and at end the vast excavated chambers in which the dead pharaoh hoped to rest amid his accumulated funeral pomp, buried with him. Actually only Tutankhamun, who was buried in a small unfinished tomb, has so survived till the present day, though the bodies of many of the other kings were found in *caches* to which they had been conveyed by later kings for safety's sake, and are now in the Cairo museum. In Saite times we have a return to ancient models in a sort of cross between a mastaba (brick built) with pylons (see *Architecture*), and a new empire tomb with columned chambers, which was very popular. The common people attained the privilege of mummification at this time, and in Ptolemaic and Roman days were buried in small graves or thrust into the ancient tombs of others in piles, one on the top of another. Ancient tombs, vacant or not, were the usual resting place of the better

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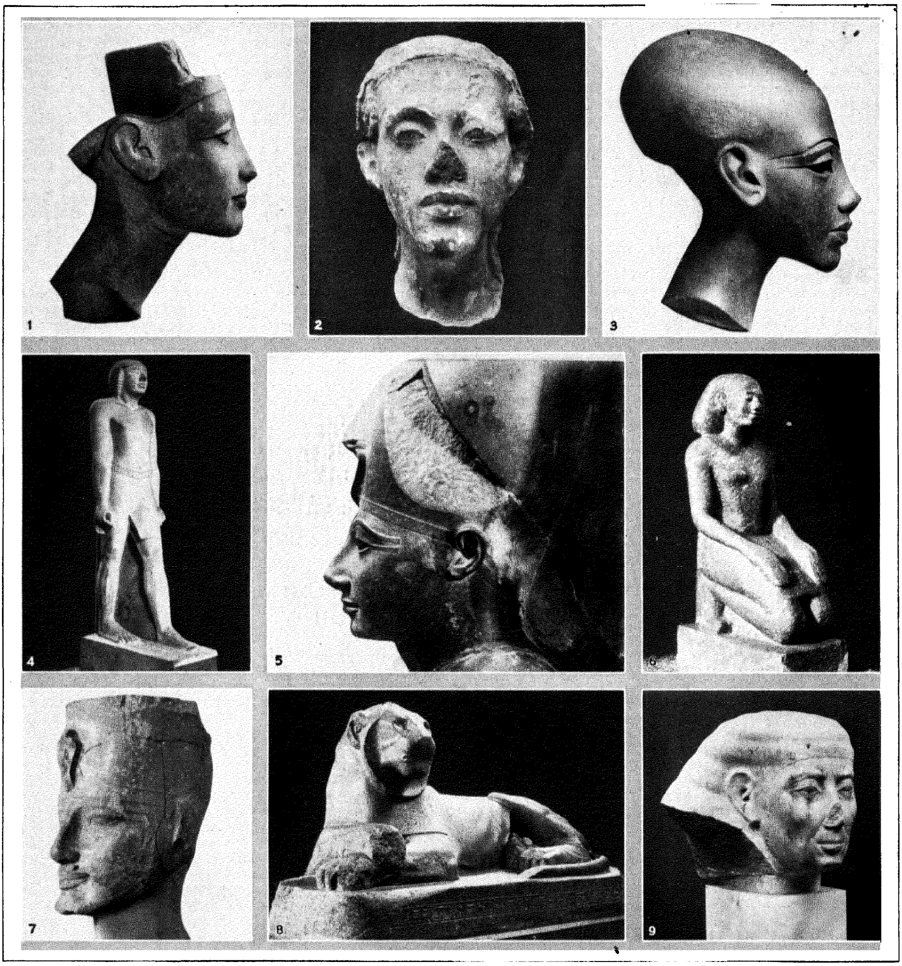
EGYPTIAN FIGURE SCULPTURE FROM THE I. TO THE XII. DYNASTY

1. Ivory figure of a king found at Abydos, one of the most precious relics of the archaic period. 1st dynasty, about 3200 B.C. 2. Cast of slate palette of Narmerza, from Hierakonpolis, 1st dynasty. 3. Statue of Zoser from Sakkara (from a cast). 3rd dynasty, about 2800 B.C. 4. Statue of the Boatbuilder 'Aperankhu. 3rd dynasty, about 2800 B.C. 5. Portrait of a lady of rank. From the statue-chamber of a tomb near Gizeh, 4th dynasty, about 2700 B.C. 6. Obsidian portrait-head of Amenemhet III., 12th dynasty, about 2000 B.C. (from a cast). 7. Granite portrait-statue of Senusret III.; Dair al-bahri, 12th dynasty. 8. Portrait-group of King Menkaure and his queen; Gizeh, 4th dynasty. 9. Augite-diorite sphinx, Hyksos type, with portrait-head of Amenemhet IV. The face was reworked in the Saite period (8th century B.C. or later)

EGYPT



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EGYPTIAN SCULPTURE OF THE XVIII. TO THE XXVI. DYNASTY

1. Head of Queen Nefertiti, queen of Ikhnaton (Akhenaton), 18th dynasty. Made of sandstone, about 1 ft. in height; from Tel-el-Amarna. A crown, now lost, made in a separate piece, was joined by the wedge here shown (*c.* 1350)
2. Portrait head of Amenhotep IV. (Ikhnaton), 18th dynasty, from Tel-el-Amarna, produced, it is thought, from an actual mask. Fillet on head was presumably to keep back hair in casting. There is a marked absence of modelling about lips and eyes
3. Head of one of the seven daughters of Ikhnaton; among discoveries of 1910–11 at Tel-el-Amarna. The eyes were probably of inlay work. The skull is artificially elongated
4. Archaistic limestone statue of the 26th dynasty, imitating 5th dynasty work. The arms placed close to sides, and the formal treatment of hair are characteristic of the earlier period (*c.* 550 B.C.)
5. Head of portrait statue of Thotmes III. (Thutmosis III.), of gray basalt, found at Karnak. The face is believed to be a true portrait, and not the representation of a conventional type (*c.* 1500 B.C.)
6. Kneeling statuette, 26th dynasty (*c.* 550 B.C.), showing the "archaic smile"
7. Sandstone head of a colossal statue of Amenhotep III., *c.* 1400 B.C., from Thebes; height 3 ft. 10 inches. The head belonged probably to one of the statues set up before a funerary temple. Uraeus, above the forehead, was a symbol of divine protection
8. Red granite lion, 18th dynasty (*c.* 1400 B.C.), 7 ft. long, probably placed in the Temple of Napata. The inscription states that Tutankhamun restored the buildings of his father, Amenhotep III.
9. Head of statue of an official, in crystalline limestone, 17th–18th dynasty

classes now, and were re-used over and over again. Mummification survived into Christian days, and Coptic mummies are not uncommon: good examples are in the Musée Guimet at Paris.

The beliefs of the Egyptians with regard to death were hopelessly confused, like those of most other peoples. The whole idea of the tomb seems originally to have been due simply to the passionate desire to deny the existence of death. "Oh ye living upon earth, who love life and hate death," begins the invocation to the living often inscribed on the tomb-walls. The Egyptians, a cheerful merry people, loathed the idea of death, and did their best to persuade themselves that the dead were not actually dead at all, but continuing to live in the underworld of the tomb in some weird fashion, and that their life there could be preserved by means of magical spells and the representations on the tomb-walls or in the shape of models of their ordinary life on earth. Then there was the idea of a sort of temporary "resurrection" of the dead, who were supposed to be able to "come forth by day" from the tomb by means of spells if they liked, or like Osiris (a confusion with his agricultural aspect), to live again as the grain sprang up again each season.

Then there was the idea that the dead lived with the gods, especially those of the underworld, and accompanied Khentamentiu (Osiris), on his nightly rounds of his realm, as the dead sun. Again there was the idea of souls: the *ka* (*ko*) or double for whom, represented as a statue, a special house in the tomb was provided in early days; the *bai* or soul proper (a human-headed bird); the *ikh* or "spirit" (a bird); the *khaibit* or "shadow" and so on. The *bai* was supposed to be able to visit the *khat* or body in the tomb, but the *ikh* flew off to the heaven-gods in the sky. Then there was the idea of moral justification of the deceased, his "negative confession" in the ritual and the judgment by Osiris and his "42 Assessors" (which in the time of Herodotus was probably actually enacted by priests over the body of great people); the weighing of the heart by Thoth against the feather of Maat, and so forth, which marked the influence on the Egyptian mind of the Semitic idea of sin, originally foreign to it. We hear very little of moral ideas except in scholastic papyri (see *Literature*). Religion was primarily an affair of ceremonies and spells, intended to bring about certain desired results by means of the help of one or some of the multitudinous deities. Even the monotheist hymns to the Aten are not ethical. They merely praise the sun for his life-giving heat, there is nothing in them depreciatory of the moral character of the praiser, in Semitic fashion. The Egyptian was never a humble person, either genuinely or hypocritically. When he confessed he did not say "I am guilty": he said "I am not guilty"; his confession was negative, and the *onus probandi* lay on his judges who, according to the funerary papyri, always gave the verdict in his favour, or at any rate it was hoped and expected would do so.

The many-sided character of Egyptian religion and its manifold contradictions and deficiencies (human and straightforward enough), will be evident from the above description. What varying views on the subject can be held by writers of differing mentalities will be seen from a perusal of the works mentioned in the bibliography below, which partly consists of works with whose theses the present writer entirely disagrees, but which he quotes in fairness to their authors and to those readers who see things in the same light as they do. That they will leave a confused impression on the mind is only to be expected from the nature of the subject.

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(H. R. H.)

DEFENCE

Army.—The youth of Egypt was liable to be called upon for service in the field under the local chiefs. Their training consisted of gymnastic and warlike exercises which developed strength and discipline that would be as useful in executing public works and in dragging large monuments, as in strictly military service. They were armed in separate companies with bows and arrows, spears, daggers and shields, and the officers carried battle-axes and maces. The army, commanded in chief by Una under the 6th dynasty for raids in Sinai or Palestine, comprised levies from every part of Egypt and from Nubia, each under its own leader. Under the New Empire, when Egypt was almost a military state, the army was a more specialized institution, the art of war in siege and strategy had developed, divisions were formed with special standards, there were regiments armed with battle-axes and scimitars, and chariots formed an essential part of the host. Egyptian cavalry are not represented upon the monuments, and we hear little of such at any time. Herodotus divides the army into two classes, the Calasiries and the Hermotybies; these names, though he was not aware of it, mean respectively horse- and foot-soldiers, but it is possible that the former name was only traditional and had characterized those who fought from chariots, a mode of warfare that was obsolete in Herodotus's own day; as a matter of fact both classes are said to have served on the warships of Xerxes' fleet. (X.)

The fellah soldier has been aptly likened to a bicycle, which although incapable of standing up alone, is very useful while under the control of a skilful master. It is generally believed that the successes gained in the time of the Pharaohs were due to foreign legions; and from Cambyses to Alexander, from the Ptolemies to Antony (Cleopatra), from Augustus to the 7th century, throughout the Arab period, and from Saladin's dynasty down to the middle of the 13th century, the military power of Egypt was dependent on mercenaries. The Mamelukes (slaves), imported from the eastern borders of the Black sea and then trained as soldiers, usurped the government of Egypt, and held it till 1517, when the Ottomans began to rule. This form of government, speaking generally, endured till the French invasion at the end of the 18th century. British and Turkish troops drove the French out after an occupation of two years, the British troops remaining till 1803. Then Mohammed Ali, coming with Albanian mercenaries, made himself governor, and later (1811), by massacring the Mamelukes, became the actual master of the country, and brought Arabia and Nubia under Egypt's rule. Requiring a larger army, he conscripted over 250,000 fellahin, and in so arbitrary a fashion that many peasants mutilated themselves to avoid the much-dreaded service. Nevertheless the experiment succeeded. The docile, yet robust and hardy peasants, under their foreign leaders, gained an unbroken series of successes in the first Syrian War; and after the bloody battle of Konia (1832), it was only European intervention which prevented the Egyptian general, Ibrahim Pasha, from marching unopposed to the Bosporus. The second Syrian War (1839), confirmed that it was possible to obtain favourable military results with Egyptians when stiffened by foreigners and well commanded. Ibrahim, the hero of Konia, declared, however, that no native Egyptian ought to rise higher than the rank of sergeant; and in the Syrian campaigns nearly all the officers were Turks or Circassians, and in the cavalry and artillery many of the privates were escaped janissaries.

Under Mohammed Ali's successors the army shrank to nothing, until Ismail who, succeeding in 1863, in seven years was able to put 100,000 men, well equipped, in the field. He conquered the greater part of the (Nile) Sudan; but an expedition to Abyssinia suffered disaster. The education of Egyptians in Continental cities had not produced the class of leaders who led the fellahin to victory at Konia. Ismail's exactions from the Egyptian peasantry reacted on the army, causing discontent; and when he was tottering on the throne he instigated military demonstrations against his own government, and by thus sapping the foundations of discipline, assisted Arabi's revolution; the result was the battle of Tell el Kebir, the British occupation, and the disbandment of the army, which at that time in Egypt proper consisted of 18,000 men. (*See* EGYPT AND SUDAN, CAMPAIGNS IN, 1882–1899.)

In January 1883, Maj.-Gen. Sir Evelyn Wood, V.C., was given

£200,000, and directed to spend it in raising a fellahin force of 6,000 men for the defence of Egypt. He was assisted at first by 26 officers, amongst whom was Lieut. H. Kitchener, R.E. Each battalion of the 1st infantry brigade had three British mounted officers, Turks and Egyptians holding corresponding positions in the battalions of the 2nd Brigade. The privates were conscripted from their villages. The earlier merciless practice had been in theory abolished by decree in 1880; but actually the 6,000 recruits represented the biggest and strongest peasants who could not purchase exemption by bribing the officials concerned. But the perseverance of British officers gave the oppressed peasants, in 1885, an equitable law, which was subsequently improved by the decree of 1900. General considerations later caused the sirdar to allow exemption by payment of (Badalia) £20 before ballot—part of this being expended in the betterment of the soldier's position.

The earlier efforts of 48 American officers, who under Gen. C. P. Stone zealously served Ismail, had failed to overcome Egyptian venality and intrigue; so that the task undertaken by the small body of British officers was difficult. That there had been no adequate auxiliary departments, without which an army cannot move or be efficient, was comparatively a minor difficulty. To succeed, it was essential that the fellah should be taught that discipline might be strict without being oppressive, that pay and rations would be fairly distributed, that brutal usage by superiors would be checked, that complaints would be thoroughly investigated, and impartial justice meted out to soldiers of all ranks. An epidemic of cholera in the summer of 1883 gave the British officers their first chance of acquiring the esteem and confidence of their men, and the regeneration of the fellahin army dates from that epidemic.

When the Egyptian Army of the Delta was dispersed at Tell el Kebir, the khedive had still 40,000 troops scattered in the Sudan. These were composed of Turks, Albanians, Circassians and some Sudanese. Ten thousand fellahin, collected mainly from Arabi's former forces, set out in September 1883, under Hicks Pasha, a dauntless retired Indian Army officer, to vanquish the Mahdi. They disappeared in the deserts of Kordofan, where they were destroyed by the mahdists about 50m. south of El Obeid. Baker Pasha, with about 4,000 constabulary, who were old soldiers, attempted to relieve Tokar in February 1884, but was attacked by 1,200 tribesmen and utterly routed.

It was then deemed advisable to rely on blacks to stiffen the fellahin—five Sudanese battalions being successively formed. But in the Gordon relief expedition of 1884 the Egyptians did remarkably good work on the line of communication from Assiut to Korti, a distance of 800m., and the honesty and discipline of the fellah were shown to be undoubtedly of a high order. By the time of the Omdurman campaign, 1898, the standard of honesty was unimpaired, and the British officers had imparted energy and activity into Egyptians of all ranks. The large depots of stores at Aswân, Halfa and Dongola could be supervised only cursorily by British officers, and yet when the stores were received at the advance depot the losses were infinitesimal.

By nature the fellah is unwarlike. Born in the valley of a great river, he resembles in many respects the Bengali, who exists under similar conditions; but the Egyptian has proved capable of greater improvement. He is stronger in frame and can undergo greater exertion. Singularly unemotional, he stood steady at Tell el Kebir after all his officers had fled. It has been aptly said "the fellah would make an admirable soldier if he only wished to kill some one!"

The well-educated Egyptian officer showed aptitude for regimental routine, and worked well when supervised by men of stronger character. The ordinary Egyptian is not self-reliant or energetic by nature. The black soldier has, on the other hand, many of the finest fighting qualities. Sudanese are very excitable and apt to get out of hand; unlike the fellahs they are not fond of drill, and are slow to acquire it; but their dash, pugnacious instincts and desire to close with an enemy, are valuable military qualities. The Sudanese, moreover, shoot better than the fellahin, whose eyesight is often defective. The Sudanese captain is slow, but self-reliant, and much respected by his men.

In 1908 the Egyptian army, with a total establishment of 18,000, consisted of three squadrons of cavalry (one composed of Sudanese); four batteries of field artillery and a Maxim battery; the camel corps, 626 of all ranks (fellahin and Sudanese); and nine fellahin and six Sudanese infantry battalions, 10,631 of all ranks. The stringent system of selecting British officers, originated by the first sirdar in 1883, is shown by the fact that of the 24 employed in creating the army, 14 rose to be generals. Competition for employment in the army became severe and the service attracted the very best of the British Army. In 1908 there were also 140 British warrant and non-commissioned officers. (E. Wo.)

Modern Developments.—So matters rested, in the main, until the World War. This had a vital influence upon military developments in Egypt, of which the end is not yet in sight. On August 5, 1914, the Egyptian Prime Minister signed a document which amounted virtually to a declaration of war by Egypt against the enemies of Great Britain. The alternative would have been the disarmament or internment of the British troops in the country, a policy which could hardly be contemplated. By October the impending hostility of Turkey wrought a complete change in the situation, and it was found necessary to proclaim martial law. By that time the regular British troops had been withdrawn, their place being taken by Territorial units, and from thenceforward Egyptian territory became a base of operations for British, Australasian, Indian and other troops. The defence of the Suez canal became a matter of primary importance to the Allied cause, not only for economic but also for military reasons.

The tale is told elsewhere of attacks upon the canal by Turks with German aid and instigation, of raids by Senussi (*q.v.*) forces in the south-west and in the west, and of subsequent British offensive operations in Palestine (*q.v.*) and Syria, using Egypt as a base. Five days after war broke out with Turkey, Egyptians were informed by proclamation that they would not be called upon for assistance, but those who gave the pledge were proved to be lacking in forward vision. Only a few Egyptians, it is true, served under arms in the defence of the Suez canal against Turkish invaders in 1914–15 but the resources of the country in man-power, in transport animals (especially camels), and in economic provisions were fully exploited to meet the ultimate needs of British empire armies. Returns of the effective strength of the Egyptian expeditionary force in November 1918 show that over 96,000 Egyptians were serving in the army, 88,000 of them being in labour units, and we find a mention of over 17,600 Egyptians described as being employed "in substitution for British personnel" (*Military Effort of the British Empire*, p. 161). There is little doubt that, without the aid of the Egyptian labour corps and the camel transport corps, the original British advance across Sinai into Palestine would have been more protracted, and the aid of these corps was invaluable during subsequent stages of the operations. Some statistics in connection therewith will be of interest, bearing in mind throughout that Egyptians as a whole did not grasp that the prosecution of a campaign in Palestine tended to their advantage. For a time the ranks were filled voluntarily, but ultimately, in the fourth year of the war, the Corvée had to be introduced again in order to obtain the monthly contingent required, which rose from 17,000 in May 1917 to 26,000 in June 1918. In the former month it was found necessary to disarm all Egyptian citizens, military considerations being held to over-ride political consequences. With these we are not here concerned, beyond mention of the disastrous effect of military measures upon the attitude of Egyptians to the British.

The Egyptian camel transport corps of the World War has been described as a unique creation which acquitted itself gloriously. 170,000 Egyptians served in this corps. Though working behind the lines, 220 of them were killed and 1,400 wounded by enemy action, 4,000 died in field hospitals. 72,000 camels were purchased from various sources for this corps; in 1917, 11,000 out of 65,000 male camels in Egypt were taken. The culminating effect of this and of other demands upon the agricultural and economic resources of Egypt was one of the factors that contributed to produce the unsettlement which led to the rebellion

of 1919, and culminated in the assassination of the British sirdar of the Egyptian army in November 1924. That event was followed in 1925 by the creation of a Sudan defence force, independent of Egypt, in place of the Egyptian army garrison. There are now therefore three military forces in Egypt and the Sudan, the British troops in both countries, the Egyptian army in Egypt and the Sudan defence force from Wady Halfa to the southwards.

Present-day Army (Egypt).—The Egyptian army is recruited on a compulsory basis, but only a small percentage of the contingent reaching military age every year is needed for service in the army. Taking the year 1925 as typical, the number inscribed on the list was 153,879. After exempting 94,250 for various reasons, and eliminating the unfit, 14,363 were passed as fit for service, and of these only 1,462 were taken into the army (*Annuaire Statistique*. Cairo, 1926). Service is for five years with the colours and five in the Reserve. The total strength of the army (1928) may be taken at about 11,400. The organization is in the usual arms: Cavalry (two squadrons), artillery (four field batteries and one garrison company), and infantry (11 battalions) with the usual ordnance, supply and transport, and medical departments.

The king is head of the army, and there is an army council on the British lines, presided over by a minister. A British General officer, with the title of Inspector-general, carries out the functions appertaining to the post of sirdar. A few British officers occupy high appointments in the army staff. The various military formations and subordinate units are now commanded by Egyptians. There are three brigade commands, the infantry and other arms being widely distributed; the battalion at Aswân is the farthest up the Nile. From Wady Halfa southwards troops of the Sudan defence force, recently formed, are to be found.

Sudan Defence Force.—In the regular troops of the Sudan defence force recruitment is voluntary, for three years with the colours up to six years for special arms of the service. Some of the units are still (1928) in embryo, so any estimates of total strength would be misleading. The 9th Sudanese battalion (at Omdurman) is the only survivor of the six battalions of Sudanese formerly in the Egyptian Army. The Sudan defence force includes, besides two battalions of British infantry, a camel corps with headquarters and a machine-gun section, two camel companies, one of mounted infantry, and four of infantry; an Eastern Arab corps containing one camel company and three infantry companies; a Western Arab corps, with three mounted infantry companies, one infantry company and a machine-gun battery; 12 companies of Sudanese reserves; an "Equatorial corps" with nine companies of infantry; and the usual departmental units, medical, ordnance supply and transport (mechanical transport forming a special feature in suitable country). With the exception of a section of guns in the Eastern Arab corps there is no artillery in the Sudan defence force. The whole force is commanded by a British General officer. For administration the British battalions are under the General officer commanding the British troops in Egypt. The subordinate commanders are British officers, a large proportion of whom served previously in the Egyptian army. The ranks which they hold in the Sudan defence force are Ferik (Major-general), Lewa (Brigadier-general or Colonel-Commandant), Miralai (Colonel), Kaimakan (Lieut.-colonel), Bimbashi (Major), Saghkolaghasi (Adjutant-major), Yuzbashi (Captain), Mulazim Awal (Lieutenant) and Mulazim Tani (2nd Lieutenant). The title of the General officer commanding is "Kaid d'Amm."

Besides the Sudan defence force there are mounted and foot police, most of whom have recently been armed with magazine rifles, replacing Lee-Enfield carbines.

The British troops in Egypt proper included in May 1928 one brigade (three regiments) of cavalry, two brigades (each of three battalions) of infantry, one brigade of field and one of light artillery, two field companies of engineers, three companies of signals, one section of tanks and one company of armoured cars (in process of transfer to the cavalry), besides supply, transport, medical, ordnance and veterinary units.

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ECONOMICS

For Egypt, the modern phase of its public finance began with the accession of the Khedive Ismail, and its story since then is a fascinating tale of the steps by which the country, after having been brought to a state of bankruptcy, passed through a period of great stress, and finally attained prosperity and a large measure of financial autonomy.

Public Finance.—In 1862 the foreign debt of Egypt stood at £3,292,000. The period of wild extravagance, reckless borrowing and merciless exploitation of the fellahin which ensued was the subject of a remarkable report by Stephen Cave, a well-known banker, who was sent by the British government in Dec. 1875 to inquire into the situation. It described Egypt in 1875 as being burdened with a debt of £91,000,000—funded or floating—for which she had no return, for even from the Suez canal she derived no revenue, owing to the sale of the khedive's shares. Soon after Cave's report appeared (March 1876), default took place on several of the loans. Nearly the whole of the debt was held in England or France, and at the instance of French financiers the stoppage of payment was followed by a scheme to unify the debt. This scheme was blocked by the British bondholders, and its place was taken by another scheme drawn up by Goschen and Joubert, who represented the British and French bondholders respectively. That settlement in turn was superseded by the Law of Liquidation of July 1880,—equally short-lived, as events were to show. But out of all these attempts to secure solvency there remained two important results. One was the establishment of a Treasury of the Public Debt, known by its French title of *Caisse de la Dette*, and commonly spoken of simply as "the Caisse." The duty of this body was to act as receivers of the revenues assigned to the service of the debt, and they were given the right to sue the Egyptian government in the Mixed Tribunals for any breach of engagement to the bondholders. The other was the "Dual Control," the appointment of an Englishman and a Frenchman to superintend the revenue and expenditure of the country.

The 1880 settlement was wrecked by the Arabi rising, the riots at Alexandria, and the events generally which led to the British occupation of Egypt in 1882, followed by the losses incurred in the Sudan in the effort to prevent it falling into the hands of the Mahdi. On the initiative of Great Britain a conference between the representatives of the great powers and Turkey was held in London, and resulted in the signing of a convention in March 1885. The terms agreed upon in this instrument, known as the London Convention, were embodied in a khedivial decree, which, with some modification in detail, remained for twenty years the organic law under which the finances of Egypt were administered.

It divided the revenue of the country between the Caisse, as representing the bondholders, and the government, assigning to the service of the debt all revenue derived from the railway, telegraphs, port of Alexandria, customs (including tobacco) and from four of the provinces. It recognized, however, that the non-assigned revenue was insufficient to meet the necessary expenses of government, and a scale of administrative expenditure was drawn up. The Caisse was authorized, after payment of the coupons on the debt, to make good out of their balance in hand the difference between the authorized expenditure and the non-assigned revenue. If a surplus remained to the Caisse after making good such deficit the surplus was to be divided equally between the Caisse and the government. The Convention empowered Egypt to raise a loan of nine millions, guaranteed by all the powers, at a rate of interest of 3%. For the service of this loan —known as the Guaranteed loan—an annuity of £315,000 was provided in the Egyptian budget for interest and sinking fund. The £9,000,000 was sufficient to pay the Alexandria indemnities, to wipe out the deficits of the preceding years, to give the Egyptian treasury a working balance of £E.500,000, and to pro-

vide a million for new irrigation works. To the wise foresight which, at a moment when the country was sinking beneath a weight of debt, did not hesitate to add this million for expenditure on productive works, the present prosperity of Egypt is largely due.

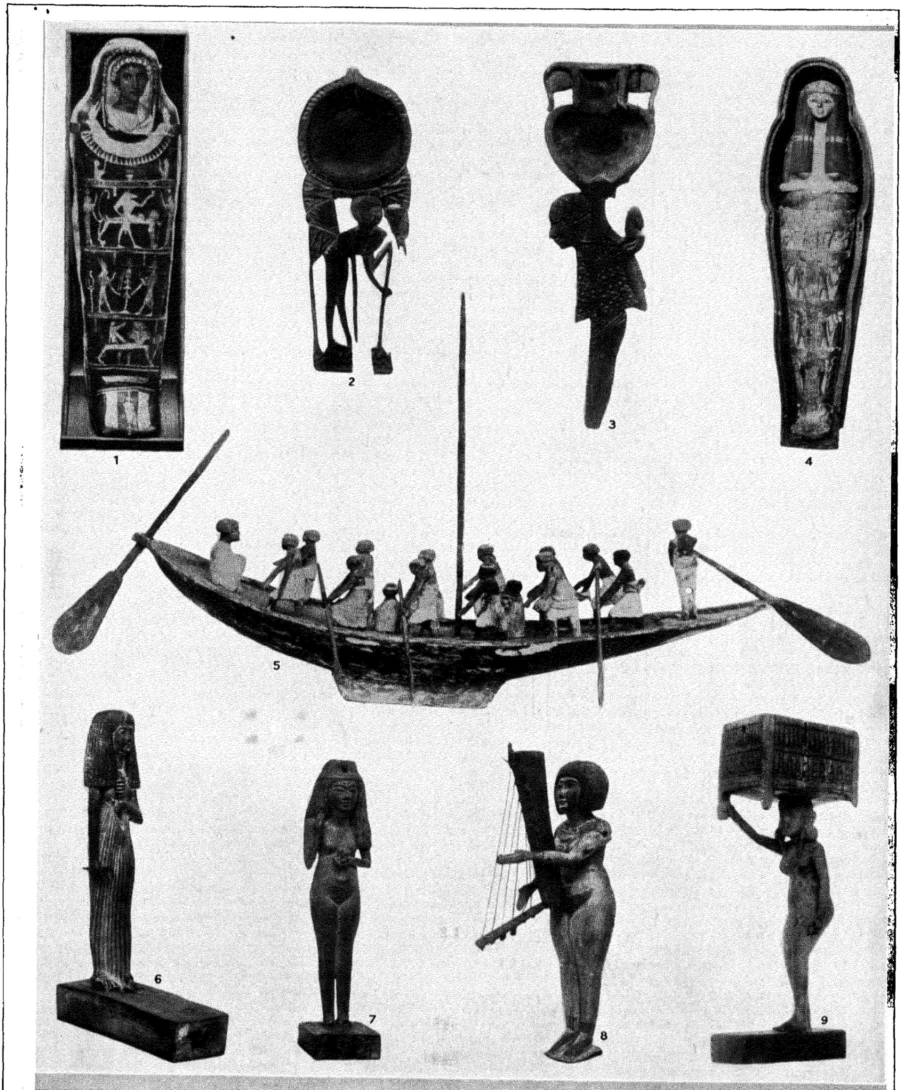
The provisions of the London Convention did not exhaust the restrictions which excluded the Egyptian government from financial autonomy. It was impossible, for example, to raise a loan without the consent of the Porte. Then it was not permissible, in virtue of the Capitulations, to levy taxes on foreigners without the consent of their respective governments. Again, no financial decision could be taken by the Egyptian government without the consent of the British official called the financial adviser, who in 1883 had replaced the Dual Control; though it is fair to add that this restriction long remained the chief safeguard for the purity of Egypt's finances. Finally came the series of commissions or boards known as Mixed Administrations and having relations of a quasi-independent character with the ministry of finance. Of these boards by far the most important was the Caisse. As first constituted it consisted of a French, an Austrian, and an Italian member; a British member was added in 1877 and a German and a Russian member in 1885. The revenue assigned to the debt charges was paid direct to the Caisse without passing through the ministry of finance. The assent of the Caisse (as well as that of the sultan) was necessary before any new loan could be issued, and in the course of a few years from its creation this body acquired very extensive powers. Besides the Caisse there was the Railway Board, which administered the railways, telegraphs and port of Alexandria for the benefit of the bondholders, and the Daïra and Domains commissions, which administered the estates mortgaged to the holders of those loans. Each of the three boards last named consisted of an Englishman, a Frenchman and an Egyptian.

During the years that immediately followed the signing of the London Convention, the financial policy of the Egyptian government was the exercise of the most rigid economy in all branches; and in his report on the financial results of 1888 Sir Evelyn Baring (afterwards Lord Cromer) was able to inform the British government that the situation was such that "it would take a series of untoward events seriously to endanger the stability of Egyptian finance and the solvency of the Egyptian government." From this moment the corner was turned, and the era of financial prosperity commenced. The principal feature of the successive Egyptian budgets of 1890–94 was the fiscal relief afforded to the population. From 1894 onward attention was turned to the legitimate demands of the spending departments and to the prosecution of public works. Of these the most notable was the construction (1898–1902) of the Aswân dam, which by bringing more land under cultivation permanently increased the resources of the country and widened the area of taxation. At the same time various changes were made in connection with the debt charges. With the consent of the powers a General Reserve Fund was created in 1888, into which was paid the Caisse's half-share in the eventual surplus of revenue. This fund, primarily intended as a security for the bondholders, might be drawn upon for extraordinary expenditure with the consent of the commissioners of the Caisse. Large sums were so advanced for the purposes of drainage and irrigation and other public works, and in relief of taxation. Secondly, by manipulation of certain sections of the public debt, a Conversion Economies Fund was established, for the purchase and cancellation of Egyptian stock. A Special Reserve Fund had been constituted in 1886 and was very largely made up of the net savings of the Egyptian government on its share of the annual surpluses from revenue. Of the three funds this last-named was the only one at the absolute disposal of the government. The whole of the extraordinary expenditure of the Sudan campaigns of 1896–98, with the exception of £800,000 granted by the British government, was paid out of this fund—a sum amounting in round figures to £1,500,000.

The inherent wealth of the country now began to assert itself against the artificial shackles of its State finance. During the four years 1883–86, both inclusive, the aggregate deficit amounted to £E.2,606,000. In 1887 there was practical equilibrium in the budget, in 1889 there was a surplus of £E.218,000. In 1895 the surplus exceeded, for the first time, £E.1,000,000. The growth of revenue was no less marked, in spite of reductions and remissions of taxation. The fact that Egypt was suffering very severely from the general fall in the price of commodities during that period makes the prosperity of the country the more remarkable. Had it not been for the great increase of production as the result of improved irrigation and the fiscal relief afforded to landowners, the agricultural depression would have impaired the financial situation. As it was, a much-needed re-assessment of the land tax, which occupied from 1899 to 1907, coupled with the remission of arrears, had been a powerful stimulus to rural prosperity. The blighting influence of international control, however, persisted, and its net result was to impose an extra charge of about £1,750,000 a year on the Egyptian treasury.

Egypt Gains Financial Liberty.—Freedom at last emerged from the 1904 understanding between France and England. A khedivial decree of Nov. 28, 1904, a decree which received the assent of the powers, swept away a host of the old restrictions, and gave the Egyptian government a free hand in the disposal of its own resources so long as the punctual payment of interest on the debt was assured. The plan of fixing a limit to administrative expenditure was abolished. The consent of the Caisse to the raising of a new loan was no longer required. The Caisse itself remained, but short of all political and administrative powers, its functions being strictly limited to receiving the assigned revenues and to ensuring the due payment of the coupon. The nature of the assigned revenue was altered, the land tax being substituted for those previously assigned, that tax being chosen as it had a greater character of stability than any other source of revenue. By this means Egypt gained complete control of its railways, telegraphs, the port of Alexandria and the customs, and as a consequence the mixed administration known as the Railway Board ceased to exist. The Conversion Economies Fund was also placed at the free disposal of the Egyptian government and a new General Reserve Fund was created, made up chiefly of the surpluses of the old General Reserve, Special Reserve, and Conversion Economies funds. This new fund started with a capital of £13,376,000 and was replenished by the surpluses of subsequent years, while it provided large capital expenditure for remunerative public works. Advance was now possible simultaneously along the lines of fiscal reform and increased administrative expenditure. Thus in 1906 the salt monopoly was abolished at a cost to the revenue of £175,000, while the reduction of import duties on coal and other fuels, livestock, etc., involved a further loss of £118,000, and an increase of over £1,000,000 in expenditure was budgeted for. In fact, from 1905 onwards it was practicable to draw up the Egyptian budget in accordance with the needs of the country and on sound financial principles. At the end of 1905 the public debt stood at £96½ millions, or at almost the exact figure it did in 1883, although by borrowing and conversion operations nearly £17,000,000 had in the meantime been added to the capital.

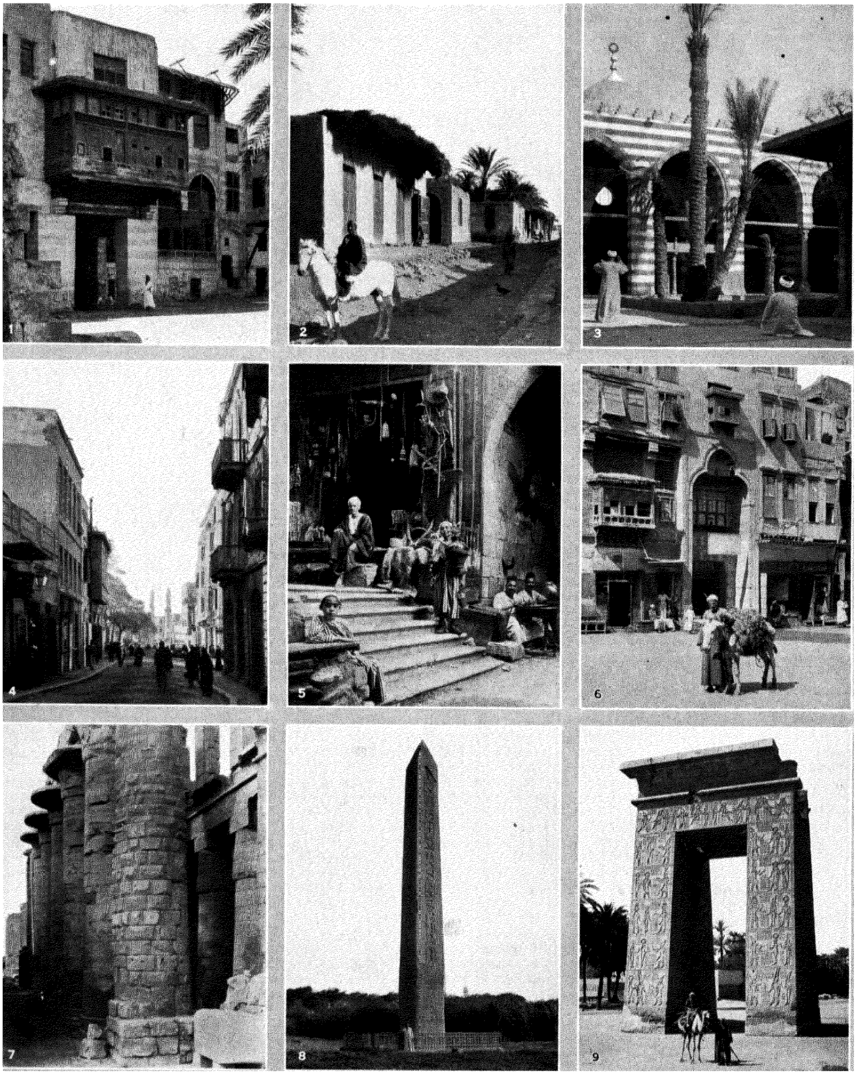
Since 1905 the public finance of the country and its material development have progressed hand in hand. Communications by road and rail have been rapidly improved, to the great advantage of the staple industry of cotton; and even more important has been the striking extension of scientific irrigation. The margin of cultivation in the Delta has been widely enlarged, 40,000 feddans south of Cairo have been converted from single to double crop production, and the 90,000 feddans previously in constant danger of being starved by a low Nile flood have been reduced to a negligible figure; all this being rendered possible by the construction (1902) and heightening (1912) of the Aswân dam, and the building of the Asyut (1902) and Isna (1909) barrages. It is the unremitting industry of the agricultural peasantry, stimulated by light and equitable taxation, by the establishment of a great measure of public security and economic freedom and by care for the public health, that has been the motive force turning these favouring conditions to such remarkable account. Private and public wealth was gradually built up thereby from impoverishment and bankruptcy, and provided funds which enabled the cul-



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

EGYPTIAN CARTONNAGES AND WOOD CARVINGS

1. Painted and gilt cartonnage coffin of Artemidorus. About A.D. 150
2, 3. Salve-spoons carved from hard wood. 18th dynasty, *c.* 1400 B.C.
4. Gilt cartonnage cover of coffin of the lady Henet-mehyet, 19th dynasty, *c.* 1300 B.C.
5. Carved wooden boat with rowers, from the furniture of a tomb, 11th dynasty, *c.* 2200 B.C.
6, 7, 8, 9. Wooden figures of girls. 17th–19th dynasties, *c.* 1400–1250 B.C.



PHOTOGRAPHS. (1) EWING GALLOWAY, (2) PUBLISHERS PHOTO SERVICE, (3, 5, 6, 8, 9) DONALD MCLEISH, (4, 7) ASSOCIATED SCREEN NEWS

STREETS AND BUILDINGS OF ANCIENT AND MODERN EGYPT

1. House in Cairo, showing type of window used for the harem, to ensure privacy. **2.** Street in Gizeh, ancient Egyptian town near Cairo, on the edge of the Sahara Desert. **3.** Muslims at prayer in the court of the Agha or Blue Mosque, Cairo. **4.** Bazaar quarters, Cairo. **5.** Curio shop in the Khalili Bazaar, Cairo. **6.** Booksellers' quarter, Cairo, with buildings of ancient Arabian architecture. **7.** Hypostyle hall in the temple of Karnak, constructed during the 18th and 19th dynasties (*c.* 1580–1322 B.C.). **8.** Obelisk at Heliopolis, one of a pair erected by Senusret I., 12th dynasty (*c.* 2000 B.C.). **9.** Portal at the Temple of Karnak. The inward slope of the perpendicular lines is characteristic of ancient Egyptian architecture

is in practice equivalent to £1-0-6 in British money, and the piastre (P.T.) to 2½d. There are silver coins of 2, 5, 10 and 20 piastres; nickel coins of 1, 2, 5 and 10 milliemes, and a bronze coin of ½ millieme; while the $\frac{1}{40}$ of a piastre, popularly called a para, is still commonly used in reckoning among the poorer classes. The dollar (Fallari) is reckoned at 20 piastres.

Agriculture and Land Tenure.—The chief industry of Egypt is agriculture. The proportions of the industry depend upon the area of land capable of cultivation. This again depends upon the fertilizing sediment brought down by the Nile and the measure in which lands beyond the natural reach of the flood water can be rendered productive by irrigation. By means of canals, "basins," dams and barrages, the Nile flood is now utilized to a greater extent than ever before (*see* IRRIGATION: *Egypt*). The result has been a great increase in the area of cultivated or cultivable land.

At the time of the French occupation of Egypt in 1798, it was found that the cultivable soil covered 4,429,400 acres, but the quantity actually under cultivation did not exceed 3,520,000 acres. Under improved conditions the area of cultivated land has risen to over 5½ million acres, and it is estimated that close on 8 million acres are cultivable.

Throughout Egypt the cultivable soil does not present any very great difference, being always the deposit of the river; it contains, however, more sand near the river than at a distance from it. Towards the Mediterranean its quality is injured by the salt with which the air is impregnated, and therefore it is not so favourable to vegetation. Of the cultivated land, some three-fourths is held, theoretically, in life tenancy. The state, as ultimate proprietor, imposes a tax which is the equivalent of rent. These lands are *Kharaji* lands, in distinction from the *Ushuri* or tithe-paying lands. The *Ushuri* lands were originally granted in fee, and are subject to a quit-rent. All tenants are under obligation to guard or repair the banks of the Nile in times of flood, or in any case of sudden emergency. Only to this extent does the *corvée* now prevail. Out of 1,153,759 proprietors of land in 1905, 1,005,705 owned less than 5 *feddans*. The number of proprietors owning over 50 *feddans* was 12,475. The acreage held by the first class was 1,264,084, that by the second class, 2,356,602. Over 1,600,000 *feddans* were held in holdings of from 5 to 50 *feddans*.

The kind of crops cultivated depends largely on whether the land is under perennial, flood or "basin" irrigation. Perennial irrigation is possible where there are canals which can be supplied with water all the year round from the Nile. This condition exists throughout the Delta and Middle Egypt, but only in parts of Upper Egypt; and under canal irrigation two and sometimes three crops can be harvested yearly. In tracts where perennial irrigation is impossible, the land is divided by rectangular dikes into "basins." Into these basins—which vary in area from 600 to 50,000 acres—water is led by shallow canals when the Nile is in flood. The silt-laden water is let in about the middle of August and the basins are begun to be emptied about the 1st of October. The land under basin irrigation grows only one crop a year; but the system is being steadily displaced by the extension of regular canals. This basin system is of immemorial use in Egypt, and it was not until Mohammed Ali (*c.* 1820) determined on the cultivation of sugar and cotton that perennial irrigation was introduced on a large scale. High land near the banks of the Nile which cannot be reached by canals is irrigated by raising water from the Nile by steam-pumps, water-wheels (*sakias*) worked by buffaloes, or water-lifts (*shadufs*) worked by hand. The *fellah* divides his land into little square plots by ridges of earth, and from the small canal which serves his holding he lets the water into each plot as needed. There are three agricultural seasons: (1) summer (*sefi*), April to October; (2) flood (*Nili*), from mid-July to the end of November; and (3) winter (*shetwi*), from November to March. Cotton, sugar and rice are the chief summer crops; wheat, barley, flax and vegetables are chiefly winter crops; maize, millet and "flood" rice are *Nili* crops; millet and vegetables are also, but in a less degree, summer crops. The approximate areas under cultivation in the various seasons are, in summer, 2,050,000 acres; in flood, 2,200,000 acres; in winter, 4,000,000 acres. The double-cropped area is over 2,500,000 acres. Although on the large farms iron ploughs, and threshing and grain-cleaning machines, have been introduced, the small cultivator prefers the simple native plough made of wood. Corn is threshed by a *norag*, a machine resembling a chair, which moves on small iron wheels or thin circular plates fixed to axle-trees, and is drawn in a circle by oxen.

Egypt is third among the cotton-producing countries of the world, its production per acre being the greatest of any country and its staple of a distinctive quality. Approximately 200,000 acres, chiefly in Lower Egypt, are devoted to cotton growing. The seed is sown in February in Upper Egypt and the crop is picked in September and October; in the Southern part of the Delta, operations are a month later, and in the Lower Delta sowings on a large scale do not take place until April or pickings until November and December. The cotton crop increasing from 1,700,000 *cantars* in 1878 to 4,100,000 in 1890, had reached 7,965,000 *cantars* in 1926. The cotton exported was valued in 1926 at £E 34,371,000, and in the previous year, before the slump in prices, it had reached the figure of £E 51,660,000.

While cotton is grown chiefly in the Delta, the sugar plantations, which cover about 65,000 acres, are mainly in Upper Egypt. The canes are planted in March and are cut in the following January or February. Beetroot is also grown to a limited extent for the manufacture of sugar. The export of sugar varies greatly with the world demand and price; in 1920, for example, £E 1,145,000 was the value of the exports; in the following year £E 313,000. The Société Générale des Sucreries has sugar factories scattered all over Upper Egypt, and their establishment at Nag Hamadi is said to be the largest of its kind in the world.

A coarse, strong tobacco used to be extensively grown, but its cultivation was prohibited in 1891, and the tobacco used locally and for cigarette manufacture comes chiefly from Greece, Turkey, and Syria. The duty derived from its import accounts for more than half the total customs revenue. Flax was an important crop in dynastic times: but neither it nor hemp is now grown to any large extent.

Maize (dhurra) occupies an even larger area than cotton, and is chiefly grown in Lower Egypt. In Upper Egypt its place is taken by millets. Both grains form the staple food of the peasantry. The stalk of the maize is also a very useful article. It is used in the building of the houses of the fellahin, as fuel, and, when green, as food for cattle. Wheat and barley are important crops. The barley in general is not of good quality, but the desert or "Mariut" barley, grown by the Bedouins in the coast region west of Alexandria, is highly prized for the making of beer. Beans and lentils are extensively sown, and form an important article of export. Rice is largely grown in the northern part of the Delta, where the soil is very wet. Two kinds are cultivated: *Sultani*, a summer crop, and *Sabaini*, a flood crop. *Sabaini* is a favourite food of the fellahin, while *Sultani* rice is largely exported. In the absence of grass, the chief green food for cattle and horses is clover, grown largely in the basin lands of Upper Egypt. To a less extent vetches and lucerne are grown for the same purpose.

Vegetables grow readily, and their cultivation is an important part of the work of the fellahin. The onion is grown in great quantities along the Nile banks in Upper Egypt, largely for export. Among other vegetables commonly raised are tomatoes (the bulk of which are exported), potatoes (of poor quality), leeks, marrows, cucumbers, cauliflowers, lettuce, asparagus and spinach.

The common fruits are the date, orange, citron, fig, grape, apricot, peach and banana. Olives, melons, mulberries and strawberries are also grown, though not in very large numbers. The olive tree flourishes only in the Fayum and the oases. The Fayum also possesses extensive vineyards. The date is a valuable economic asset, being one of the chief foods of the people: and efforts are being made to improve the breeds and the fertility of the universal date-palm.

There are fields of roses in the Fayum, which supply the market with rose-water. Of plants used for dyeing, the principal are bastard, saffron, madder, woad and the indigo plant. The leaves of the henna plant are used to impart a bright red colour to the palms of the hands, the soles of the feet, and the nails of both hands and feet, of women and children, the hair of old ladies and the tails of

horses. Indigo is very extensively employed to dye the shirts of the poorer classes, and is, when very dark, the colour of mourning; therefore, women at funerals, and generally after a death, smear themselves with it.

The Egyptians are not particularly a pastoral people, though the wealth of the Bedouin in the Eastern or Arabian desert consists in their camels, horses, sheep and goats. In the Nile valley the chief domestic animals are the camel, donkey, mule, ox, buffalo, sheep and goat. Horses are comparatively few, and are seldom seen outside the large towns, the camel and donkey being the principal beasts of burden. The cattle are short-horned, rather small and well formed. They are quiet in disposition, and much valued for agricultural labour by the people, who rarely slaughter them for meat. Buffaloes are largely employed for turning the *sakias*. Sheep (of which the greater number are black) and goats are abundant, and mutton is the ordinary butcher's meat. The wool is coarse and short. Poultry is plentiful and eggs form a considerable item in the exports. Pigeons are kept in every village and their flesh is a common article of food.

The chief fishing-ground is Lake Menzala, where some 4,000 persons are engaged in the industry, but fish are caught also in large quantities along the coast of the Delta. The salting and curing of the fish is done chiefly at Mataria, on Lake Menzala, and at Damietta. Dried and salted fish eggs, called *batarekh*, command a ready market. The Nile abounds in fish, but they are not table delicacies.

Canals.—The irrigation canals have from time immemorial been an outstanding feature in the agricultural life of Egypt, as they supplement the operations of the annual inundation of the Nile. Their role is becoming of increasing scope and importance, with the steady substitution of systematic perennial irrigation for the old wasteful system of basin irrigation. There are about 12,000 m. of irrigation canals, of which about 1,000 m., particularly in the Delta, are navigable for passengers and food. An essential concomitant of both the canals and the basins is an adequate system of drainage to prevent water-logging; and over 4,000 m. of main drainage courses are in operation.

The Delta canals derive their supply from four main channels. The Rayya Behera, known in its lower courses first as the Khatatba and afterwards as the Rosetta canal, follows the west bank of the Rosetta branch of the Nile and has numerous offshoots. The most important is the Mahmudia (50 m. long), which connects Alexandria with the Rosetta branch and supplies Alexandria with fresh water. The Rayya Menufia, or Menuf canal, connects the two branches of the Nile and supplies water to the large number of canals in the central part of the Delta. Following the right (eastern) bank of the Damietta branch is the Rayya Tewfiki, known below Benha as the Mansuria, and below Mansura as the Fareskur, canal. This canal has many branches. Farther east are other canals, of which the most remarkable occupy in part the beds of the Tanitic and Pelusiac branches. The superfluous water from all the Delta canals is drained off by *bahrs* (rivers) into the coast lakes.

The Ismailia or Fresh-water canal branches from the Nile at Cairo and follows, in the main, the course of the canal which anciently joined the Nile and the Red sea. It dates from Pharaonic times, having been begun by "Sesostris," continued by Necho II. and by Darius Hystaspes, and at length finished by Ptolemy Philadelphus. This canal, having fallen into disrepair, was restored in the 7th century A.D. by the Arabs who conquered Egypt, but appears not long afterwards to have again become unserviceable. The existing canal was dug in 1863 to supply fresh water to the towns on the Suez Canal.

In Upper Egypt the most important canals are the Ibrahimia and the Bahr Yusuf. They are both on the west side of the Nile. The Ibrahimia takes its water from the Nile at Assiut, and runs south to below Beni Suef. It now supplies the Bahr Yusuf, which runs parallel with and west of the Ibrahimia, until it diverges to supply the Fayum—a distance of some 350 m. It leaves the Ibrahimia at Derut near its original point of departure from the Nile. The Joseph whose name it bears was the famous Saladin: but he did little more than repair it, for it was probably executed under the Pharaohs. Besides supplying the canals of the Fayum with summer water, it fills many of the "basins" of Upper Egypt with water in flood time.

Weights and Measures.—The metrical system of weights and measures is in official but not in popular use. The most common Egyptian measures are the *fitr*, or space taken by the extension of the thumb and first finger; the *shibr* or span; and the cubit, varying from 22 to 26 inches. The land unit is the *feddan*, = nearly 1·04 acres, and divided into 24 *kirats*. The chief measure of weight is the *cantar* (of 100 *rotls* or 36 *okes*), and usually = 99·05 lb.; but a *cantar* of ginned cotton = 100 lb. and of unginned cotton = 315 lb. For delicate weights the *dirhem* (of 16 *kirats*) = 48 grams troy. The *Ardeb* = nearly 43½ gallons or 5½ bushels; and there are no specific liquid measures, as fluids are generally bought and sold by weight.

Time.—The time kept is that of 30 E., and is thus 2 hours ahead of Greenwich. In A.D. 1928, the Muslim year 1347 began on June 19, and the Coptic year 1645 on Sept. 11.

Manufactures and Industries.—Although essentially an agricultural country, Egypt is steadily developing its industrial capacity; and an integral feature of the nationalist movement is the extension of the manufacturing activities of the country and the larger conversion within the country itself of its raw materials into their finished products. The primary Egyptian industry, cotton, is still largely in the export stage; there are about 150 ginning factories scattered about the country, and some 200 presses; but the spinning of yarn and the extraction of oil from the seed are both yet on a very small scale. One consequence of the recent slump in prices has been a scheme for the erection of a large weaving factory near the Barrage. Sugar stands on a very different footing, the manufacture of refined sugar and molasses being efficiently exploited by a powerful French company, owning a number of highly organized refineries in Upper Egypt; their output of fine sugar has in some years exceeded 100,000 tons. Several towns in the Delta possess rice mills; and flour mills are found in every part of the country, the maize and other grains being ground for home consumption. Cement (about 50,000 tons a year) is manufactured by a Belgian company at Massaarah. Soap-making and leather-tanning are carried on, and there are breweries at Alexandria and Cairo. The manufacture of imported tobacco into cigarettes, carried on largely at Alexandria and Cairo, is an industry of considerable importance, though somewhat affected by the growing preference in Europe, since the war, for cheaper brands. Indigenous industries include the weaving of silk, woollen, linen and cotton goods, the handwoven silk shawls and draperies being often rich and elegant. The silk looms are chiefly at Mehallet el-Kubra, Cairo and Damietta. The Egyptians are noted for the making of pottery of the commoner kinds especially water-jars. There is at Cairo and in other towns a considerable industry in ornamental wood and metal work, inlaying with ivory and pearl, brass trays, copper vessels, gold and silver ornaments, etc. At Cairo and in the Fayum, attar of roses and other perfumes are manufactured. Boat-building is an important trade.

Mines. (*See* also under *Minerals*.)—Of recent years a systematic effort has been made by the Government to facilitate mineral discovery and development. The geological survey of the country, started in 1896, has been steadily pursued ever since; and ten years later, standard mining licences and leases were substituted for concessions covering large areas and shutting out general prospecting. In 1926 the mining industry as a whole gave employment to an average of 3,224 Egyptians and 135 Europeans; while continued interest was shown in prospecting. Apart from the carbonate of soda obtained from the natron lakes, petroleum and manganese ore are the chief products of the industry, and the output of phosphate, due largely to an Italian company at Kosseir, rose to 232,000 metric tons in 1926. There is a substantial quarrying business in stone and materials for concrete, plaster and brick-making; all this of course is confined to the desert area.

Trade Routes and Communications.—Its geographical position gives Egypt command of one of the most important trade

routes in the world; for it lies across the highway from Europe to the East. This has been the case from time immemorial, and the provision, in 1869, of direct maritime communication between the Mediterranean and the Red sea, by the completion of the Suez canal, ensured for the Egyptian route the supremacy in sea-borne traffic to Asia, which the discovery of the passage to India by way of the Cape of Good Hope had menaced for three and a half centuries. The Suez canal (*q.v.*), however, has economic and political reactions on Egypt which far transcend its importance as a route for local trade. Still the value of a harbour like Port Said, which is visited by the many steamship lines which use the canal, is inestimable. Besides the shipping which passes through the canal, other steamers run direct from European ports to Alexandria. There is also a direct mail service between Suez and Port Sudan.

The chief means of internal communication are, in the Delta the railways, in Upper Egypt the railway and the river. The railways are of two kinds: (1) those state-owned and state-worked, (2) light railways owned and worked by private companies. Railway construction dates from 1852, when the line from Alexandria to Cairo was begun, by order of Abbas I. The state railways have a gauge of 4 ft. 8½ in. The main system is extremely simple. Trunk lines from Alexandria (via Damanhur and Tanta) and from Port Said (via Ismailia) traverse the Delta and join at Cairo. From Cairo the railway is continued south up the valley of the Nile and close to the river. At first it follows the west bank, crossing the stream at Nag Hamadi, 354 m. from Cairo, by an iron bridge 437 yd. long. Thence it continues on the east bank to Shellal, 3 m. above Aswan and 685 m. from Alexandria. This main line service is supplemented by a steamer service on the Nile from Shellal to Wadi Halfa, on the northern frontier of the Anglo-Egyptian Sudan, whence there is direct railway communication with Khartum and the Red sea (*see* SUDAN).

Branch lines connect Cairo and Alexandria with Suez and with almost every town in the Delta. Before the Suez canal was opened passengers and goods were taken to Suez from Cairo by a railway 84 m. long which ran across the desert. This line, now disused, had itself superseded the "overland route" organized by Lieutenant Thomas Waghorn, R.N., *c.* 1830, for the conveyance of passengers and mails to India. In Upper Egypt a line, 40 m. long, runs west from Wasta, a station 56 m. S. of Cairo, to Abuksa in the Fayum. Another railway (narrow gauge) goes from Kharga Junction, a station on the main line 24 m. S. of Girga, to the oasis of Kharga.

In the Delta the light railways supplement the ordinary lines and connect the villages with the towns and seaports. There is also a network of private lines in the Fayum: all these being on the 75 c.m. gauge. In 1880 944 m. of state lines were open; in 1900 the figure was 1,393, and it is now close on 2,500 m. For several years before 1904 the administration of the railways was carried on by an international or mixed board for the security of foreign creditors. In the year named the railways came directly under the control of the Egyptian government, and development has been steady though not rapid. The light railways owned by private companies are over 800 m. in length.

Westward from Alexandria a railway, begun in 1904 by the khedive, Abbas II., runs parallel with the coast, and is intended to be continued to Tripoli. The line forms the eastern end of the great railway system which will eventually extend from Tangier to Alexandria. During the World War railway connection with Palestine was effected from Kantara on the Canal across Northern Sinai, and has since been maintained.

The Nile is navigable throughout its course in Egypt, and is largely used as a means of cheap transit of heavy goods. Lock and bridge tolls were abolished in 1899 and 1901, respectively. Above Cairo the Nile is the favourite tourist route, while between Shellal and the Sudan frontier it is the only means of communication. Among the craft using the river the dahabīya is a characteristic native sailing vessel, somewhat resembling a house-boat. From the Nile, caravan routes lead westward to the various oases and eastward to the Red sea, the shortest (120 m.) and most used of the eastern routes being that from Kena to Kosseir. Roads suitable for wheeled vehicles are found in Lower Egypt, but the majority of the tracks are bridle-paths, the camel being still the chief vehicle of trade, especially in the desert. Modern methods, however, are asserting themselves. The use of the motor-car is increasing; and in 1927 the number of motor vehicles registered was 9,712 cars, 3,195 cycles, 1,866 vans, 5,086 cabs and 1,087 omnibuses. The Imperial Airways, Ltd., has begun a weekly service for mails and passengers between Cairo and Basra, via Gaza and Baghdad.

The Egyptian postal system is highly organized and efficient, and in striking contrast with its condition in 1870, when there were but nineteen post-offices in the country. All the branches of business transacted in European post-offices are carried on by the Egyptian service, Egypt being a member of the Postal Union. It was the first foreign country to establish a penny postage with Great Britain, and there are now over 500 post-offices and 3,000 postal stations. Post-office savings banks are making substantial headway.

All the important towns are connected by telegraph, the telegraphs being state-owned and worked by the railway administration. Egypt is also connected by cables and land-lines with the outside world. One land-line connects at El-Arish with the line through Syria and Asia Minor to Constantinople. Another line connects at Wadi Halfa with the Sudan system, affording direct telegraphic communication via Khartum and Gondokoro with Uganda and Mombasa. The Eastern Telegraph Company, by concessions, have telegraph lines across Egypt from Alexandria via Cairo to Suez, and from Port Said to Suez, connecting their cables to Europe and the East. The principal cables are from Alexandria to Malta, Gibraltar and England; from Alexandria to Crete and Brindisi; from Suez to Aden, Bombay, China and Australia. Wireless stations at Alexandria and Cairo are open to the public, and an agreement was concluded with the Marconi Co. in 1926 for establishing commercial wireless telegraphy at Abu Zabal near Cairo.

Commerce.—The trade of Egypt has developed enormously since the British occupation in 1882. In that year the total value of its external trade was £19 millions; in 1926 it was £95 millions, and in the interval it had frequently been even higher. Its general movement in recent years is shown in the following table:—

Annual Returns of Value of Imports and Exports in Millions of £E

Year	Imports	Exports	Year	Imports	Exports
1911	27·3	28·9	1919	47·4	75·9
1912	25·9	34·6	1920	101·9	85·5
1913	27·9	31·7	1921	55·5	36·4
1914	21·7	24·1	1922	43·3	48·7
1915	19·4	27·0	1923	45·3	58·4
1916	31·1	37·5	1924	50·7	65·7
1917	33·2	41·1	1925	58·2	59·2
1918	51·2	45·4	1926	52·4	41·8

The wealth of Egypt lying in the cultivation of its soil, almost all the exports are agricultural produce, while the imports are mostly manufactured goods, minerals and hardware. The chief exports in order of importance are: raw cotton, cotton seed, sugar, cigarettes, onions, eggs, phosphates, rice and gum-arabic. The gum is not of native produce, being in transit from the Sudan. Of less importance are the exports of hides and skins, wheat and other grains, wool, quails, lentils, dates and Sudan produce in transit. The principal articles imported are: cotton goods and other textiles, coal, iron and steel, timber, tobacco, machinery, flour, automobiles, alcoholic liquors, petroleum, fruits, coffee and live animals. There is an *ad valorem* duty of 8% on imports and of about 1% on exports. Alcohol, mineral oils and certain articles of luxury pay heavier duties; and there is an elaborate and high tariff on tobacco. The tobacco is imported chiefly from Turkey, Syria and Greece, is made into cigarettes in Egypt, and in this form exported to a value which has been as high as £1,000,000 a year, but is now down to about one-third of that figure.

In comparison with cotton, all other exports are of minor account. The cotton exported, of which Great Britain takes nearly one-half, is worth over four-fifths of the total value of goods sent

abroad. Next to cotton, sugar is the most important article exported. A large proportion of the sugar manufactured is, however, consumed in the country and does not figure in the trade returns. Of the imports the largest single item is cotton goods, three-fourths of which are sent from England. Woollen goods come chiefly from England and Germany, silk goods from France. Iron and steel goods, machinery, locomotives, etc., come chiefly from England, Belgium, the U.S.A. and Germany, coal from England, live stock from Turkey and the Red sea ports, coffee from Brazil, timber from Russia, Turkey and Sweden.

In 1926 the largest importing nation was Great Britain, though its share in the total imports was down to 22% against a considerably higher ratio in previous years; the rest of the British empire provided another 11%. France had a fairly steady share in the import business at 11%; and Italy had fallen to 9%. Next to these countries came Germany with 7%, the U.S.A. with 5%, and Belgium with 4%; while Turkey, which once ranked second in the list, had less than 3%. In her export trade, Egypt's best customer continues to be Great Britain, though its part in the total exports had fallen from a more predominant figure to 45% in 1926. Next came the U.S.A. with 13% and France with 12% of the trade; Italy had less than 6% and Germany less than 5%; Japan and Switzerland following with still smaller ratios. The normal distribution of the external commerce was, it should be noted, to some extent dislocated in 1926 by the coal stoppage in England and the appreciation of the lira in Italy.

Cotton.—Egypt's disposable wealth for purposes of foreign trade is predominantly represented by the value of her cotton exports, which has been as high as £80 millions in 1920, and stood at £55 millions before the great fall in prices of 1926. Although these exports satisfy only about 4% of the world's consumption, the length and strength of the best Egyptian fibre enables it to command a marked premium in price over practically all other cottons. It is this virtual monopoly of the finest cotton and the great rise in the price of cotton generally which set the scale of Egypt's leap into prosperity. No reliable analysis can be given of the amount of the total payment annually remitted by other countries to Egypt for her cotton, which represents this premium: but its importance and the seriousness of the loss if Egyptian cotton did not possess the advantage mentioned can be gauged by comparing the average price, over a series of years of Egyptian standard cotton with what is known as American middling. At the beginning of this century, the advantage in favour of the Egyptian product was 35%. It steadily rose, until during the war period it reached the striking figure of 82%: and since the war it has averaged over 50%. While these premiums are simply indices of the relative demand for Egyptian and American standard cottons in the market of the most important outside purchaser, the maintenance of the higher quality of which they are the reflection is of outstanding importance to Egypt, as otherwise her cotton would become a satellite of American and follow its price levels. While Egypt's primary economic interest is thus the maintenance of the present pre-eminence in the quality of her cotton, the danger that this advantage may be discounted by a falling off in quantity also calls for serious attention. The general statistics of the crop have indicated for a long time past a decline in the yield per feddan; it was 5·2 cantars at the beginning of this century; it is now under 4 cantars per feddan. Fears have been expressed that the cotton lands are suffering from want of an adequate rotation of crops; or from over-saturation: or from the loss of fertilizing silt which the old inundation system provided but which is lacking in canal water. Even, however, if we assume the dependability and equal weight of the statistics throughout, there have been important disturbing factors at work, which make it advisable to accept with caution as yet the deduction that the culture of the cotton plant is, for one or other reason, generally less successful than it used to be. Among such factors may be mentioned the extension of cotton culture into less fertile districts and the cultivation of varieties, such as Sakellarides, which appear to combine better quality lint with lower yield. (*See* COTTON.) A congress of the International Federation of Master Cotton Spinners' and Manufacturers' Associations was held in Egypt early in 1927 and urged the Government to make every effort to improve the quality and increase the yield of Egyptian cotton, and to maintain and improve the drainage system.

Shipping.—More than 90% of the external trade used to pass through the port of Alexandria; but the ratio has been reduced by the canal ports to about two-thirds. Over 4,000 ships enter and clear harbour at Alexandria every year. The total tonnage entering the port was 4¾ million tons in 1925. Of the total volume of cargo landed and shipped at all the Egyptian ports in 1926, about 45% is carried by British vessels, 14% by Italian, 11% by Greek and 6% by German. Of the total number of passengers landed and embarked, 44% travelled in British, 25% in Italian and 15% in French vessels.

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(*b*) Administration: Sir John Bowring's *Report on Egypt . . .* to Lord Palmerston (1840) shows the system obtaining at that period. For the study of the state of Egypt at the time of the British occupation, 1882, and the development of the country since, the most valuable documents are:

I. *Official.*—The *Reports on the Finances, Administration and Condition of Egypt*, issued yearly since 1892 (the reports 1888–91 were exclusively financial). Annual returns are published in Cairo in English or French by the various ministries, and a useful report on the *Economic and Financial Situation of Egypt* is published annually by the British department of Overseas Trade on the trade of Egypt and of Alexandria and of the tonnage and shipping of the Suez Canal are also issued yearly.

II. *Non-official.*—Lord Cromer, *Modern Egypt* (2 vols., 1908), an authoritative record; Alfred (Lord) Milner, *England in Egypt*, first published in 1892, the story being brought up to 1904 in the 11th edition; Sir A. Colvin, *The Making of Modern Egypt* (1906). *See* also the works cited in *History*, last section.

(*c*) Law: H. Lamba, *De l'évolution de la condition juridique des Européens en Égypte* (1896); J. H. Scott, *The Law affecting Foreigners in Egypt . . .* (1907); *The Egyptian Codes* (1892).

(*d*) Irrigation, agriculture, geology, etc.: *Despatch from Sir Evelyn Baring Enclosing Report on the Condition of the Agricultural Population in Egypt* (1888). The reports (*Egypt*, No. 2, 1901, and *Egypt*, No. 2, 1904), by Sir William Garstin on irrigation projects on the Upper Nile are very valuable records—notably the 1904 report. W. Willcocks, *Egyptian Irrigation* (2nd ed., 1899). Annual meteorological reports are issued by the Public Works Department, Cairo. The same department issues special irrigation reports. *See* for geology Carl von Zittel, *Beiträge zur Geologie und Paläontologie der libyschen Wüste* (Cassel, 1883); *Reports of the Geological Survey of Egypt* (Cairo, 1900, *et seq.*).

HISTORY

I. EARLIEST TIMES TO MUSLIM CONQUEST

The Prehistoric Age.—Tradition, mythology and later customs make it possible to recover a scrap of the political history of prehistoric Egypt. Menes, the founder of the 1st Dynasty, united the two kingdoms of Upper and Lower Egypt. In the prehistoric period, therefore, these two realms were separate. The capital of Upper Egypt was Nekheb, now represented by the ruins of El Kab, with the royal residence across the river at Nekhen (Hieraconpolis); that of Lower Egypt was at Buto in the marshes, with the royal residence in the quarter called Pe. Nekhêbi, goddess of El Kab, represented the Upper or Southern Kingdom, which was also under the tutelage of the god Seth, the goddess Buto and the god Horus similarly presiding over the Lower Kingdom. The royal god in the palace of each was a hawk or Horus. The spirits of the deceased kings were honoured respectively as the jackal-headed spirits of Nekhen and the hawk-headed spirits of Pe. As we hear also of the "Spirits of On" it is probable that Heliopolis was at one time capital of a kingdom. In

after days the prehistoric kings were known as "Worshippers of Horus" and in Manetho's list they are the νέκυες, "Dead" and ἥρωες, "Heroes," being looked upon as intermediate between the divine dynasties and those of human kings.

It is doubtful whether we possess any writing of the prehistoric age. A few names of the kings of Upper and of Lower Egypt are preserved in the first line of the Palermo stone, but no annals are attached to them.

Archaic Period.—Names of a number of kings attributable to the 1st dynasty are known from tombs at Abydos. Unfortunately, with few exceptions they are "Horus titles" in place of personal names by which they were recorded in lists of Abydos and Manetho. Perhaps the earliest king of the dynasty is one whose name has been provisionally read Nar-mer; of him there exists a magnificent carved and inscribed slate palette found at Hieraconpolis with figures of the king and his vizier, war standards and prisoners. Another very early king is Aha; his name is found in two tombs, one at Nagāda, north of Thebes and nearly opposite the road to the Red Sea, the other at Abydos. Manetho makes the 1st dynasty "Thinite"; Thīs being the capital of the "nome" in which Abydos lay, Menes must represent either Narmer or Aha or both. Upper Egypt always had precedence over Lower Egypt and it seems clear that Menes came from the former and conquered the latter. According to tradition he founded Memphis, which lay on the frontier of his conquest; probably he resided there as well as at Abydos; at any rate relics of one of the later kings of the 1st dynasty have already been recognized in its vast necropolis. Of the eight kings of the 1st dynasty, three—the fifth, sixth and seventh in the Ramesside list of Abydos—are positively identified by their names on objects from the royal tombs at Abydos and others are scarcely less certain. Two of the kings have also left tablets at the copper and turquoise mines of Wadi Maghāra in Sinai. The royal tombs are built of brick, but one of them, that of Usaphais, had its floor of granite from Elephantine. They must have been filled with magnificent furniture and provisions of every kind, including even annual record-tablets of the reigns, carved in ivory and ebony. The annals of the Palermo stone commenced with the 1st dynasty.

The 2nd dynasty of Manetho appears to have been separated from the 1st even on the Palermo stone; it also was Thinite, and the tombs of several of its nine (?) kings were found at Abydos. The 3rd dynasty is given as Memphite by Manetho. Two of the kings built huge mastaba-tombs at Bêt Khallaf near Abydos, but the architect and learned scribe Imhōtp designed for one of these two kings, named Zoser, a second and mightier monument at Memphis, the great step-pyramid of Sakkara with all its wonderful appurtenances. Zoser and Imhōtp built also at Heliopolis. (In Ptolemaic times Imhōtp received the honour of deification.) Monuments and written records are henceforth more numerous and important, and the fragments of the Palermo annals show a very full scale of record for the reign of Snefru at the end of this dynasty. The events in the three years that are preserved include a successful raid upon the Nubians and the construction of ships and gates of cedar-wood which must have been brought from the forests of the Lebanon. Snefru also set up a tablet at Wadi Maghāra in Sinai. He built two pyramids, one of them at Mēdūm in steps, the other, probably in the perfected form, at Dahshūr, both lying between Memphis and the Fayūm.

The Pyramid Period.—Pyramids did not cease to be built in Egypt till the New Kingdom; but from the end of the 3rd to the 6th dynasty is pre-eminently the time when the royal pyramid in stone was the chief monument left by each successive king. Zoser and Snefru have been already noticed. The personal name enclosed in a cartouche is henceforth the commonest title of the king. We now reach the 4th dynasty containing the famous Herodotean names of Cheops (*q.v.*), Chephren (Khafrê) and Mycerinus (Menkeurê), builders respectively of the Great, the Second and the Third Pyramids of Giza. In the best art of this time there was a grandeur which was never again attained. Perhaps the noblest example of Egyptian sculpture in the round is a diorite statue of Chephren, one of several found by Mariette in the so-called Temple of the Sphinx. This "temple" proves to be a monumental gate at the lower end of the great causeway leading to the plateau on which the pyramids were built. A king Dedefrê, between Cheops and Chephren, built a pyramid at Abu-Roāsh. Shepseskaf is one of the last in the dynasty. Tablets of most of these kings have been found at the mines of Wadi Maghāra. In the neighbourhood of the pyramids there are numerous mastabas of the court officials with fine sculpture in the chapels, and a few decorated tombs from the end of this centralized dynasty of absolute monarchs are known in Upper Egypt. A tablet which describes Cheops as the builder of various shrines about the Great Sphinx has been shown to be a priestly forgery, but the Sphinx itself may have been carved out of the rock under the splendid rule of the 4th dynasty.

The 5th dynasty is said to be of Elephantine, but this must be a mistake. Its kings worshipped Rē, the sun, rather than Horus, as their ancestor, and the title "son of the Sun" began to be written by them before the cartouche containing the personal name, while another "solar" cartouche, containing a name compounded with Rē, followed the title "king of Upper and Lower Egypt." Sahurē and the other kings of the dynasty built magnificent temples with obelisks dedicated to Rē, one of which, that of Neuserrē at Abusīr has been thoroughly explored. The marvellous tales of the Westcar Papyrus, dating from the Middle Kingdom, narrate how three of the kings were born of a priestess of Rē. The pyramids of several of the kings are known. The early ones are at Abusīr, and the best preserved of the pyramid temples, that of Sahurē, excavated by the German Orient-Gesellschaft, in its architecture and sculptured scenes, has revealed an astonishingly complete development of art and architecture as well as warlike enterprise by sea and land at this remote period; the latest pyramid belonging to the 5th dynasty, that of Unas at Sakkāra, is inscribed with long ritual and magical texts. Exquisitely sculptured tombs of this time are very numerous at Memphis and are found throughout Upper Egypt. Of work in the traditional temples of the country no trace remains, probably because, being in limestone, it has all perished. The annals of the Palermo stone were engraved and added to during this dynasty; the chief events recorded for the time are gifts and endowments for the temples. Evidently priestly influence was strong at the court. Expeditions to Sinai and Puoni (Punt) are commemorated on tablets.

The 6th dynasty if not more vigorous was more articulate; inscribed tombs are spread throughout the country. The most active of its kings was the third, named Pepi or Phiops, from whose pyramid at Sakkāra the capital, hitherto known as "White Walls," derived its later name of Memphis (MN-NFR, Mempi); a tombstone from Abydos celebrates the activity of a certain Una during the reigns of Pepi and his successor in organizing expeditions to the Sinai peninsula and south Palestine, and in transporting granite from Elephantine and other quarries. Herkhuf, prince of Elephantine and an enterprising leader of caravans to the south countries both in Nubia and the Libyan oases, flourished under Merenrē and Pepi II. called Neferkerē. On one occasion he brought home a dwarf dancer from the Sudan, described as being like one brought from Puoni in the time of the 5th dynasty king Asesa; this drew from the youthful Pepi II. an enthusiastic letter which was engraved in full upon the façade of Herkhuf's tomb. The reign of the last-named king, begun early, lasted over 90 years, a fact so long remembered that even Manetho attributes to him 94 years; its length probably caused the ruin of the dynasty. The local princelings and monarchs had been growing in culture, wealth and power, and after Pepi II. an ominous gap in the monuments, pointing to civil war, marks the end of the Old Kingdom.

The Early Intermediate Period.—The 7th and 8th dynasties are said to have been Memphite, but of them scarcely any record survives beyond some names of kings in the lists. Literary texts record a complete upset of social order and the intrusion of an invading race. The duration of this dark and miserable period is unknown. The long Memphite rule was broken by the 9th and 10th dynasties of Heracleopolis Magna (Hnês) in Middle Egypt. They may have spread their rule by conquest over Upper Egypt

and then overthrown the Memphite dynasty. Kheti or Achthoës was apparently a favourite name with the kings, but they are very obscure. It would seem that after they in turn were overthrown their monuments at Heracleopolis were systematically destroyed. The chief relics of the period are certain inscribed tombs at Assiût; it appears that one of the kings, whose praenomen was Mikerê, supported by a fleet and army from Upper Egypt, and especially by the prince of Assiût, was restored to his paternal city of Heracleopolis, from which he had been driven out; his pyramid, however, was built in the old royal necropolis at Memphis.

The Middle Kingdom.—The princes of Thebes asserted their independence and founded the 11th dynasty, which pushed its frontiers northwards until finally it occupied the whole country. Its kings were named Menthotp (from Mont, one of the gods of Thebes) and Antef, and were buried at Thebes, Nibhôtp Menthotp I. probably established his rule over all Egypt. The funerary temple of Nebhepré Menthotp III., the last but one of these kings, has been excavated by the Egypt Exploration Fund at Deir el Bahri, and must have been a magnificent monument. His successor, Sankhkerê Menthotp IV. is known to have sent an expedition by the Red sea to Puoni.

Monuments of the Theban 12th dynasty are abundant and often of splendid design and workmanship, whereas previously there had been little produced since the 6th dynasty that was not half barbarous. Although not much of the history of the 12th dynasty is ascertained, the Turin papyrus and many dated inscriptions fix the succession and length of reign of the eight kings very accurately. The troubled times that the kingdom had passed through taught the long-lived monarchs the precaution of associating a competent successor on the throne. The "nomarchs" and the other feudal chiefs were inclined to strengthen themselves at the expense of their neighbours; a firm hand was required to hold them in check and distribute the honours as they were earned by faithful service. The tombs of the most favoured and wealthy princes are magnificent, particularly those of certain families in Middle Egypt at Beni Hasan, El Bersha, Assiût and Deir Rîfa, and it is probable that each had a court and organization within his districts or "nome" like that of the royal palace in miniature. Eventually, in the reigns of Senwosri III. and Amenemhē III. the succession of strong kings appears to have centralized all authority very completely. The names in the dynasty are Amenemhē (Ammenemes) and Senwosri (formerly read Usertsen or Senusert). The latter seems to be the origin of Sesostris (*q.v.*) of the legends. Amenemhē I., the first king, whose connection with the previous dynasty is not known, reigned for 30 years, ten of them being in partnership with his son Senwosri I. He had to fight for his throne and then reorganize the country, removing his capital or residence from Thebes to a central situation near Lisht, about 25m. south of Memphis. His monuments are widespread in Egypt, the quarries and mines in the desert as far as Sinai bear witness to his great activity, and we know of an expedition which he made against the Nubians. The "Instructions of Amenemhē to his son Senwosri," whether really his own or a later composition, refer to these things, to his care for his subjects, and to the ingratitude with which he was rewarded, an attempt on his life having been made by the trusted servants in his own palace. The story of Sinûhi is the true or realistic history of a soldier, who having overheard the secret intelligence of Amenemhē's death, fled in fear to Palestine or Syria and there became rich in the favour of the prince of the land; growing old, however, he successfully sued for pardon from Senwosri and permission to return and die in Egypt.

Senwosri I. was already the executive partner in the time of the co-regency, warring with the Libyans and probably in the Sudan. After Amenemhē's death he fully upheld the greatness of the dynasty in his long reign of 45 years. The obelisk of Heliopolis is amongst his best-known monuments, and the damming of the Lake of Moeris (*q.v.*) must have been in progress in his reign. He built a temple far up the Nile at Wadi Halfa and there set up a stela commemorating his victories over the tribes of Nubia. The fine tombs of Ameni at Beni Hasan and of Hepzefa at Assiût belong to his reign. The pyramids of both father and son are at Lisht.

Amenemhē II. was buried at Dahshûr; he was followed by Senwosri II., whose pyramid is at Illahûn at the mouth of the Fayûm. In his reign were executed the fine paintings in the tomb of Khnemhotp at Beni Hasan, which include a remarkable scene of Semitic Bedouins bringing eye-paint to Egypt from the eastern deserts. In Manetho he is identified with Sesostris (*see* above), but Senwosri I. and still more Senwosri III. have a better claim to this distinction. The latter warred in Palestine and in Nubia, and marked the south frontier of his kingdom by a statue and stelae at Semna beyond the Second Cataract. Near his pyramid was discovered the splendid jewellery of some princesses of his family. The tomb of Thethotp at El Bersha, celebrated for the scene of the transport of a colossus amongst its paintings was finished in this reign.

Amenemhē III. completed the work of Lake Moeris and began a series of observations of the height of the inundation at Semna which was continued by his successors. In his reign of 46 years he built a pyramid at Dahshûr, and at Hawara near the Lake of Moeris another pyramid, together with the Labyrinth which seems to have been an enormous funerary temple attached to the pyramid. His name was remembered in the Fayûm during the Graeco-Roman period and his effigy worshipped there as Pera-marres; *i.e.*, Pharaoh Marres (Marres being his praenomen graecized). Amenemhē IV.'s reign was short, and the dynasty ended with a queen Sebeknefru (Scemiophris), whose name is found in the scanty remains of the Labyrinth. The 12th dynasty numbered eight rulers and lasted for 213 years. Great as it was, it created no empire outside the Nile valley, and the Labyrinth, its most imposing monument, which according to the testimony of the ancients rivalled the pyramids, is now represented only by a vast bed of quarrymen's chips.

The Later Intermediate Period.—The history of this is very obscure. Manetho gives us the 13th (Diospolite) dynasty, the 14th (Xoite from Xois in Lower Egypt), the 15th and 16th (Hyksos) and the 17th (Diospolite) but his names are lost except for some Hyksos kings. The Abydos tablet ignores all between the 12th and 18th dynasties. The Turin papyrus preserves many names on its shattered fragments, and the monuments are for ever adding to the list, but it is difficult to assign them accurately to their places. The Hyksos names can in some cases be recognized by their foreign aspect, the peculiar style of the scarabs on which they are engraved or by resemblances to those recorded in Manetho. The kings of the 17th dynasty too are generally recognizable by the form of their name and other circumstances. Manetho indicates marvellous crowding for the 12th and 14th dynasties, but it seems better to suggest a total duration of 300 or 400 years for the whole period than to adopt Meyer's estimate of about 210 years.

Amongst the kings of the 13th dynasty (including perhaps the 14th) not a few are represented by granite statues of colossal size and fine workmanship, especially at Thebes and Tanis, some by architectural fragments, some by graffiti on the rocks about the First Cataract. Some few certainly reigned over all Egypt. Sebkhotp is a favourite name, no doubt to be connected with the god of the Fayûm. Several of the Theban kings named Antef must be placed here rather than in the 11th dynasty. A decree of one of them degrading a nomarch who had sided with his enemies was found at Coptos engraved on a doorway of Senwosri I.

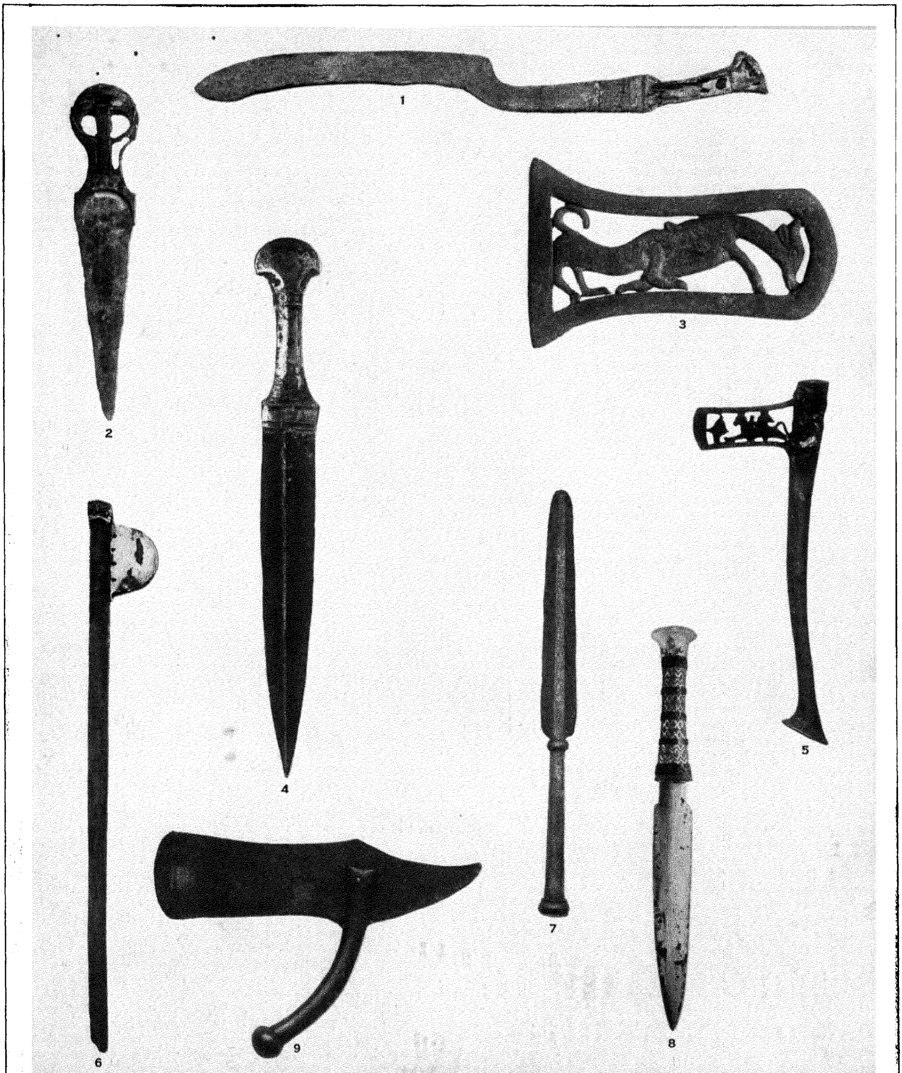
In its divided state Egypt would fall an easy prey to the foreigner. Manetho says that the Hyksos (*q.v.*) gained Egypt without a blow. Their domination must have lasted a considerable time, the Rhind mathematical papyrus having been copied in the 33rd year of a king Apophis. The monuments and scarabs of the Hyksos kings are found throughout Upper and Lower Egypt and even in Nubia; those of Khian somehow spread as far as Crete and Baghdad. The Hyksos, in whom Josephus recognized the children of Israel, worshipped their own Syrian deity, identifying him with the Egyptian god Seth, and endeavoured to establish his cult throughout Egypt, to the detriment of the native gods. It is to be hoped that definite light may one day be forthcoming on the whole of this critical episode which had such a profound effect on the character and history of the Egyptian people. The spirited overthrow of the Hyksos ushered in the glories in arms and arts which marked the New Empire. The 17th dynasty, in which the

chief names are Seqenenrê and Kamosi, probably began the struggle, at first as semi-independent kinglets at Thebes. The mummy of Seqenenrê, the earliest in the great find of royal mummies at Deir el Bahri, shows the head frightfully hacked and split, perhaps in a battle with the Hyksos.

The New Empire.—The epithet "new" is generally attached to this period, and "empire" instead of "kingdom" marks its wide conquests and organized rule abroad. The glorious 18th dynasty seems to have been closely related to the 17th. Its first task was to crush the Hyksos power in the north-east of the Delta; this was fully accomplished by its founder Ahmosi (or Amasis) capturing their great stronghold of Avaris. Amasis next attacked them in south-west Palestine, where he captured Sharuhen after a siege of three years. He fought also in Nubia, besides overcoming factious opposition in his own land. The principal source for the history of this time is the biographical inscriptions at El Kab of a namesake of the king, Ahmosi son of Abana, a sailor and warrior whose exploits extend to the reign of Tuthmosis I. Amenophis I. (Amenhotp) succeeding Amasis, fought in Libya and extinguished finally an Ethiopian kingdom which, centred at Kerma near the Third Cataract, had flourished since the end of the 12th dynasty, Tuthmosis I. (*c.* 1540 B.C.) was perhaps of another family, but obtained his title to the throne through his wife Ahmosi. After some 30 years of settled rule uninterrupted by revolt, Egypt was now strong enough and rich enough to indulge to the full its new taste for war and lust of conquest. It had become essentially a military state. The whole of the administration was in the hands of the king with his vizier and other court officials; no trace of the feudalism of the Middle Kingdom survived. Tuthmosis thoroughly subdued Cush, which had already been placed under the government of a viceroy, whose dominion extended from Napata just below the Fourth Cataract on the south to El Kab in the north, so that it included the first three "nomes" of Upper Egypt, which agriculturally were not greatly superior to Nubia. Turning next to Syria, Tuthmosis carried his arms as far as the Euphrates. He made the first of those great additions to the temple of the Theban Ammon at Karnak by which the pharaohs of the empire rendered it by far the greatest of the existing temples in the world; the temple of Deir el Bahri was also designed by him. Towards the end of his reign, his elder sons being dead, Tuthmosis associated Hatshepsut, his daughter by Ahmosi, with himself upon the throne. He was the first of a long line of kings to be buried in the Valley of the Tombs of the Kings at Thebes. A son, Tuthmosis II., succeeded as the husband of his half-sister Hatshepsut, but reigned only two or three years, during which he warred in Nubia and placed Tuthmosis III., his son by a concubine Esi, upon the throne beside him (*c.* 1500 B.C.). After her husband's death the ambitious Hatshepsut assumed the full regal power; upon her monuments she wears the masculine garb and aspect of a king, though the feminine gender is retained for her in the inscriptions. On some monuments of this period her name appears alone, on others in conjunction with that of Tuthmosis III., while the latter again may appear without the queen's; but this extraordinary woman must have had a great influence over her stepson and was the acknowledged ruler of Egypt. Hatshepsut cultivated the arts of peace. She restored the worship in those temples of Upper and Lower Egypt which had not yet recovered from the religious oppression and neglect of the Hyksos. She completed and decorated the temple of Deir el Bahri, embellishing its walls with scenes calculated to establish her claims, representing her divine origin and upbringing under the protection of Ammon, and her association on the throne by her human father. The famous sculptures of the great expedition by water to Puoni, the land of incense on the Somali coast, are also here, with many others. At Karnak, Hatshepsut laboured chiefly to complete the works projected in the reigns of Tuthmosis I. and II., and set up two obelisks in front of the entrance as it then was. One of these, still standing, is the most brilliant ornament of that wonderful temple. A date of the 22nd year of her reign has been found at Sinai, no doubt counted from the beginning of the co-regency with Tuthmosis I. Not much later, in his 22nd year, Tuthmosis III. is reigning alone in full vigour. While she lived, the personality of the queen secured the devotion of her servants and held all ambitions in check. Not long after her death there was a violent reaction. Prejudice against the rule of a woman, particularly one who had made her name and figure so conspicuous, was probably the cause of this outbreak, and perhaps sought justification in the fact that, however complete was her right, she had in some degree usurped a place to which her stepson (who was also her nephew) had been appointed. Her cartouches began to be defaced or her monuments hidden by other buildings, and the same rage pursued some of her most faithful servants in their tombs. But the beauty of the work seems to have restrained the hand of the destroyer. Then came the religious fanaticism of Ikhnaton, mutilating all figures of Ammon and all inscriptions containing his name; this made havoc of the exquisite monuments of Hatshepsut; and the restorers of the 19th dynasty, refusing to recognize the legitimacy of the queen, had no scruples in replacing her names by those of the associate kings, Tuthmosis I., II. or III. In the royal lists of Sethos I. and Rameses II., Hatshepsut has no place, nor is her reign referred to on any later monument.

The immense energy of Tuthmosis III. now found its outlet in war. Syria had revolted, perhaps on Hatshepsut's death, but by his 22nd year the monarch was ready to lead his army against the rebels. Unlike his predecessors, who merely overran one after another a series of isolated city states, Tuthmosis had to face the organized resistance of a large combination, embracing the whole of western Syria and headed by the city of Kadesh on the Orontes. Six carefully planned campaigns had to be fought in order to reach and capture that city. In the 33rd year of his reign he marched through Kadesh, fought his way to Carchemish, defeated the forces that opposed him there and crossed over the Euphrates into the territory of the king of Mitanni. In all he fought 17 campaigns in Syria until the spirit of revolt was entirely crushed in a second capture of Kadesh. The wars in Libya and Ethiopia were of less moment. In the intervals of war Tuthmosis III. proved himself a wonderfully efficient administrator, with his eye on every corner of his dominions. The Syrian expeditions occupied six months in most of his best years, but the remaining time was spent in activity at home, repressing robbery and injustice, rebuilding and adorning temples with the labour of his captives and the plunder and tribute of conquered cities, or designing with his own hand the gorgeous sacred vessels of the sanctuary of Ammon. In his later years some expeditions took place into Nubia. The children of the subdued princelings in Asia and elsewhere were taken as hostages to Egypt and there educated to succeed their fathers with a due understanding of the might of Pharaoh both to protect and to punish. Thus was an empire established on a sound basis, probably for the first time in history. Tuthmosis died in the 54th year of his reign. His mummy, found in the *cachette* at Deir el Bahri is remarkable for the low forehead; yet we consider him the greatest of all the Pharaohs.

Tuthmosis III. was succeeded by his son Amenophis II., whom he had associated on the throne at the end of his reign. One of the first acts of the new king was to lead an army into Syria where revolt was again rife; he reached and perhaps crossed the Euphrates and returned home to Thebes with seven captive kings of Tikhsi and much spoil. The kings he sacrificed to Ammon and hanged six bodies on the walls, while the seventh was carried south to Napata and there exposed as a terror to the Ethiopians. Amenophis reigned 26 years and left his throne to his son, Tuthmosis IV., who is best remembered by a granite tablet recording his clearance of the Great Sphinx. He also warred in northern Syria and in Cush. His son, Amenophis III. (*c.* 1400 B.C.), was a mighty builder, especially at Thebes, where his reign marks a new epoch in the history of the great temples, Luxor being his creation, while avenues of rams, pylons, etc., were added on a vast scale to Karnak. He married a certain Taia, who, though apparently of humble parentage, was held in great honour by her husband as afterwards by her son. Amenophis III. warred in Ethiopia, but his sway was long unquestioned from Napata to the Euphrates. Small objects with his name and that of Taia are found on the mainland and in the islands of Greece. Through the fortunate discovery of cuneiform tablets deposited by his successor in the archives at Tell el-Amarna, we can see how the rulers of the great kingdoms beyond



BY COURTESY OF (1-7, 9) THE TRUSTEES OF THE BRITISH MUSEUM, (8) FROM CARTER, "THE TOMB OF TUT-ANKH-AMEN"

EGYPTIAN TOOLS AND WEAPONS

1. Bronze khepesh-scimitar, 19th dynasty, 1350 B.C. 2. Dagger with characteristic haft, 12th dynasty (*c.* 2000 B.C.). 3. Bronze axe-blade, 18th dynasty. Open work; dog hunting gazelle. 4. Bronze dagger; haft of carved sheet-gold; 18th dynasty (*c.* 1580 B.C.). 5. Axe with open-work blade, in original hafting; 18th dynasty. 6. Pole-axe with copper blade, probable date *c.* 2700 B.C. 7. Cast of ceremonial spear-head, 17th dynasty *c.* 1600 B.C. 8. Iron dagger, 18th dynasty. Decorated gold haft with knob of rock crystal. 9. Bronze razor, probably of 18th dynasty

FROM CARTER, "THE TOMB OF TUT·-ANKH AMEN"

FURNITURE FROM TOMB OF TUTANKHAMUN (c. 1400 B.C.), LUXOR

1 and 2. A state chair of wood, overlaid with gold and richly decorated with carving. On the back and sides are patterns of papyrus rushes and water fowl in low relief. The lions' heads are of chased gold. Tutankhamun and his queen are represented in the panel

3. Casket of wood covered with gesso, decorated with a series of paintings representing Tutankhamun in his chariot, vanquishing his enemies. The paintings are full of action and are considered one of the greatest artistic treasures of tomb

the river, Mitanni, Assyria and even Babylonia, corresponded with Amenophis, gave their daughters to him in marriage and congratulated themselves on having his friendship. Within the empire the descendants of the Syrian dynasts conquered by his father, having been educated in Egypt, ruled their paternal possessions as the abject slaves of Pharaoh. A constant stream of tribute poured into Egypt, sufficient to defray the cost of all the splendid works that were executed. Amenophis caused a series of large scarabs unique in their kind to be engraved with the name and parentage of his queen Taia, followed by varying texts commemorating like medals the boundaries of his kingdom, his secondary marriage with Gilukhipa, daughter of the king of Mitanni, the formation of a sacred lake at Thebes, a great hunt of wild cattle, and the number of lions the king slew in the first ten years of his reign. The colossi known to the Greeks by the name of the Homeric hero Memnon which look over the western plain of Thebes, represent this king and were placed before the entrance of his funerary temple, the rest of which has disappeared. His palace lay farther south on the west bank, built of crude brick covered with painted stucco. Towards the end of his reign of 36 years, Syria was invaded by the Hittites from the north and the people called Khabiri from the eastern desert; some of the kinglets conspired with the invaders to overthrow the Egyptian power, while those who remained loyal sent alarming reports to their sovereign.

Amenophis IV., son of Amenophis III. and Taia, was perhaps the most remarkable character in the long line of the Pharaohs. He was a religious fanatic, who had probably been high priest of the sun-god at Heliopolis, and had come to view the sun as the visible source of life, creation, growth and activity, whose power was demonstrated in foreign lands almost as clearly as in Egypt. Thrusting aside all the multitudinous deities of Egypt and all the mythology even of Heliopolis, he devoted himself to the cult of the visible sun-disc, applying to it as its chief name the hitherto rare word Aton, meaning "sun"; the traditional divine name Harakht (Horus of the horizon), given to the hawk-headed sun-god of Heliopolis, was however allowed to subsist and a temple was built at Karnak to this god. The worship of the other gods was officially recognized until his fifth year, but then a sweeping reform was initiated by which apparently the new cult alone was permitted. Of the old deities Ammon represented by far the wealthiest and most powerful interests, and against this long-favoured deity the Pharaoh hurled himself with fury. He changed his own name from Amenhotep, "Ammon is satisfied," to Ikhnaton, "pious to Aton," erased the name and figure of Ammon from the monuments, even where it occurred as part of his own father's name, abandoned Thebes, the magnificent city of Ammon, and built a new capital at El Amarna in the plain of Hermopolis, on a virgin site upon the edge of the desert. This with a large area around he dedicated to Aton in the sixth year while splendid temples, palaces, houses and tombs for his god, for himself and for his courtiers were rising around him. In all local temples the worship of Aton was instituted. The confiscated revenues of Ammon and the tribute from Syria and Cush provided ample means for adorning Akhetaton, "the horizon of Aton," the new capital, and for richly rewarding those who adopted the Aton teaching fervently. But meanwhile the political needs of the empire were neglected; the dangers which threatened it at the end of the reign of Amenophis III. were never properly met; the dynasts in Syria were at war amongst themselves, intriguing with the great Hittite advance and with the Khabiri invaders. Those who relied on Pharaoh and remained loyal as their fathers had done sent letter after letter appealing for aid against their foes. But though a general was despatched with some troops, he seems to have done more harm than good in misjudging the quarrels. At length the tone of the letters becomes one of despair, in which flight to Egypt appears the only resource left for the adherents of the Egyptian cause. Before the end of the reign Egyptian rule in Syria had probably ceased altogether. Ikhnaton died in or about the 17th year of his reign, *c.* 1350 B.C. He had a family of daughters who appeared constantly with him in all ceremonies, but no son. Two sons-in-law, mere boys, followed him with brief reigns, but the second, Tutankhaton, soon changed his name to Tutankhamun and without abandoning Akhetaton entirely, began to restore to Karnak its ancient splendour, with new monuments dedicated to Ammon. Ikhnaton's reform had not reached deep amongst the masses of population; they probably retained all their old religious customs and superstitions, while the priesthoods throughout the country must have been fiercely opposed to the heretic's work, even if silenced during his lifetime by force and bribes. Tutankhamun died after six years of reign and was buried at Thebes in the famous tomb which Lord Carnarvon and Howard Carter found still packed with its precious furniture. One more adherent of Ikhnaton, a priest named Ay, ruled for a short time. At length a soldier Haremhab, came to the throne as a whole-hearted supporter of the old religion without the heretical family taint of his predecessors; soon Aton and the whole of his royal following suffered the fate they had imposed upon Ammon; their monuments were destroyed and their names and figures erased, while those of Ammon were restored. From the time of Rameses II. onwards the years of the reigns of the heretics were counted to Haremhab, and Ikhnaton was described as "that criminal of Akhetaton." Haremhab had to bring order as a practical man into the long-neglected administration of the country and to suppress the extortions of the official classes by severe measures. His laws to this end were engraved on a great stela in the temple of Karnak, of which sufficient remains to bear witness to his high aims, while the prosperity of the succeeding reigns shows how well he realized the necessities of the state. He probably began also to re-establish the prestige of Egypt by military expeditions in the surrounding countries.

Haremhab appears to have legitimated his rule by marriage to a royal princess, but it is probable that Rameses I. who succeeded as founder of the 19th dynasty, was not closely related to him. Rameses in his brief reign of two years planned and began the great colonnaded hall of Karnak. His son, Seti I., having subdued the Bedouin Shasu, who had invaded Palestine and withheld all tribute, proceeded to the Lebanon. Here cedars were felled for him by the Syrian princes, and the Phoenicians paid homage before he returned home in triumph. The Libyans had also to be dealt with, and afterwards Seti advanced again through Palestine, ravaged the land of the Amorites and came into conflict with the Hittites. The latter, however, were now firmly established in the Orontes valley, and a treaty with Mutallu, the king of Kheta, reigning far away in Cappadocia, probably ended the wars of Seti. In his ninth year he turned his attention to the gold-mines in the eastern desert of Nubia and improved the road thither. Meanwhile the great work at Karnak projected by his father was going forward, and throughout Egypt the injuries done to the monuments by Ikhnaton were thoroughly repaired; the erased inscriptions and figures were restored, not without many blunders. Seti's temple at Abydos and his galleried tomb in the Valley of the Tombs of the Kings stand out as the most splendid examples of their kind in design and in decoration. Rameses II. succeeded at an early age and reigned 67 years, during which he finished much that was begun by Seti and filled all Egypt and Nubia with his own monuments, some of them beautiful but most, necessarily entrusted to inferior workmen, of coarse execution. The excavation of the rock temple of Abu Simbel and the completion of the great hall of Karnak were his greatest achievements in architecture. His wars began in his second year, their field comprising the Nubians, the Libyans, the Syrians and the Hittites. In his fifth year, near Kadesh on the Orontes, his army was caught unprepared and divided by a strong force of chariots of the Hittites and their allies, and Rameses himself was placed in the most imminent danger; but through his personal courage the enemy was kept at bay till reinforcements came up and turned the disaster into a victory. The incidents of this episode were a favourite subject in the sculptures of his temples, where their representation was accompanied by a poetical version of the affair and other explanatory inscriptions. Kadesh, however, was not captured, and after further contests, in his 21st year, Rameses and the Hittite king Khattusil (Kheta-sar) made peace, with a defensive alliance against foreign aggression and internal revolt (*see* HITTITES). In the 34th year, *c.* 1250 B.C., Khattusil with his friend or subject, the king of Kode, came from his distant capital to see the wonders of Egypt in person, bringing one of

his daughters to be wife of the splendid Pharaoh. Rameses II. paid much attention to the Delta, which had been neglected until the days of Seti I., and resided there constantly; the temple of Tanis must have been greatly enlarged and adorned by him; a colossus of the king placed here was over 90ft. in height, exceeding in scale even the greatest of the Theban colossi which he had erected in his mortuary temple of the Rameseum. Towards the end of the long reign the vigilance and energy of the old king diminished. The military spirit awakened in the struggle with the Hyksos had again departed from the Egyptian nation; mercenaries from the Sudan, from Libya and from the northern nations supplied the armies, while foreigners settled in the rich lands of the Delta and harried the coasts. It was a time too when the movements of the nations that so frequently occurred in the ancient world were about to be particularly active. Mineptah, (*c.* 1225 B.C), succeeding his father Rameses II., had to fight many battles for the preservation of his kingdom and empire. Apparently most of the fighting was finished by the fifth year of his reign; in his mortuary temple at Thebes he set up a stela of that date recording a great victory over the Libyan immigrants and invaders, which rendered the much harried land of Egypt safe. The last lines picture this condition with the crushing of the surrounding tribes. Libya was wasted, the Hittites pacified, Canaan, Ashkelon, Gezer, Yenoam sacked and plundered; "Israel is desolated, his seed is not, Khor (Palestine) has become a widow (without a protector) for Egypt." The Libyans are accompanied by allies whose names, Sherden, Shekelesh, Ekwash, Lukku, Teresh, suggest identifications with Sardinians, Sicels, Achaeans, Lycians and Tyrseni or Etruscans. The Sherden had been in the armies of Rameses II. and are distinguished by their remarkable helmets and, apparently, body armour of metal. The Lukku are certainly the same as the Lycians. Probably they were all sea-rovers from the shores and islands of the Mediterranean, who were willing to leave their ships and join the Libyans in raids on the rich lands of Egypt. Mineptah was one of the most unconscionable usurpers of the monuments of his predecessors, including those of his own father, who, it must be admitted, had set him the example. The coarse cutting of his cartouches contrasts with the splendid finish of the Middle Kingdom work which they disfigure. It may be questioned whether it was due to a wave of enthusiasm amongst the priests and people, leading them to re-dedicate the monuments in the name of their deliverer, or a somewhat insane desire of the king to perpetuate his own memory in a singularly unfortunate manner. Mineptah, the 13th son in the huge family of Rameses, must have been old when he ascended the throne; after his first years of reign his energies gave way, and he was followed by a quick succession of inglorious rulers, Seti II., the queen Tuosri, Amenmesse, Siptah; the names of the last two were erased from their monuments.

A great papyrus written after the death of Rameses III. and recording his gifts to the temples briefly reviews the conditions of the troublous times which preceded his reign. "The land of Egypt was in the hands of chiefs and rulers of towns, great and small slaying each other; afterwards a certain Syrian made himself chief; he made the whole land tributary before him; he united his companions and plundered their property (*i.e.*, of the other chiefs). They made the gods like men, and no offerings were presented in the temples. But when the gods inclined themselves to peace . . . they established their son Setnekht to be ruler of every land." Of the Syrian occupation we know nothing further. Setnekht (*c.* 1200 B.C.), had a very short reign and was not counted as legitimate, but he established a lasting dynasty (probably by conciliating the priesthood). He was father of Rameses III., who revived the glories of the empire. The dangers that menaced Egypt were similar to those which Mineptah had to meet at his accession. Again the Libyans and the "peoples of the sea" were acting in concert. The latter now comprised Peleset (probably Cretan ancestors of the Philistines) Thekel, Shekelesh, Denyan (Danaoi?) and Weshesh; they had invaded Syria from Asia Minor, reaching the Euphrates, destroying the Hittite cities and progressing southwards, while their ships gathered plunder from the coasts of the Delta. This fleet joined the Libyan invaders, but was overthrown with heavy loss by the Egyptians, in whose ranks there actually served many Sherdan and Kehaka, Sardinian and Libyan mercenaries. Egypt itself was thus clear of enemies; but the chariots and warriors of the Philistines and their associates were advancing through Syria, their families and goods following in ox-carts, and their ships accompanying them along the shore. Rameses led out his army and fleet against them and struck them so decisive a blow that the migrating swarm submitted to his rule and paid him tribute. In his 11th year another Libyan invasion had to be met, and his suzerainty in Palestine forcibly asserted. His vigour was equal to all these emergencies and the later years of his reign were spent in peace. Rameses III., however, was not a great ruler. He was possessed by the spirit of decadence, imitative rather than originating. It is evident that Rameses II. was the model to which he endeavoured to conform, and he did not attempt to preserve himself from the weakening influences of priestcraft. To the temples he not only restored the property which had been given to them by former kings, but he also added greatly to their wealth, the Theban Ammon receiving by far the greatest share. The land held in the name of different deities is estimated at about 15% of the whole of Egypt; various temples of Ammon owned two-thirds of this, Rē of Heliopolis and Ptah of Memphis being next in wealth. His palace was at Medinet Habu on the west bank of Thebes in the south quarter; and here he built a great temple to Ammon, adorned with scenes from his victories and richly provided with divine offerings. Shortly before the death of the old king a plot in the harem to assassinate him and apparently to place one of his sons on the throne, was discovered and its investigation ordered, leading after his death to the condemnation of many high-placed men and women. Nine kings of the name of Rameses now followed each other ingloriously in the space of about 80 years to the end of the 20th dynasty, the power of the high priests of Ammon ever growing at their expense. The Libyans began again their encroachments, and there was undoubtedly great distress amongst certain portions of the population. We read in a papyrus of a strike of starving labourers in the Theban necropolis who would not work until corn was given to them, and apparently the government storehouse was empty at the time, perhaps in consequence of a bad Nile. At this time the Theban necropolis was being more systematically robbed than ever before. Under Rameses IX. an investigation took place which showed that one of the royal tombs before the western cliffs had been completely ransacked and the mummies burnt. Three years later the Valley of the Tombs of the Kings was attacked and the sepulchres of Seti I. and Rameses II. were robbed. The authority of the last king of the 20th dynasty, Rameses XII., was shadowy. Hrihor, the high priest, gathered into his own hands the real power, and succeeded him at Thebes, *c.* 1100 B.C.

The Libyan Dynasties in the Delta.—At this juncture a prince at Tanis named Smendes, (Esbentêti) founded a separate dynasty in the Delta (21st dynasty). From this period dates a remarkable papyrus containing the report of an envoy named Unamûn, sent to Syria by Hrihor with a recommendation to Smendes, in order to obtain cedar timber from Byblus; Unamûn learned to his cost that the ancient prestige of Egypt in Syria had entirely disappeared. The Tanite line of kings generally had the overlordship of the high priests of Thebes; the descendants of Hrihor, however, sometimes by marriage with princesses of the other line, could assume cartouches and royal titles, and in some cases perhaps ruled the whole of Egypt. Ethiopia may have been ruled with the Thebais, but the records of the time are very scanty. The mummies from the despoiled tombs of the kings were the object of much anxious care to the kings of this dynasty; after being removed from one tomb to another, they were finally deposited in a shaft near the temple of Deir el Bahri, where they remained till our day. Eventually these royal mummies were all secured for the Cairo museum.

Libyan soldiers had long been employed in the army, and their military chiefs settled in the large towns and acquired wealth and power, while the native rulers grew weaker and weaker. The Tanite dynasty may have risen from a Libyan stock, though there is nothing to prove it; the 22nd dynasty are clearly, from their names, of foreign extraction, and their genealogy indicates distinctly a Lib-

yan military origin in a family of rulers of Heracleopolis Magna in Middle Egypt. Sheshonk (Shishak) I., the founder of the dynasty, (*c.* 950 B.C.), seems to have fixed his residence at Bubastis in the Delta, and his son married the daughter of the last king of the Tanite dynasty. Heracleopolis seems henceforth for several centuries to have been capital of Middle Egypt, which was considered as a more or less distinct province. Sheshonk secured Thebes, making one of his sons high priest of Ammon, and whereas Solomon appears to have dealt with a king in Egypt on something like an equal footing, Sheshonk re-established Egyptian rule in Palestine and Nubia and his expedition in the fifth year of Rehoboam subdued Israel as well as Judah, to judge by the list of city names which he inscribed on a wall of the temple of Karnak. Osorkon I. inherited a prosperous kingdom from his father, but no further progress was made. It required a strong hand to curb the Libyan chieftains, and divisions soon began to show themselves in the kingdom. The 22nd dynasty lasted through many generations; but there were rival kings, and it seems that the 23rd dynasty was contemporaneous with the end of the 22nd. The kings of the 23rd dynasty had little hold upon the subject princes, who spent the resources of the country in feuds amongst themselves. A separate kingdom had meanwhile been established in Ethiopia, probably under a Libyan chieftain. Our first knowledge of it is at this moment, when the Ethiopian king Pankhi, already held the Thebais. The energetic prince of Sais, Tefnakht, followed by most of the princes of the Delta, subdued most of Middle Egypt, and by uniting these forces, threatened the Ethiopian border. Heracleopolis Magna, however, with its petty king Pefteuaubasti, held out against Tefnakht, and Pankhi coming to its aid not only drove Tefnakht out of Middle Egypt, but also captured Memphis and received the submission of the princes and chiefs; in all, these included four "kings" and fourteen other chiefs. According to Diodorus the Ethiopian state was theocratic, ruled through the king by the priests of Ammon. The account is probably exaggerated; but even in Pankhi's record the piety of the king, especially towards Ammon, is very marked.

The 24th dynasty consisted of a single Saite king named Bocchoris (Bekerrinf), son of Tefnachthus, apparently the above Tefnakht. Another Ethiopian invader, Shabako (Sabacon) is said to have burnt Bocchoris alive.[1] The Ethiopian rule of the 25th dynasty was now firmly established, and the resources of the two countries together might have been employed in conquest of Syria and Phoenicia; but at this very time the Assyrian empire, risen to the highest pitch of military greatness, began to menace Egypt. The Ethiopian could do no more than encourage or support the Syrians in their fight for freedom against Sargon and Sennacherib. Shabako was followed by Shebitku and Shebitku by Tirhaka. Tirhaka was energetic in opposing the Assyrian advance, but in 671 B.C., Esarhaddon defeated his army on the border of Egypt, captured Memphis with the royal harem and took great spoil. The Egyptian resistance to the Assyrians was probably only half-hearted; in the north especially there must have been a strong party against Ethiopian rule. Tirhaka laboured to propitiate the north country, and probably rendered the Ethiopian rule more acceptable throughout Egypt. Notwithstanding, the Assyrian king entrusted the Government and collection of tribute to the native chiefs; twenty princes in all are enumerated in the records, including one Assyrian to hold the key of Egypt at Pelusium. Scarcely had Esarhaddon withdrawn before Tirhaka returned from his refuge in the south and the Assyrian garrisons were massacred. Esarhaddon promptly prepared a second expedition, but died on the way to Egypt in 668 B.C.; his son, Assur-bani-pal sent it forward, routed Tirhaka and reinstated the governors. At the head of these was Necho (Niku), king of Sais and Memphis, father of Psammetichus, who founded the 26th dynasty; and no doubt was related to Bocchoris and Tefnakht, the victims of Ethiopian invasion. We next hear that correspondence with Tirhaka was intercepted, and that Necho, together with Pekrûr of Psapt (at the entrance to the Wadi Tumilat) and the Assyrian governor of Pelusium, was taken

[1]Bocchoris is represented by Mycerinus in Herodotus, but confused with Menkeure of the 14th dynasty, whose name is correctly rendered as Mencheres by Manetho.

to Nineveh in chains to answer the charge of treason. Whatever may have occurred, it was deemed politic to send Necho back loaded with honours and surrounded by a retinue of Assyrian officials. Upper Egypt, however, was loyal to Tirhaka, and even at Memphis the burial of an Apis bull was dated by the priests as in his reign. Immediately afterwards he died. His nephew Tandamane, received by the upper country with acclamations, besieged and captured Memphis, Necho being probably slain in the encounter. But in 661 (?) Assur-bani-pal drove the Ethiopian out of Lower Egypt, pursued him up the Nile and sacked Thebes. This was the last and most tremendous visitation of the Assyrian scourge. All the Ethiopian kings from Pankhi to Tandamane were buried in pyramids at their ancestral home at Napata.

Psammetichus (Psamêtk), 664–610 B.C., the son of Necho, succeeded his father as a vassal of Assyria in his possessions of Memphis and Sais, allied himelf with Gyges, king of Lydia, and aided by Ionian and Carian mercenaries, extended and consolidated his power.[1] By the ninth year of his reign he was in full possession of Thebes. Assur-bani-pal's energies throughout this crisis were entirely occupied with revolts nearer home, in Babylon, Elam and Arabia. The Assyrian armies triumphed everywhere, but at the cost of complete exhaustion. Under the firm and wise rule of Psammetichus, Egypt recovered its prosperity after terrible losses inflicted by internal wars and the decade of the Assyrian invasions. The revenue went up by leaps and bounds. Psammetichus guarded the frontiers of Egypt with three strong garrisons, placing the Ionian and Carian mercenaries especially at the Pelusian Daphnae in the north-east, from which quarter the most formidable enemies were likely to appear. A great Scythian horde, destroying all before it in its southward advance, is said by Herodotus to have been turned back by presents and entreaties. Diplomacy backed up by vigorous preparations may have deterred the Scythians from the dangerous enterprise of crossing the desert to Egypt. Towards the end of his reign he loyally sent support to the Assyrians against the attacks of the Medes and Babylonians.

When Psammetichus began to reign, the situation of Egypt was very different from what it had been under the empire. The development of trade in the Mediterranean and contact with new peoples and new civilizations in peace and war had given birth to new ideas among the Egyptians and at the same time to a loss of confidence in their own powers. The Theban supremacy was gone and the Delta was now the wealthy and progressive part of Egypt; piety increased amongst the masses, unenterprising and unwarlike, but proud of their illustrious antiquity. The Ethiopians had already turned for their models to the times of the ancient supremacy of Memphis, and the sculptures and texts on tomb and temple were made to conform as closely as possible to those of the Old Kingdom. In non-religious matters, however, the Egyptians were inventing and perhaps borrowing. To enumerate a few examples of this which are already definitely known: we find that the forms of legal and business documents became more precise; the mechanical arts of casting in bronze on a core and of moulding figures and pottery were brought to the highest pitch of excellence; and portraiture in the round on its highest plane was better than ever before, and admirably lifelike, revealing careful study of the external anatomy of the individual.

Psammetichus died in the 54th year of his reign and was succeeded by his son Necho, 610–594 B.C. The Assyrians finally succumbed in 610 and the new Pharaoh prepared an expedition to recover the long-lost possessions of the Egyptian empire in Syria. Josiah alone opposed him with his feeble force at Megiddo and was easily overcome and slain. Necho went forward to the Euphrates, put the land to tribute and, in the case of Judah at any rate, filled the throne with his own nominee (*see* JEHOIAKIM). The division of the Assyrian spoil gave its inheritance in the west to Nabopolasser, king of Babylon, who soon despatched his son Nebuchadrezzar to fight Necho. The Babylonian and Egyptian forces met at Carchemish (605), and the rout of the latter was so complete that Necho relinquished Syria and might have lost Egypt as well had not the death of Nabopolasser recalled

[1]This, it may be remarked, is the time vaguely represented by the Dodecarchy of Herodotus.

the victor to Babylon. Herodotus relates that in Necho's reign a Phoenician ship despatched from Egypt actually circumnavigated Africa, and the attempt was made to complete a canal through the Wadi Tumilat connecting the Mediterranean and the Red Sea by way of the Lower Egyptian Nile (*see* SUEZ). The next king, Psammetichus II., 594–589 B.C., according to one account, visited Syria or Phoenicia, and apparently sent a mercenary force into Ethiopia as far as Abu Simbel. Pharaoh Hophra (Apries), 589–570 B.C., fomented rebellion against the Babylonian suzerainty in Judah, but accomplished little there. Herodotus, however, describes his reign as exceedingly prosperous. The mercenary troops at Elephantine mutinied and attempted to desert to Ethiopia, but were brought back and punished. Later, however, a disastrous expedition sent to aid the Libyans against the Greek colony of Cyrene roused the suspicion and anger of the native soldiery at favours shown to the mercenaries, who of course had taken no part in it. Amasis (Ahmosi) II. was chosen king by the former (570–525 B.C.) and his swarm of adherents overcame the Greek troops in Apries' pay. None the less Amasis employed Greeks in numbers, and cultivated the friendship of their tyrants. His rule was confined to Egypt (and perhaps Cyprus), but Egypt itself was very prosperous. At the beginning of his long reign of 44 years he was threatened by Nebuchadrezzar; later he joined the league against Cyrus and saw with alarm the fall of his old enemy. A few months after his death, 525 B.C., the invading host of the Persians led by Cambyses reached Egypt and dethroned his son Psammetichus III.

Cambyses at first conciliated the Egyptians and respected their religion; but, perhaps after the failure of his expedition into Ethiopia, he entirely changed his policy. He left Egypt so completely crushed that the subsequent usurpation of the Persian throne was marked by no revolt in that quarter. Darius, 521–486 B.C., proved himself a beneficent ruler, and in a visit to Egypt displayed his consideration for the religion of the country. In the great oasis he built a temple to Ammon. The annual tribute imposed on the satrapy of Egypt and Cyrene was heavy, but it was probably raised with ease. The canal from the Nile to the Red sea was completed or repaired, and commerce flourished. Documents dated in the 34th and 35th years of Darius are not uncommon, but apparently at the very end of his reign, some years after the disaster of Marathon, Egypt was induced to rebel. Xerxes (486–467 B.C.), who put down the revolt with severity, and his successor Artaxerxes (466–425 B.C.), like Cambyses, were hateful to the Egyptians. The disorders which marked the accession of Artaxerxes gave Egypt another opportunity to rebel. The leaders were Inaros, the Libyan of Marea, and the Egyptian Amyrtaeus. Aided by an Athenian force, Inaros slew the satrap Achaemenes at the battle of Papremis and destroyed his army; but the garrison of Memphis held out, and a fresh host from Persia raised the siege and in turn besieged the Greek and Egyptian forces on the island of Papremis. At last, after two years, having diverted the river from its channel, they captured and burnt the Athenian ships and quickly ended the rebellion. The reigns of Xerxes II. and Darius II. are marked by no recorded incident in Egypt until a successful revolt about 405 B.C. interrupted the Persian domination.

Monuments of the Persian rule in Egypt are exceedingly scanty. The inscription of Pefteuauneit, priest of Neith at Sais and from his position the native authority who was most likely to be consulted by Cambyses and Darius, tells of his relations with these two kings. For the following reigns Egyptian documents hardly exist, but some papyri written in Aramaic have been found at Elephantine and at Memphis. Those from the former locality show that a colony of Jews with a temple dedicated to Yahweh (Jehovah) had established themselves at that garrison and trading post (*see* ASWAN). Herodotus visited Egypt in the reign of Artaxerxes, about 440 B.C. His description of Egypt, partly founded on Hecataeus, who had been there about 50 years earlier, is the chief source of information for the history of the Saite kings and for the manners of the times, but his statements prove to be far from correct when they can be checked by the scanty native evidence.

Amyrtaeus (Amnertais) of Sais, perhaps a son of Pausiris and grandson of the earlier Amyrtaeus, revolted from Darius II., *c.* 405 B.C., and Egypt regained its independence for about 60 years. The next king, Nefeurēt (Nepherites I.) was a Mendesian and founded the 29th dynasty. After Hakor and Nefeurēt II. the sovereignty passed to the 30th Dynasty, the last native Egyptian line. Monuments of all these kings are known and art flourished particularly under the Sevennyte kings Nekhtnebf and Nekhtharheb (Nectanebes I. and II.). The former came to the throne when a Persian invasion was imminent, 379 B.C. Hakor had already formed a powerful army, largely composed of Greek mercenaries. This army Nekhtnebf entrusted to the Athenian Chabrias. The Persians, however, succeeded in causing his recall and in gaining the services of his fellow-countryman Iphicrates. The invading army consisted of 200,000 barbarians under Pharnabazus and 20,000 Greeks under Iphicrates. After the Egyptians had experienced a reverse, Iphicrates counselled an immediate advance on Memphis. His advice was not followed by Pharnabazus; the Egyptian king collected his forces and won a pitched battle near Mendes. Pharnabazus retreated and Egypt was free.

Nekhtnebf was succeeded by Tachos or Teos, whose short reign was occupied by a war with Persia, in which the king of Egypt secured the services of a body of Greek mercenaries under the Spartan king Agesilaus and a fleet under the Athenian general Chabrias. He entered Phoenicia with every prospect of success, but having offended Agesilaus he was dethroned in a military revolt which gave the crown to Nekhtharheb; but a large Egyptian party supported a prince of Mendes, who was probably named Khebobesh, and almost succeeded in overthrowing the new pharaoh. Agesilaus defeated the rival pretender and left Nekhtharheb established on the throne; but the opportunity of a decisive blow against Persia was lost. The new king Artaxerxes III. Ochus, determined to reduce Egypt. A first expedition was defeated by the Greek mercenaries of Nekhtharheb, but a second, commanded by Ochus himself, subdued Egypt with no further resistance than that of the Greek garrison of Pelusium. Nekhtharheb, last of the native pharaohs, instead of endeavouring to relieve them retreated to Memphis and fled thence to Ethiopia, 341 (?) B.C.

Ochus treated his conquest barbarously. From this brief re-establishment of Persian dominion (counted by Manetho as the 31st dynasty) no document survives except one papyrus that appears to be dated in the reign of Darius III.

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The Conquest by Alexander.—When in 332 B.C., after the battle of Issus, Alexander entered Egypt, he was welcomed as a deliverer. The Persian governor had not forces enough to oppose him and he nowhere experienced even the show of resistance. He visited Memphis, founded Alexandria, and went on pilgrimage to the oracle of Ammon (Oasis of Siwa). The god declared him to be his son, renewing thus an old Egyptian convention or belief; Olympias was supposed to have been in converse with Ammon, even as the mothers of Hatshepsut and Amenophis III. are represented in the inscriptions of the Theban temples to have received the divine essence. At this stage of his career the treasure and tribute of Egypt were of great importance to the Macedonian conqueror. He conciliated the inhabitants by the respect which he showed for their religion; he organized the government of the natives under two officers, who must have been already known to them (of these Petisis, an Egyptian, soon resigned his share into the charge of his colleague Doloaspis, who bears a Persian name). But Alexander designed his Greek foundation of Alexandria to be

the capital, and entrusted the taxation of Egypt and the control of its army and navy to Greeks. Early in 331 B.C. he was ready to depart; and led his forces away to Phoenicia. A granite gateway to the temple of Khnûm at Elephantine bears his name in hieroglyphic, and demotic documents are found dated in his reign.

The Ptolemaic Period.—On the division of Alexander's dominions in 323 B.C., Egypt fell to Ptolemy, the son of Lagus, the founder of the Ptolemaic dynasty (*see* PTOLEMIES). Under these rulers the rich kingdom was heavily taxed to supply the sinews of war and to support every kind of lavish expenditure. Officials, and the higher ones were nearly all Greeks, were legion, but the whole system was so judiciously worked that there was little discontent amongst the patient peasantry. During the reign of Philadelphus the land gained from the bed of the lake of Moeris was assigned to veteran soldiers; the great armies of the Ptolemies were rewarded or supported by grants of farm lands, and men of Macedonian, Greek and Hellenistic extraction were planted in colonies and garrisons or settled themselves in the villages throughout the country. Upper Egypt, farthest from the centre of government at Alexandria, was probably least affected by the new influences, though the first Ptolemy established the Greek colony of Ptolemais to be its capital. Intermarriages, however, gradually had their effect; after the revolt in the reigns of Ptolemy IV. and V. we find the Greek and Egyptian elements closely intermingled. Ptolemy I. had established the cult of the Memphite Serapis in a Graeco-Egyptian form, affording a common ground for native and Hellenistic worshippers, and endless temples to the native deities were built or re-built under the Ptolemies. No serious effort was made to extend the Ptolemaic rule into Ethiopia, and Ergamenes, the Hellenizing king of Ethiopia, was probably in alliance with Philopator; in the last year of Philopator (Ptolemy IV.), 204 B.C., came the great native revolt which continued through most of the reign of Epiphanes and affected the whole country. Down to 186 B.C. Harmakhis and Ankhmakhis native kings supported by Ethiopia reigned in succession at Thebes, and two years later there was still trouble in Lower Egypt. Thebes lost all except its religious importance under the Ptolemies; after the "destruction" or dismantling by Lathyrus (Ptolemy X.) it formed only a series of villages. The population of Egypt in the time of Ptolemy I. is put at 7,000,000 by Diodorus, who also says that it was greater then than it ever was before; at the end of the dynasty, in his own day, it was not much less, though somewhat diminished. It is remarkable that, while the building and decoration of temples continued in the reigns of Ptolemy Auletes (XIII.), Cleopatra, etc., papyri of those times, whether Greek or Egyptian, are scarcely to be found.

The Roman Period.—In 30 B.C. Augustus took Egypt as the prize of conquest. He treated it as a part of his personal domain, free from any interference by the senate. In the main lines the Ptolemaic organization was preserved, but Romans were gradually introduced into the highest offices. On Egypt Rome depended for its supplies of corn; entrenched there, a revolting general would be difficult to attack, and by simply holding back the grain ships could threaten Rome with starvation. No senator, therefore, was permitted to take office or even to set foot in the country without the emperor's special leave, and by way of precaution the highest position, that of prefect, was filled by a Roman of equestrian rank only. As the representative of the emperor, this officer assumed the place occupied by the king under the old order, except that his power was limited by the right of appeal to Caesar. The first prefect, Cornelius Gallus, tamed the natives of Upper Egypt to the new yoke by force of arms, and meeting ambassadors from Ethiopia at Philae, established a nominal protectorate of Rome over the frontier district, which had been abandoned by the later Ptolemies. The third prefect, Gaius Petronius, cleared the neglected canals for irrigation; he also repelled an invasion of the Ethiopians and pursued them far up the Nile, finally storming the capital of Napata. But no attempt was made to hold Ethiopia and the boundary of the empire was fixed 70 miles south of the First Cataract, the limit of the Dodecaschoenus. In succeeding reigns much trouble was caused by jealousies and quarrels between the Greeks and the Jews, to whom Augustus had granted privileges as valuable as those accorded the Greeks. Aiming at the spice trade, Aelius Gallus, the second prefect of Egypt under Augustus, had made an unsuccessful expedition to conquer Arabia Felix; the valuable Indian trade, however, was secured by Claudius for Egypt at the expense of Arabia, and the Red Sea routes were improved. Nero's reign especially marks the commencement of an era of prosperity which lasted about a century. Under Vespasian the Jewish temple at Leontopolis in the Delta, which Onias had founded in the reign of Ptolemy Philometor, was closed; worse still, a great Jewish revolt and massacre of the Greeks in the reign of Trajan resulted, after a stubborn conflict of many months with the Roman army under Marcius Livianus Turbo, in the virtual extermination of the Jews in Alexandria and the loss of all their privileges. Hadrian, who twice visited Egypt (A.D. 130, 134), founded Antinoë in memory of his drowned favourite. From this reign onwards buildings in the Graeco-Roman style were erected throughout the country. A new Sothic cycle began in A.D. 139. Under Marcus Aurelius a revolt of the Bucolic or native troops recruited for home service was taken up by the whole of the native population and was suppressed only after several years of fighting. The Bucolic war caused infinite damage to the agriculture of the country, and marks the beginning of its rapid decline under a burdensome taxation. The province of Africa was now of equal importance with Egypt for the grain supply of the capital. Avidius Cassius, who led the Roman forces in the war, usurped the purple and was acknowledged by the armies of Syria and Egypt. On the approach of Marcus Aurelius, the adherents of Cassius slew him, and the clemency of the emperor restored peace. After the downfall of the house of the Antonines, Pescennius Niger, who commanded the forces in Egypt, was proclaimed emperor on the death of Pertinax (A.D. 193). Severus overthrew his rival (A.D. 194) and, the revolt having been a military one, did not punish the province; in 202 he gave a constitution to Alexandria and the "nome" capitals. In his reign the Christians of Egypt suffered the first of their many persecutions.

Caracalla, in revenge for an affront, massacred all the men capable of bearing arms in Alexandria. His granting of the Roman citizenship to all Egyptians in common with the other provincials was only to extort more taxes. Under Decius (A.D. 250) the Christians again suffered from persecution. When the empire broke up in the weak reign of Gallienus, the prefect Aemilianus, who took the surname Alexander or Alexandrinus, was made emperor by the troops at Alexandria, but was conquered by the forces of Gallienus. In his brief reign of only a few months he had driven back an invasion of the Blemmyes. This predatory tribe, issuing from Nubia, was long to be the terror of Upper Egypt. Zenobia, queen of Palmyra, after an unsuccessful invasion, on a second attempt conquered Egypt, which she added to her empire, but lost it when Aurelian made war upon her (A.D. 272). The province was, however, unsettled, and the conquest of Palmyra was followed in the same year by the suppression of a revolt in Egypt (A.D. 273). Probus, who had governed Egypt for Aurelian and Tacitus, was subsequently chosen by the troops to succeed Tacitus, and is the first governor of this province who obtained the whole of the empire. He expelled the Blemmyes, who were dominating the whole of the Thebaid. Diocletian invited the Nobatae to settle in the Dodecaschoenus as a barrier against their incursions, and subsidized both Blemmyes and Nobatae. The country, however, was still disturbed, and in A.D. 296 a formidable revolt broke out, led by Achilleus, who as emperor took the name Domitius Domitianus. Diocletian, finding his troops unable to determine the struggle, came to Egypt, captured Alexandria, and put his rival to death (296). He then reorganized the whole province, and the well-known "Pompey's Pillar" was set up by the grateful and repentant Alexandrians to commemorate his gift to them of part of the corn tribute.

The Coptic era of Diocletian or of the Martyrs dates from the accession of Diocletian (A.D. 284). The edict of A.D. 303 against the Christians, and those which succeeded it, were rigorously carried out in Egypt, where Paganism was still strong and face to face with a strong and united church. Galerius, who succeeded Diocletian in the government of the East, implacably pursued his

policy, and this great persecution did not end until the persecutor, perishing, it is said, of the dire malady of Herod and Philip II. of Spain, sent out an edict of toleration (A.D. 311).

At the Council of Nicaea the most conspicuous controversialist on the Orthodox side was the young Alexandrian deacon Athanasius, who returned home to be made archbishop of Alexandria (A.D. 326). After being four times expelled by the Arians and once by the Emperor Julian, he died A.D. 373, at the moment when an Arian persecution began. So large a proportion of the population had taken religious vows that under Valens it became necessary to abolish the privilege of monks which exempted them from military service. The reign of Theodosius I. witnessed the overthrow of Arianism, and this was followed by the suppression of Paganism, against which a final edict was promulgated A.D. 390. In Egypt, the year before, the temple of Serapis at Alexandria had been captured after much bloodshed by the Christian mob and turned into a church. Cyril, the patriarch of Alexandria (A.D. 415), expelled the Jews from the capital with the aid of the mob, and murdered the beautiful philosopher Hypatia. A schism now produced lengthened civil war and alienated Egypt from the empire. The distinction between religion and politics seemed to be lost, and the government grew weaker and weaker. The system of local government by citizens had entirely disappeared. Offices, with new Byzantine names, were now almost hereditary in the wealthy land-owning families. The Greek rulers of the Orthodox faith were unable to protect the tillers of the soil, and these being of the Monophysite persuasion and having their own church and patriarch, hated the Orthodox patriarch (who from the time of Justinian onwards was identical with the prefect) and all his following. Towards the middle of the 5th century, the Blemmyes, quiet since the reign of Diocletian, recommenced their incursions, and were even joined in them by the Nobatae. These tribes were twice brought to account severely for their misdoings, but were not effectually checked. It was in these circumstances that Egypt fell without conflict when attacked by Chosroës (A.D. 616). After ten years of Persian dominion the success of Heraclius restored Egypt to the empire, and for a time it again received a Greek governor. The Monophysites, who had taken advantage of the Persian occupation, were persecuted and their patriarch expelled. The Arab conquest was welcomed by the native Christians, but with it they ceased to be the Egyptian nation.

The decline of Egypt was due to the purely military government of the Romans, and their subsequent alliance with the Greek party of Alexandria, which never represented the country. Under weak emperors, the rest of Egypt was exposed to the inroads of savages, and left to fall into a condition of barbarism. Ecclesiastical disputes tended to alienate both the native population and the Alexandrians. Thus at last the country was merely held by force, and the authority of the governor was little recognized beyond the capital, except where garrisons were stationed. There was no military spirit in a population unused to arms, nor any disinclination to be relieved from an arbitrary and persecuting rule. Thus the Muslim conquest was easy.

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II. MOHAMMEDAN PERIOD

Muslim Conquest of Egypt.—Towards the end of the year 639 an army of some 4,000 men was sent against Egypt under the command of 'Amr (*see* 'AMR-IBN-EL-ASS), by the second caliph, Omar I. The commander marched from Syria through El-'Arish, easily took Farama or Pelusium, and thence proceeded to Bilbeis, where he was delayed for a month; having captured this place, he proceeded to a point on the Nile called Umm Dunain, the siege of which also occasioned him some difficulty. After taking it, he crossed the Nile to the Fayum. On June 6 of the following year (640) a second army of 12,000 men, despatched by Omar, arrived at Heliopolis (On). 'Amr recrossed the river and joined it, but presently was confronted by a Roman army, which he defeated at the battle of Heliopolis (July 640); this victory was followed by the siege of Babylon, which after some futile attempts at negotiation was taken on Good Friday, April 6, 641. 'Amr next proceeded in the direction of Alexandria, which was surrendered to him on Nov. 8, 641, on the condition that it should be occupied by the Muslims on Sept. 29 of the following year. The interval was spent by him in founding the city Fostat (Fusṭāṭ), near the modern Cairo, and called after the camp (*Fossatum*) occupied by him while besieging Babylon; and in reducing those coast towns that still offered resistance. The Thebaid seems to have surrendered with scarcely any opposition.

The ease with which this valuable province was wrenched from the Roman empire appears to have been due to the treachery of the governor of Egypt, Cyrus, patriarch of Alexandria, and the incompetence of the Roman generals. The former, called by the Arabs Mukaukis (Muqauqis) from his Coptic name Pkauchios, had for ten years before the arrival of 'Amr maintained a fierce persecution of the Jacobite sect, to which the bulk of the Copts belonged. During the siege of Babylon he had been recalled and exiled, but after the death of Heraclius had been reinstated as patriarch by Heraclonas, and was welcomed back to Alexandria with general rejoicing in Sept. 641. Since Alexandria could neither have been stormed nor starved out by the Arabs, his motives for surrendering it, and with it the whole of Egypt, have been variously interpreted, some supposing him to have been secretly a convert to Islam. The notion that the Arab invaders were welcomed and assisted by the persecuted Copts, conflicts with the fact that the invaders treated both Copts and Romans with the same ruthlessness; but the dissensions which prevailed in the Christian communities certainly weakened resistance to the common enemy. An attempt was made in the year 645 with a force under Manuel, commander of the Imperial forces, to regain Alexandria; the city was surprised, and held till the summer of 646, when it was again stormed by 'Amr. In 654 a fleet was equipped by Constans with a view to an invasion, but it was repulsed, and partly destroyed by storm. From that time no serious effort was made by the Eastern empire to regain possession of the country. The terms on which the Arabs received the submission of Egypt were those on which conquered communities were ordinarily taken under Muslim protection. In return for a tribute of money and food for the troops of occupation, the Christian inhabitants of Egypt were to be excused military service, and to be left free in the observance of their religion and the administration of their affairs.

From 639 to 968 Egypt was a province of the Eastern caliphate, and was ruled by governors sent from the cities which at different times ranked as capitals. Like other provinces of the later Abbasid caliphate its rulers were, during this period, able to establish quasi-independent dynasties, such being those of the Tulunids who ruled from 868 to 905, and the Ikshidis from 935–969. In 969 the country was conquered by Jauhar for the Fatimite caliph Mo'izz, who transferred his capital from Mahdia (*q.v.*) in the Maghrib to Cairo. This dynasty lasted till 1171, when Egypt was again embodied in the Abbasid empire by Saladin, who, however, was himself the founder of a quasi-independent dynasty called the Ayyubites or Ayyubids, which lasted till 1252. The Ayyubites were followed by the Mameluke dynasties, usually classified as Baḥri from 1252–1382, and Burji from 1382–1517; these sovereigns were nominally under the suzerainty of Abbasid caliphs, who were in reality instruments of the Mameluke sultans, and resided at Cairo. In 1517 Egypt became part of the Ottoman empire and was governed by pashas sent from Constantinople, whose influence about 1707 gave way to that of officials chosen from the Mamelukes who bore the title Sheik al-balad. After the episode of the French occupation, government by pashas was

restored; Mehemet Ali (appointed pasha in 1805) obtained from the Porte in 1841 the right to bequeath the sovereignty to his descendants, one of whom, Ismail Pasha, received the title Khedive.

Period Under Governors Sent from the Metropolis of the Eastern Caliphate.—The first governor of the newly acquired province was the conqueror 'Amr, whose jurisdiction was presently restricted to Lower Egypt; Upper Egypt being assigned to Abdallāh b. Sa'd, who subsequently obtained Lower Egypt also, 'Amr being recalled, owing to his unwillingness to extort from his subjects as much money as would satisfy the caliph. In the troubles which overtook the Islamic empire with the accession of Othman, Egypt was greatly involved, and it had to be reconquered from the adherents of Ali for Moawiya (Mo'awiyah) by 'Amr, who in A.H. 38 was rewarded for his services by being reinstated as governor, with the right to appropriate the surplus revenue instead of sending it as tribute to the metropolis. In the confusion which followed on the death of the Omayyad caliph Yazīd the Egyptian Muslims declared themselves for Abdallāh b. Zobair, but their leader was defeated in a battle near Ain Shams (Dec. 684) by Merwān b. Ḥakam (Merwān I.) who had assumed the caliphate, and the conqueror's son Abd al-'Azīz was appointed governor. They also declared themselves against the usurper Merwān II. in 745, whose lieutenant al-Ḥautharah had to enter Fostat at the head of an army. In 750 Merwān II. himself came to Egypt as a fugitive from the Abbasids, but found that the bulk of the Muslim population had already joined with his enemies, and was defeated and slain in the neighbourhood of Giza in July of the same year. The Abbasid general, Ṣāliḥ b. Ali, who had won the victory, was then appointed governor.

During the period that elapsed between the Muslim conquest and the end of the Omayyad dynasty the nature of the Arab occupation had changed from what had originally been intended, the establishment of garrisons, to systematic colonization. Conversions of Copts to Islam were at first rare, and the old system of taxation was maintained for the greater part of the first Islamic century. The nature of this fiscal system is illustrated by papyri which show that the old division of the country into "districts" (*nomoi*) was maintained. To the inhabitants of these districts demands were directly addressed by the governor of Egypt, while the head of the community, ordinarily a Copt, but in some cases a Muslim, was responsible for compliance with the demand. An official called "receiver" (*qabbāl*) was chosen by the inhabitants of each district to take charge of the produce till it was delivered into the public magazines, and received 5% for his trouble. Other evidence shows that the sum for which each district was responsible was distributed over the unit in such a way that artisans and tradesmen paid at a rate similar to that which was enforced on those employed in agriculture. The researches of Wellhausen and Becker have made it clear that the difference which is marked in later Islam between a poll-tax (*jizyah*) and a land-tax (*kharāj*) did not at first exist: the papyri of the 1st century know only of the jizyah, which, however, is not a poll-tax but a land-tax (in the main). The development of the poll-tax imposed on members of tolerated cults seems to be due to various causes, chief of them the acquisition of land by Muslims, who were not at first allowed to possess any, the conversion of Coptic landowners to Islam, and the enforcement (towards the end of the 1st century of Islam) of the poll-tax on monks. The treasury could not afford to lose the land-tax, which it would naturally forfeit by the first two of the above occurrences, and we read of various expedients being tried to prevent this loss. Such were making the Christian community to which the proselyte had belonged pay as much as it had paid when his lands belonged to it, making proselytes pay as before their conversion, or compelling them to abandon their lands on conversion. Eventually the theory spread that all land paid land-tax, whereas members of tolerated sects paid a personal tax also; but during the evolution of this doctrine the relations between conquerors and conquered became more and more strained, and from the time when the control of the finance was separated from the administration of the country (A.D. 715) complaints of extortion became serious.

Coptic Revolt.—The resentment of the Copts, who were being excluded from public office, produced a revolt in 725, which was suppressed with difficulty. Two years after, in order that the Arab element in Egypt might be strengthened, a colony of North Arabians (Qaisites) was planted near Bilbeis, reaching the number of 3,000 persons; an event which tended to restore the balance between the two branches of the Arab race, as the first immigrants had belonged almost exclusively to the South Arabian stock. Meanwhile the employment of the Arabic language had been steadily gaining ground, and in 706 it was made the official language of the bureaux, though the occasional use of Greek for this purpose is attested by documents as late as the year 780. Other revolts of the Copts are recorded for the years 739 and 750, the last year of Omayyad domination. The outbreaks in all cases are attributed to increased taxation.

The beginning of the Abbasid period was marked by the erection of a new capital to the north of Fostat, bearing the name '*Askar* or "camp." Apparently at this time the practice of farming the taxes began, which naturally led to even greater extortion than before; and a fresh rising of the Copts is recorded for the fourth year of Abbasid rule. Governors were frequently changed. The three officials of importance whose nomination is mentioned by the historians in addition to that of the governor were the commander of the bodyguard, the minister of finance and the judge. Towards the beginning of the 3rd Islamic century the practice of giving Egypt in fief to a governor was resumed by the caliph Mamūn, who bestowed this privilege on 'Abdallāh b. Ṭāhir, who in 827 was sent to recover Alexandria, which for some ten years had been held by exiles from Spain. 'Abdallāh b. Ṭāhir decided to reside at Baghdad, sending a deputy to Egypt to govern for him; and this example was afterwards followed. In 828, when Mamūn's brother Motaṣim was feudal lord, a violent insurrection broke out in the Ḥauf, occasioned, as usual, by excessive taxation; it was partly quelled in the next year by Motaṣim, who marched against the rebels with an army of 4,000 Turks. Rebellion broke out repeatedly in the following years, and in 831 the Copts joined with the Arabs against the Government; the state of affairs became so serious that the caliph Mamūn himself visited Egypt, arriving at Fostat in Feb. 832; his general Afshin fought a decisive battle with the rebels at Bāsharūd in the Ḥauf region, at which the Copts were compelled to surrender; the males were massacred and the women and children sold as slaves.

This event finally crushed the Coptic nation, which never again made head against the Muslims. In the following year the caliph Motaṣim, who surrounded himself with a foreign bodyguard, withdrew the stipends of the Arab soldiers in Egypt; this measure caused some of the Arab tribes who had been long settled in Egypt to revolt, but their resistance was crushed, and the domination of the Arab element in the country from this time gave way to that of foreign mercenaries, who, belonging to one nation or another, held it for most of its subsequent history. Egypt was given in fief to a Turkish general Ashnās (Ashinas), who never visited the country, and the rule of individuals of Turkish origin prevailed till the rise of the Fāṭimites, who for a time interrupted it. The presence of Turks in Egypt is attested by documents as early as 808. While the governor was appointed by the feudal lord, the finance minister continued to be appointed by the caliph. On the death of Ashnās in 844 Egypt was given in fief to another Turkish general Ītākh, but in 850 this person fell out of favour, and the fief was transferred to Montaṣir, son of the caliph Motawakkil. In 856 it was transferred from him to the vizier Fatḥ b. Khāqān, who for the first time appointed a Turkish governor. The chief places in the State were also filled with Turks. The period between the rise of the Abbasids and the quasi-independent dynasties of Egypt was marked by much religious persecution, occasioned by the fanaticism of some of the caliphs, the victims being generally Muslim sectarians. (For Egypt under Motawakkil see CALIPHATE.)

Tulunid Dynasty.—In 868 Egypt was given in fief to a Turkish general Bāyikbeg, who sent thither as his representative his stepson Aḥmad b. Tūlūn, the first founder of a quasi-independent dynasty. When in 870 his stepfather died, the fief was

given to his father-in-law, who retained him in the lieutenancy, and indeed extended his authority to Alexandria, which had till that time been outside it. The enterprise of a usurper in Syria in the year 872 caused the caliph to require the presence of Aḥmad in that country at the head of an army to quell it; and although this army was not actually employed for the purpose, it was not disbanded by Aḥmad, who on his return founded a fresh city called Kaṭā'i', "the fiefs," S.E. of modern Cairo, as quarters for it. On the death of Aḥmad's father-in-law in the same year, when Egypt was given in fief to the caliph's brother Mowaffaq (famous for his defeat of the Zanj), Aḥmad secured himself in his post by extensive bribery at headquarters; and in the following year the administration of the Syrian frontier was conferred on him as well. By 875 he found himself strong enough to refuse to send tribute to Baghdad, preferring to spend the revenues of Egypt on the maintenance of his army and the erection of great buildings, such as his famous mosque; and though Mowaffaq advanced against him with an army, the project of reducing Aḥmad to submission had to be abandoned for want of means. In 877 and 878 Aḥmad advanced into Syria and obtained the submission of the chief cities, and at Tarsus entered into friendly relations with the representatives of the Byzantine emperor.

In 882 relations between Aḥmad and Mowaffaq again became strained, and the former conceived the bold plan of getting the caliph Mo'tamid into his power, which, however, was frustrated by Mowaffaq's vigilance; but an open rupture was the result, as Mowaffaq formally deprived Aḥmad of his lieutenancy, while Aḥmad equally formally declared that Mowaffaq had forfeited the succession. A revolt that broke out at Tarsus caused Aḥmad to traverse Syria once more in 883, but illness compelled him to return, and on May 10, 884, he died at his residence in Kaṭā'i'. He was the first to establish the claim of Egypt to govern Syria, and from his time Egypt grew more and more independent of the Eastern caliphate. He appears to have invented the fiction which afterwards was repeatedly employed, by which the money spent on mosque-building was supposed to have been furnished by discoveries of buried treasure.

He was succeeded by his son Khomārūya, then 20 years of age, who immediately after his accession had to deal with an attempt on the part of the caliph to recover Syria. By 886 Mowaffaq found it expedient to grant Khomārūya the possession of Egypt, Syria, and the frontier towns for a period of 30 years, and ere long, owing to the disputes of the provincial governors, Khomārūya found it possible to extend his domain to the Euphrates and even the Tigris. On the death of Mowaffaq in 891 the Egyptian governor was able to renew peaceful relations with the caliphs, and receive fresh confirmation in his possessions for 30 years. The security which he thereby gained gave him the opportunity to indulge his taste for costly buildings, parks and other luxuries, of which the chroniclers give accounts bordering on the fabulous. After the marriage of his daughter to the caliph, which was celebrated at enormous expense, an arrangement was made giving the Tūlūnid sovereign the viceroyalty of a region extending from Barca on the west to Hīt on the east; but tribute, ordinarily to the amount of 300.000 dinars, was to be sent to the metropolis. His realm enjoyed peace till his death in 896, when he fell a victim to some palace intrigue at Damascus.

His young son and successor Abu'l-'Asākir Jaish was murdered after a reign of six months by his troops, who gave his place to his brother Hārūn. In the eight years of his government the Ṭūlūnid empire contracted, owing to the revolts of the deputies which Hārūn was unable to quell, though in 898 he endeavoured to secure a new lease of the sovereignty in Egypt and Syria by a fresh arrangement with the caliph, involving an increase of tribute. The following years witnessed serious troubles in Syria caused by the Carmathians, which called for the intervention of the caliph, who at last succeeded in defeating these fanatics; the officer Mohammed b. Solaimān, to whom the victory was due, was then commissioned by the caliph to reconquer Egypt from the Ṭūlūnids, and after securing the allegiance of the Syrian prefects he invaded Egypt by sea and land at once. Before the arrival of these troops Hārūn had met his death at the hands of an assassin, or else in an affray, and his uncle Shaibān, who was placed on the throne, found himself without the means to collect an adequate army. Fostat was easily taken by 'Mohammed b. Solaimān at the beginning of 905, and after the infliction of severe punishment on the inhabitants Egypt was once more put under a deputy, 'Īsā al-Naushārī, appointed directly by the caliph.

In the middle of the year 914 Egypt was invaded for the first time by a Fāṭimite force sent by the caliph al-Mahdī 'Obaidallah, now established at Kairawān. The Mahdi's son succeeded in taking Alexandria, and advancing as far as the Fayūm; but once more the Abbasid caliph sent a powerful army to assist his viceroy, and the invaders were driven out of the country, though the Fāṭimite caliph continued to maintain active propaganda in Egypt. In 919 Alexandria was again seized by the Mahdi's son, afterwards the caliph al-Qā'im, and while his forces advanced northward as far as Ushmunain (Eshmunain) he was reinforced by a fleet which arrived at Alexandria. This fleet was destroyed by a far smaller one sent by the Baghdad caliph to Rosetta; but Egypt was not freed from the invaders till the year 921, after reinforcements had been repeatedly sent from Baghdad to deal with them. The extortions necessitated by these wars and the incompetence of the viceroys brought Egypt into a miserable condition; and the numerous political crises at Baghdad prevented for a time any serious measures being taken to improve it. After a struggle between various pretenders to the viceroyalty, Mohammed b. Ṭughj, son of a Ṭūlūnid prefect of Damascus, was sent by the caliph to restore order; he had to force his entrance into the country by an engagement with one of the pretenders, Ibn Kaighlagh, in which he was victorious, and entered Fostat in Aug. 935.

Ikshidite Dynasty.—Mohammed b. Ṭughj was the founder of the Ikshīdī dynasty, so called from the title Ikshīd, conferred on him at his request by the caliph shortly after his appointment to the governorship of Egypt; it is said to have had the sense of "king" in Ferghana, whence this person's ancestors had come to enter the service of the caliph Motaṣim. He had himself served in various capacities under the governor of Egypt, Takīn, whose son he displaced, and had afterwards held various governorships in Syria. He united in his person the offices of governor and minister of finance, which had been separate since the time of the Ṭūlūnids. He endeavoured to replenish the treasury not only by extreme economy, but by inflicting fines on a vast scale on persons who had held offices under his predecessor and others who had rendered themselves suspect. The disaffected in Egypt kept up communications with the Fāṭimites, against whom the Ikshīd collected a vast army, which, however, had first to be employed in resisting an invasion of Egypt threatened by Ibn Rāiq, an adventurer who had seized Syria; after an indecisive engagement at Lajūn the Ikshīd decided to make peace with Ibn Rāiq, undertaking to pay him tribute. In 941, after the latter's death, the Ikshīd took the opportunity of invading Syria, which the caliph permitted him to hold with the addition of the sacred cities of Mecca and Medina, which the Ṭūlūnids had aspired to possess.

In the year 944 he was summoned to Mesopotamia to assist the caliph, who had been driven from Baghdad; and he proposed, though unsuccessfully, to take the caliph with him to Egypt. At this time he obtained hereditary rights for his family in the government of that country and Syria. The Ḥamdānid Saif addaula shortly after this assumed the governorship of Aleppo, and became involved in a struggle with the Ikshīd, whose general, Kāfūr, he defeated in an engagement between Homs and Hamah (Hamath). In a later battle he was himself defeated by the Ikshīd, when an arrangement was made permitting Saif addaula to retain most of Syria, while a prefect appointed by the Ikshīd was to remain in Damascus. The Buyid ruler, who was now supreme at Baghdad, permitted the Ikshīd to remain in possession of his viceroyalty, but shortly after receiving this confirmation he died at Damascus in 946.

The second of this dynasty was the Ikshīd's son Ūnjūr, who had been proclaimed in his father's time, and began his government under the tutelage of the negro Kāfūr. Syria was immediately overrun by Saif addaula, but he was defeated by Kāfūr in two engagements, and was compelled to recognize the overlord-

ship of the Egyptian viceroy. At the death of Ūnjūr in 961 his brother Abu'l-Ḥasan 'Alī was made viceroy with the caliph's consent by Kāfūr, who continued to govern for his chief as before. The land was during this period threatened at once by the Fāṭimites from the west; the Nubians from the south, and the Carmathians from the east; when the second Ikshīdī died, Kāfūr at first made a pretence of appointing his young son Aḥmad as his successor, but deemed it safer to assume the viceroyalty himself, setting an example which in Mameluke times was often followed. He occupied the post little more than three years, and on his death in 968 the aforementioned Aḥmad, called Abu'l-Fawāris, was appointed successor, under the tutelage of a vizier named Ibn Furāt, who had long served under the Ikshīdīs. The accession of this prince was followed by an incursion of the Carmathians into Syria, before whom the Ikshīdī governor fled into Egypt, where he had for a time to undertake the management of affairs, and arrested Ibn Furāt, who had proved himself incompetent.

The administration of Ibn Furāt was fatal to the Ikshīdīs and momentous for Egypt, since a Jewish convert, Jacob, son of Killis, who had been in the Ikshīd's service, and was ill-treated by Ibn Furāt, fled to the Fāṭimite sovereign, and persuaded him that the time for invading Egypt with a prospect of success had arrived, since there was no one in Fostat capable of organizing a plan of defence, and the dissensions between the Buyids at Baghdad rendered it improbable that any succour would arrive from that quarter. The Fāṭimite caliph Mo'izz li-dīn allāh was also in correspondence with other residents in Egypt, where the Alid party from the beginning of Abbasid times had always had many supporters; and the danger from the Carmathians rendered the presence of a strong Government necessary. The Fāṭimite general Jauhar, who enjoyed the complete confidence of the Fāṭimite sovereign, started from Rakkāda at the beginning of March 969 with the view of seizing Egypt.

Before his arrival the administration of affairs had again been committed to Ibn Furāt, who, on hearing of the threatened invasion, at first proposed to treat with Jauhar for the peaceful surrender of the country; but the majority of the troops at Fostat preferred to make some resistance, and an advance was made to meet Jauhar in the neighbourhood of Giza. He had little difficulty in defeating the Egyptian army, and on July 6, 969, entered Fostat at the head of his forces. The name of Mo'izz was immediately introduced into public prayer, and coins were struck in his name. The Ikshīdī governor of Damascus, a cousin of Abu'l-Fawāris Aḥmad, endeavoured to save Syria, but was defeated at Ramleh by a general sent by Jauhar and taken prisoner. Thus the Ikshīdī dynasty came to an end, and Egypt was transferred from the Eastern to the Western caliphate, of which it furnished the metropolis.

The Fatimite Period begins with the taking of Fostat by Jauhar, who immediately began the building of a new city, al-Kāhira or Cairo, to furnish quarters for his army. A palace for the caliph and a mosque for the army were immediately constructed, the latter still famous as al-Azhar, and for many centuries the centre of Muslim learning. Almost immediately after the conquest of Egypt, Jauhar found himself engaged in a struggle with the Carmathians (*q.v.*), and the Carmathian leader al-Ḥasan b. Aḥmad al-A'ṣam received aid from Baghdad for the purpose of recovering Syria to the Abbasids. The Fāṭimite general Ja'far, hoping to deal with this enemy independently of Jauhar, met the Carmathians without waiting for reinforcements from Egypt, and was defeated and killed. Damascus, which he had previously occupied, was taken by the Carmathians, and the name of the Abbasid caliph substituted for that of Mo'izz in public worship. Ḥasan al-A'ṣam advanced from Damascus through Palestine to Egypt, encountering little resistance on the way; and in the autumn of 971 Jauhar found himself besieged in his new city. By a timely sortie, preceded by the administration of bribes to various officers in the Carmathian host, Jauhar succeeded in inflicting a severe defeat on the besiegers, who were compelled to evacuate Egypt and part of Syria.

Meanwhile Mo'izz had been summoned to enter the palace that had been prepared for him, and after leaving a viceroy to take charge of his western possessions he arrived in Alexandria on May 31, 973, and proceeded to instruct his new subjects in the particular form of religion (Shī'ism) which his family represented. As this was in origin identical with that professed by the Carmathians, he hoped to gain the submission of their leader by argument; but this plan was unsuccessful, and there was a fresh invasion from that quarter in the year after his arrival, and the caliph found himself besieged in his capital. The Carmathians were gradually forced to retreat from Egypt and from Syria, and Mo'izz was able to take the offensive against the Byzantines, with whom his generals fought in Syria with varying fortune. Before his death he was acknowledged as caliph in Mecca and Medina, as well as Syria, Egypt and North Africa as far as Tangier.

In the reign of the second Egyptian Fāṭimite 'Azīz billah, Jauhar, who appears to have been cashiered by Mo'izz, was again employed at the instance of Jacob b. Killis, who had been raised to the rank of vizier, to deal with the situation in Syria, where a Turkish general Aftakīn had gained possession of Damascus, and was raiding the whole country; on the arrival of Jauhar in Syria the Turks called the Carmathians to their aid, and after a campaign of many vicissitudes Jauhar had to return to Egypt to implore the caliph himself to take the field. In Aug. 977 'Azīz met the united forces of Aftakīn and his Carmathian ally outside Ramleh in Palestine and inflicted a crushing defeat on them, which was followed by the capture of Aftakīn; this able officer was taken to Egypt, and honourably treated by the caliph, thereby incurring the jealousy of Jacob b. Killis, who caused him, it is said, to be poisoned. This vizier had the astuteness to see the necessity of codifying the doctrines of the Fāṭimites, and himself undertook this task; in the newly-established mosque of el-Azhar he got his master to make provision for a perpetual series of teachers and students of his manual. It would appear, however, that a large amount of toleration was conceded by the first two Egyptian Fāṭimites to the other sects of Islam, and to other communities. Indeed at one time in 'Azīz's reign the vizierate of Egypt was held by a Christian, Jesus, son of Nestorius, who appointed as his deputy in Syria a Jew, Manasseh b. Abraham. These persons were charged by the Muslims with unduly favouring their co-religionists, and the belief that the Christians of Egypt were in league with the Byzantine emperor, and even burned a fleet which was being built for the Byzantine war, led to some persecution. 'Azīz attempted without success to enter into friendly relations with the Buyid ruler of Baghdad, 'Aḍod addaula. He then tried to gain possession of Aleppo, as the key to 'Irāk, but this was prevented by the intervention of the Byzantines. His North African possessions were maintained and extended by 'Ali, son of Bulukkīn, whom Mo'izz had left as his deputy; but the recognition of the Fāṭimite caliph in this region was little more than nominal.

His successor *'Abū 'Alī al-Manṣūr,* who reigned under the title *al-Ḥākim bi'amr allāh,* came to the throne at the age of 11, being the son of 'Azīz by a Christian mother. He was at first under the tutelage of the Slav Burjuwān, whose policy it was to favour the Turkish element in the army as against the Maghribine, on which the strength of the Fāṭimites had till then rested; his conduct of affairs was vigourous and successful, and he concluded a peace with the Greek emperor. After a few years' regency he was assassinated at the instance of the young sovereign, who at an early age developed a dislike for control and jealousy of his rights as caliph. He is branded by historians as the Caligula of the East, who took a delight in oppression and persecution. He is perhaps best remembered by his destruction of the church of the Holy Sepulchre at Jerusalem (1010), a measure which helped to provoke the Crusades, but was only part of a general scheme for converting all Christians and Jews in his dominions to his own opinions by force. A more reputable expedient with the same end in view was the construction of a great library in Cairo, with ample provision for students; this was modelled on a similar institution at Baghdad. It formed part of the great palace of the Fāṭimites, and was intended to be the centre of their propaganda. At times, however, he ordered the destruction of all Christian churches in Egypt, and the banishment of all who did not adopt

Islam, though he nevertheless continued to employ Christians in high official positions. His system of persecution was not abandoned till in the last year of his reign (1020) he thought fit to claim divinity; the violent opposition which this aroused among the Muslims probably led him to adopt milder measures towards his other subjects, and those who had been forcibly converted were permitted to return to their former religion and rebuild their places of worship. Whether his disappearance at the beginning of the year 1021 was due to the resentment of his outraged subjects, or, as the historians say, to his sister's fear that he would bequeath the caliphate to a distant relative to the exclusion of his own son, will never be known. In spite of his caprices he appears to have shown competence in the management of external affairs; enterprises of pretenders both in Egypt and Syria were crushed with promptitude; and his name was at times mentioned in public worship in Aleppo and Mosul.

His son *Abū'l-Ḥasan 'Ali,* who succeeded him with the title *al-Ẓāhir li'i'zāz din Allāh,* was 16 years of age at the time, and for four years his aunt Sitt al-Mulk acted as regent; she appears to have been an astute but utterly unscrupulous woman. After her death the caliph was in the power of various ministers, under whose management of affairs Syria was for a time lost to the Egyptian caliphate, and Egypt itself raided by the Syrian usurpers, of whom one, Ṣāliḥ b. Mirdās, succeeded in establishing a dynasty at Aleppo, which maintained itself after Syria and Palestine had been recovered for the Fāṭimites by Anushtakin al-Dizbarī at the battle of Ukhuwānah in 1029. His successor, *Abū Tamīm Ma'add,* who reigned with the title *al-Mostanṣir,* was also an infant at the time of his accession, being little more than seven years of age. The power was largely in the hands of his mother, a negress, who promoted the interests of her kinsmen at court, where indeed even in Ḥākim's time they had been used as a counterpoise to the Maghribine and Turkish elements in the army. In the first years of this reign affairs were administered by the vizier al-Jarjarā'ī, by whose mismanagement Aleppo was lost to the Fāṭimites. At his death in 1044 the chief influence passed into the hands of Abu Sa'd, a Jew, and the former master of the queen-mother, and at the end of four years he was assassinated at the instance of another Jew (Ṣadakah, perhaps Zedekiah, b. Joseph al-Falāḥī), whom he had appointed vizier. In this reign Mo'izz b. Badis, the 4th ruler of the dependent Zeirid dynasty which had ruled in the Maghrib since the migration of the Fāṭimite Mo'izz to Egypt, definitely abjured his allegiance (1049) and returned to Sunnite principles and subjection to the Baghdad caliphate. The Zeirids maintained Mahdia (*see* ALGIERS), while other cities of the Maghrib were colonized by Arab tribes sent thither by the Cairene vizier. This loss was more than compensated by the enrolment of Yemen among the countries which recognized the Fāṭimite caliphate through the enterprise of one 'Ali b. Mohammed al-Ṣulaiḥī, while owing to the disputes between the Turkish generals who claimed supremacy at Baghdad, Mostanṣir's name was mentioned in public prayer at that metropolis on Jan. 12, 1058, when a Turkish adventurer Basāsirī was for a time in power. The Egyptian court, chiefly owing to the jealousy of the vizier, sent no efficient aid to Basāsiri, and after a year Baghdad was retaken by the Seljūk Toghrul Beg, and the Abbasid caliph restored to his rights. In the following years the troubles in Egypt caused by the struggles between the Turkish and negro elements in Mostanṣir's army nearly brought the country into the dominion of the Abbasids. After several battles of various issue the Turkish commander Nāṣir addaula b. Hamdān occupied Cairo, and at the end of 1068 plundered the caliph's palace; the valuable library which had been begun by Ḥākim was pillaged, and an accidental fire caused great destruction. The caliph and his family were reduced to destitution, and Nāṣir addaula began negotiations for restoring the name of the Abbasid caliph in public prayer; he was, however, assassinated before he could carry this out, and his assassin, also a Turk, appointed vizier. Mostanṣir then summoned to his aid Badr al-Jamālī, an Armenian who had displayed competence in various posts which he had held in Syria. Early in 1074 he arrived in Cairo accompanied by a bodyguard of Armenians; he contrived to massacre the chiefs of the party at the time in possession of power, and was given by Mostanṣir complete control of affairs. The period of internal disturbances, which had been accompanied by famine and pestilence, had caused usurpers to spring up in all parts of Egypt, and Badr was compelled practically to reconquer the country. During this time, however, Syria was overrun by an invader in league with the Seljūk Malik Shah, and Damascus was permanently lost to the Fāṭimites; other cities were recovered by Badr himself or his officers. The time of Mostanṣir is otherwise memorable for the rise of the Assassins (*q.v.*), who at the first supported the claims of his eldest son Nizār to the succession against the youngest Aḥmed, who was favoured by the family of Badr. When Badr died in 1094 his influence was inherited by his son, al-Afḍal Shāhinshāh, and this, at the death of Mostanṣir in the same year, was thrown in favour of *Aḥmed,* who succeeded to the caliphate with the title *al-Mosta'lī billāh.*

The Crusades.—The beginning of his reign coincided with the beginning of the crusades. Jerusalem had recently been recovered from the Turks by al-Afḍal, and its garrison was unable to make a prolonged resistance to the Frankish attack (1099). Al-Afḍal himself was defeated near Ascalon, and the Franks obtained much of the Fāṭimite territory in Palestine. After a reign of seven years Mosta'lī died and the caliphate was given by al-Afḍal to an infant son, aged five years at the time, who was placed on the throne with the title *al-Āmir biahkām allāh,* and for 20 years was under the tutelage of al-Afḍal. He made repeated attempts to recover the Syrian and Palestinian cities from the Franks, but with poor success. In 1118 Egypt was invaded by Baldwin I., who burned the gates and the mosques of Farama, and advanced to Tinnis, whence illness compelled him to retreat. In Aug. 1121, possibly with the connivance of the caliph, al-Afḍal was assassinated and his offices were given to one of the caliph's creatures, Mohammed b. Fātik al-Batā'iḥī, who took the title *al-Ma'mūn.* His external policy was not more fortunate than that of his predecessor, as he lost Tyre to the Franks, and a fleet equipped by him was defeated by the Venetians. On Oct. 4, 1125, he with his followers was seized and imprisoned by order of the caliph Āmir, who was now resolved to govern by himself, with the assistance of only subordinate officials, of whom two were drawn from the Samaritan and Christian communities. The vizier was afterwards crucified with his five brothers. The caliph's personal government appears to have been incompetent, and to have been marked by extortions and other arbitrary measures. He was assassinated in Oct. 1129 by some members of the sect who believed in the claims of Nizār, son of Mostanṣir.

The succeeding caliph, *Abu'l-Maimūn 'Abd al-Majīd,* who took the title *al-Ḥāfiẓ lidīn allāh,* was his predecessor's cousin and of ripe age. His reign was disturbed by the factions of the soldiery, and for a time he became subject to his own son Ḥasan. Before his death in 1149 he had recovered his authority. His son *Abu'l-Manṣūr Ismā'il,* who was 17 years old, succeeded him with the title *al-Ẓāfir lia'dā allāh.* From this reign to the end of the Fāṭimite period we have the journals of two eminent men, Usāmah b. Muniqdh and Umārah of Yemen, which throw light on the leading characters. The civil dissensions of Egypt were notorious at the time. The new reign began by an armed struggle between two commanders for the post of vizier, which in Jan. 1150 was decided in favour of the Amir Ibn Sallār. This vizier was presently assassinated by the direction of his stepson 'Abbās, who was raised to the vizierate in his place. This event was shortly followed by the loss to the Fāṭimites of Ascalon, the last place in Syria which they held; its loss was attributed to dissensions between the parties of which the garrison consisted. Four years later (April 1154) the caliph was murdered by his vizier 'Abbās, according to Usāmah, because the caliph had suggested to his favourite, the vizier's son, to murder his father; and this was followed by a massacre of the brothers of Ẓāfir, followed by the raising of his infant son *Abu'l-Qāsim 'Isā* to the throne.

The new caliph, who was not five years old, received the title *al-Fā'iz binaṣr allāh,* and was at first in the power of 'Abbās. The women of the palace, however, summoned to their aid Ṭalā'i' b. Ruzzik, prefect of Ushmunain, at whose arrival in Cairo the

troops deserted 'Abbās, who was compelled to flee into Syria, taking his son and Usāmah with him. 'Abbās was killed by the Franks near Ascalon, his son sent in a cage to Cairo where he was executed, while Usāmah escaped to Damascus.

The infant Fā'iz, who had been permanently incapacitated by the scenes of violence which accompanied his accession, died in 1160. Ṭalā'i' chose to succeed him a grandson of Zāfir, who was nine years of age, and received the title *al-āḍid lidīn allāh.* Ṭala'i', who had complete control of affairs, introduced the practice of farming the taxes for periods of six months instead of a year, which led to great misery, as the taxes were demanded twice. His death was brought on by the rigour with which he treated the princesses, one of whom, with or without the connivance of the caliph, organized a plot for his assassination, and he died in Sept. 1160. His son Ruzzīk inherited his post and maintained himself in it for more than a year, when another prefect of Upper Egypt, Shāwar b. Mujīr, brought a force to Cairo, before which Ruzzīk fled, to be shortly afterwards captured and beheaded. Shāwar's entry into Cairo was at the beginning of 1163; after nine months he was compelled to flee before another adventurer, an officer in the army named Ḍirghām. Shāwar's flight was directed to Damascus, where he was favourably received by the prince Nureddin, who sent with him to Cairo a force of Kurds under Asad al-dīn Shīrgūh. At the same time Egypt was invaded by the Franks, who raided and did much damage on the coast. Ḍirghām was defeated and killed, but a dispute then arose between Shāwar and his Syrian allies for the possession of Egypt. Shāwar, being unable to cope with the Syrians, demanded help of the Frankish king of Jerusalem Amalric (Amauri) I., who hastened to his aid with a large force, which united with Shāwar's and besieged Shīrgūh in Bilbeis for three months; at the end of this time, owing to the successes of Nureddin in Syria, the Franks granted Shīrgūh a free passage with his troops back to Syria, on condition of Egypt being evacuated (Oct. 1164). Rather more than two years later Shīrgūh persuaded Nureddin to put him at the head of another expedition to Egypt, which left Syria in Jan. 1167, and, entering Egypt by the land route, crossed the Nile at Itfīḥ (Atfih), and encamped at Giza; a Frankish army hastened to Shāwar's aid. At the battle of Bābain (April 11, 1167) the allies were defeated by the forces commanded by Shīrgūh and his nephew Saladin, who was presently made prefect of Alexandria, which surrendered to Shīrgūh without a struggle. Saladin was soon besieged by the allies in Alexandria; but after 75 days the siege was raised, Shīrgūh having made a threatening movement on Cairo, where a Frankish garrison had been admitted by Shāwar. Terms were then made by which both Syrians and Franks were to quit Egypt, though the garrison of Cairo remained; the hostile attitude of the Muslim population to this garrison led to another invasion at the beginning of 1168 by King Amalric, who after taking Bilbeis advanced to Cairo. The caliph, who up to this time appears to have left the administration to the viziers, now sent for Shīrgūh, whose speedy arrival in Egypt caused the Franks to withdraw. Reaching Cairo on Jan. 6, 1169, he was soon able to get possession of Shāwar's person, and after the prefect's execution, some ten days later, he was appointed vizier by the caliph. After two months Shīrgūh died of indigestion (March 23, 1169), and the caliph appointed Saladin as successor to Shīrgūh; the new vizier professed to hold office as a deputy of Nureddin, whose name was mentioned in public worship after that of the caliph. Nureddin loyally aided his deputy in dealing with Frankish invasions of Egypt, but the anomaly by which he, being a Sunnite, was made in Egypt to recognize a Fāṭimite caliph could not long continue. On Sept. 17, 1171, the name of the Abbasid caliph was substituted for that of 'Āḍid in public worship. The latter's death occurred almost at the same moment, and it is uncertain whether he ever heard of his deposition. The last of the Fāṭimite caliphs was not quite 21 years old at his death.

Ayyūbite Period.—Saladin by the advice of his chief Nureddin cashiered the Fāṭimite judges and encouraged the study of orthodox theology and jurisprudence in Egypt by the foundation of colleges and chairs. On the death of the ex-caliph he was confirmed in the prefecture of Egypt as deputy of Nureddin; and on the decease of the latter in 1174 (April 12) he took the title sultan, so that with this year the Ayyūbite period of Egyptian history properly begins. During the whole of it Damascus rather than Cairo counted as the metropolis of the empire. The Egyptian army, which was motley in character, was disbanded by the new sultan, whose troops were Kurds. Though he did not build a new metropolis he fortified Cairo with the addition of a citadel, and from this time till the French occupation of Egypt the citadel of Cairo was the political centre of the country. It was in 1183 that Saladin's rule over Egypt and North Syria was consolidated. His famous wars with the Franks belong to the history of the crusades and to his personal biography (*q.v.*).

Saladin at his death divided his dominions between his sons, of whom 'Othman succeeded to Egypt with the title *Malik al-Azīz 'Imād al-aīn.* The division was not satisfactory to the heirs, and after three years (beginning of 1196) the Egyptian sultan conspired with his uncle Malik al-'Ādil to deprive Saladin's son al-Afḍal of Damascus, which had fallen to his lot. The war between the brothers was continued with intervals of peace, during which al-'Ādil repeatedly changed sides: eventually he with al-'Azīz besieged and took Damascus, and sent al-Afḍal to Sarkhad, while al-'Ādil remained in possession of Damascus. On the death of al-'Azīz on Nov. 29, 1198, in consequence of a hunting accident, his infant son Mohammed was raised to the throne with the title *Malik al-Manṣūr Nāṣir al-dīn,* and his uncle al-Afḍal sent for from Sarkhad to take the post of regent. So soon as al-Afḍal had got possession of his nephew's person, he started on an expedition for the recovery of Damascus: al-'Ādil not only frustrated this, but drove him back to Egypt, where on Jan. 25, 1200, a battle was fought between the armies of the two at Bilbeis, resulting in the defeat of al-Afḍal, who was sent back to Sarkhad, while al-'Ādil assumed the regency, for which after a few months he substituted the sovereignty, causing his nephew to be deposed. He reigned under the title *Malik al-'Ādil Saif al-dīn.* His name was Abū Bakr.

Though the early years of his reign were marked by numerous disasters, famine, pestilence and earthquake, of which the second seems to have been exceedingly serious, he reunited under his sway the whole of the empire which had belonged to his brother, his generals conquered parts of Mesopotamia and Armenia, and in 1215 he got possession of Yemen. He followed the plan of dividing his empire between his sons, the eldest Mohammed, called *Malik al-Kāmil,* being his viceroy in Egypt, while al-Mu'azzam 'Īsā governed Syria, al-Ashraf Mūsā his eastern and al-Malik al-Auḥad Ayyūb his northern possessions. His death occurred at Alikin (1218), a village near Damascus, while the Franks were besieging Damietta, which was defended by al-Kāmil, to whom his father kept sending reinforcements. Damietta was taken by the Franks on Nov. 6, 1219; al-Kāmil thereupon proclaimed the Jihād, and was joined at his fortified camp, afterwards the site of Manṣūra, by troops from various parts of Egypt, Syria and Mesopotamia, including the forces of his brothers 'Īsā and Mūsā. With these allies, and availing himself of the advantages offered by the inundation of the Nile, al-Kāmil was able to cut off both the advance and the retreat of the invaders, and on Aug. 31, 1221, a peace was concluded, by which the Franks evacuated Egypt.

For some years the dominions of al-'Ādil remained divided between his sons: when the affairs of Egypt were settled, al-Kāmil determined to reunite them as before. Various cities in Palestine and Syria were yielded to Frederick II. as the price of his help against the son of Mu'azzam 'Īsā, who reigned at Damascus with the title of Malik al-Nāṣir. About 1231–32 Kāmil led a confederacy of Ayyūbite princes against the Seljuk Kaikobad into Asia Minor, but his allies mistrusted him and victory rested with Kaikobad (*see* SELJUKS). Before Kāmil's death he was mentioned in public prayer at Mecca as lord of Mecca (Hejāz), Yemen, Zabīd, Upper and Lower Egypt, Syria and Mesopotamia.

At his death (May 8, 1238) at Damascus, his son Abū Bakr was appointed to succeed with the title *Malik al-'Ādil Saif al-dīn;* but his elder brother Malik al-Sālīḥ Najm al-dīn Ayyūb, after various adventures, supplanted him and entered Cairo as sultan

in June 1240. His administration is highly praised by Ibn Khallikan, who lived under it. He made large purchases of slaves (Mamelukes) for his army, and when the inhabitants of Cairo complained of their lawlessness, he built barracks for them on the island of Roda (Rauḍa), whence they were called Bahrī or Nile Mamelukes, which became the name of the first dynasty that originated from them. Much of his time was spent in campaigns in Syria: eventually he succeeded in recovering most of the Syrian cities. Jerusalem was occupied in 1244. His name is commemorated by the town of Salihia, which he built in the year 1246 as a resting-place for his armies on their marches through the desert from Egypt to Palestine. In 1249 he was recalled from the siege of Homs by the news of the invasion of Egypt by Louis IX., and in spite of illness he hastened to Ushmum Tannā, in the neighbourhood of Damietta, which he provisioned for a siege. Damietta was taken on June 6, 1249, owing to the treachery of its commanders: 54 chieftains were afterwards executed for this by the sultan. On Nov. 22 the sultan died at Manṣūra, but his death was carefully concealed by the amirs Lājīn and Aktai, acting in concert with the Queen Shajar al-durr, till the arrival from Syria of the heir to the throne, *Tūrānshāh,* who was proclaimed some four months later. At the battle of Fāriskūr, April 6, 1250, the invaders were utterly routed and the French king fell into the hands of the Egyptian sultan. The sultan, who himself had had no share in the victory, advanced after it from Manṣūra to Fāriskūr, where his conduct became menacing to the amirs who had raised him to the throne, and to Shajar al-durr by whom he was overthrown.

Period of Bahrī Mamelukes.—The dynasties that succeeded the Ayyūbites till the conquest of Egypt by the Ottomans bore the title Dynasties of the Turks, but are more often called Mameluke dynasties, because the sultans were drawn from the enfranchised slaves who constituted the court, and officered the army. The family of the fourth of these sovereigns, Ka'ā'ūn (Qalā'ūn), reigned for 110 years, but otherwise no sultan was able to found a durable dynasty: after the death of a sultan he was usually succeeded by an infant son, who after a short time was dethroned by a new usurper.

After the death of the Sultan Tūrānshāh, his step-mother at first was raised to the vacant throne, but the rule of a queen caused scandal to the Muslim world, and Shajar al-durr gave way to this sentiment by marrying Aibek, the captain of the retainers, and allowing the title sultan to be conferred on him. For policy's sake, however, Aibek nominally associated with himself on the throne a scion of the Ayyūbite house, Malik al-Ashraf Musa, who died in prison (1252 or 1254). Aibek meanwhile immediately became involved in war with the Ayyūbite Malik al-Nāṣir, who was in possession of Syria, with whom the caliph induced him after some indecisive actions to make peace: he then successfully quelled a mutiny of Mamelukes, whom he compelled to take refuge with the last Abbasid caliph Mostasim in Baghdad and elsewhere. On April 10, 1257, Aibek was murdered by his wife Shajar al-durr, who was indignant at his asking for the hand of another queen: but Aibek's followers immediately avenged his death, placing on the throne his infant son *Malik al-Manṣūr,* who, however, was almost immediately displaced by his guardian *Koṭuz,* on the plea that the Mongol danger necessitated the presence of a grown man at the head of affairs. In 1260 the Syrian kingdom of al-Nāṣir was destroyed by Hulaku (Hulagu), the great Mongol chief, founder of the Ilkhan Dynasty (*see* MONGOLS), who, having finally overthrown the caliph of Baghdad (*see* CALIPHATE), also despatched a threatening letter to Koṭuz; but later in the same year Syria was invaded by Koṭuz, who defeated Hulagu's lieutenant at the battle of 'Ain Jālūt (Sept. 3, 1260), in consequence of which event the Syrian cities all rose against the Mongols, and the Egyptian sultan became master of the country with the exception of such places as were still held by the crusaders.

Before Koṭuz had reigned a year he was murdered at Sālihia by his lieutenant Bibars (Oct. 23, 1260), who assumed the sovereignty with the title of *Malik al-Qāhir,* presently altered to *al-Ẓāhir.* He had originally been a slave of Malik al-Sāliḥ, had distinguished himself at the battle after which Louis IX. was captured, and had helped to murder Tūrānshāh. Sultan Bibars, who proved to be one of the most competent of the Baḥrī Mamelukes, made Egypt the centre of the Muslim world by re-establishing in theory the Abbasid caliphate, which had lapsed through the taking of Baghdad by Hulagu, followed by the execution of the caliph. Bibars recognized the claim of a certain Abu'l-Qāsim Aḥmed to be the son of Ẓāhir, the 35th Abbasid caliph, and installed him as Commander of the Faithful at Cairo with the title *al-Mostanṣir billāh.* Mostanṣir then proceeded to confer on Bibars the title sultan, and to address to him a homily, explaining his duties. The sultan appears to have contemplated restoring the new caliph to the throne of Baghdad; but the force which he sent with him for this purpose was quite insufficient, and Mostanṣir was defeated and slain. This did not prevent Bibars from maintaining his policy of appointing an Abbasid for the purpose of conferring legitimacy on himself; but he encouraged no further attempts at re-establishing the Abbasids at Baghdad, and his principle, adopted by successive sultans, was that the caliph should not leave Cairo except when accompanying the sultan on an expedition.

The reign of Bibars was spent largely in successful wars against the crusaders, the Armenians and the Seljukids of Asia Minor. He further reduced the Ismā'īlians or Assassins, whose existence as a community lasted on in Syria after it had nearly come to an end in Persia. He made Nubia tributary, therein extending Muslim arms farther south than any previous sultan had brought them. His authority was before his death recognized all over Syria (with the exception of the few cities still in the power of the Franks), over Arabia, with the exception of Yemen, on the Euphrates from Birah to Kerkesia (Circesium) on the Chaboras (Khabur), whilst the amirs of north-western Africa were tributary to him. He was the first sultan who acknowledged the equal authority of the four schools of law, and appointed judges belonging to each in Egypt and Syria; he was thus able to get his measures approved by one school when condemned by another.

On July 1, 1277, Bibars died. His son Malik al-Sa'īd was soon superseded by his father-in-law, *Kalā'ūn,* a Mameluke who had risen high in the former sovereign's service. Kalā'ūn, without pursuing any career of active conquest, successfully defended Syria from a Mongol invasion which he defeated in 1281 at the battle of Homs (Emesa). He did much to consolidate his dominions, and especially to extend Egyptian commerce, for which purpose he started passports enabling merchants to travel with safety through Egypt and Syria as far as India. He directed his energies towards capturing the last places that remained in the hands of the Franks, and proceeded to take Markab, Latakia and Tripoli (April 26, 1289). In 1290 he planned an attack on Acre, but died (Nov. 10) in the middle of his preparations. Under him we first hear of the Burjite Mamelukes, who owe their name to the citadel (Burj) of Cairo, where 3,700 of the whole number of 12,000 Mamelukes maintained by this sovereign were quartered. He also set an example, frequently followed, of the practice of dismissing all non-Muslims from Government posts: this was often done by his successors with the view of conciliating the Muslims, but it was speedily found that the services of the Jewish and Christian clerks were again required. He further founded a hospital for clinical research on a scale formerly unknown.

Kalā'ūn was followed by his son *Khalīl* (*Malik al-Ashraf Salāḥ al-dīn*), who carried out his father's policy of driving the Franks out of Syria and Palestine, and proceeded with the siege of Acre, which he took (May 18, 1291) after a siege of 43 days. The capture and destruction of this important place were followed by the capture of Tyre, Sidon, Haifa, Athlit and Beirut, and thus Syria was cleared of the crusaders. He also planned an expedition against the prince of Lesser Armenia, which was averted by the surrender of Behesna, Marash and Tell Ḥamdūn. The disputes between his favourite, the vizier Ibn al-Sa'lūs, and his viceroy Baidara, led to his being murdered by the latter (Dec. 12, 1293), who was proclaimed sultan, but almost immediately fell a victim to the vengeance of the deceased sultan's party, who placed a younger son of Kalā'ūn, *Mohammed Malik al-Nāṣir,* on the throne.

Malik al-Nāṣir.—This prince had the singular fortune of reigning three times, being twice dethroned: he was first installed on

Dec. 14, 1293, when he was nine years old, and the affairs of the kingdom were undertaken by a cabinet, consisting of a vizier ('Alam al-dīn Sinjar), a viceroy (Kitboga), a war minister (Ḥusām al-dīn Lājīn al-Rūmī), a prefect of the palace (Rokneddin Bibars Jāshengir) and a secretary of State (Rokneddin Bibars Manṣūrī). This cabinet naturally split into rival camps, in consequence of which Kitboga, himself a Mongol, with the aid of other Mongols who had come into Egypt after the battle of Homs, succeeded in ousting his rivals, and presently, with the aid of the surviving assassins of the former sultan, compelling Malik al-Nāṣir to abdicate in his favour (Dec. 1, 1294). The usurper was, however, able to maintain himself for two years only, and in 1296 one of the murderers of Khalil, Ḥusām al-dīn *Lājīn*, son-in-law of the sultan Bibars and formerly governor of Damascus, was installed in his place (Nov. 26, 1296). It had become the practice of the Egyptian sultans to bestow all offices of importance on their own freedmen (Mamelukes) to the exclusion of the older amirs, whom they could not trust so well, but who in turn became still more disaffected. Ḥusām al-dīn fell a victim to the jealousy of the older amirs and was murdered on Jan. 16, 1299. His short reign was marked by some fairly successful incursions into Armenia, and by a fresh survey and division of land in Egypt and Syria, which occasioned much discontent. After his murder the deposed sultan Malik al-Nāṣir, who had been living in retirement at Kerak, was reinstated by the army as sultan in Cairo (Feb. 7, 1299), though still only 14 years of age, so that public affairs were administered not by him, but by Salār the viceroy, and Bibars Jāshengir, prefect of the palace. The 7th Ilkhan, Ghazan Mahmud, took advantage of the disorder in the Mameluke empire to invade Syria in the latter half of 1299, when his forces seized several cities, including the capital Damascus, of which, however, they were unable to storm the citadel; in 1300, when a fresh army was collected in Egypt, the Mongols evacuated Damascus and made no attempt to secure their other conquests. The fear of further Mongolian invasion led to the imposition of fresh taxes in both Egypt and Syria, including one of 33% on rents, which occasioned many complaints. The invasion did not take place till 1303, when at the battle of Marj al-Ṣaffar (April 20) the Mongols were defeated. This was the last time that the Ilkhans gave the Egyptian sultans serious trouble. The fact that the Mongols were in ostensible alliance with Christian princes led to a renewal by the sultan of earlier ordinances against Jews and Christians, which led to missions from various Christian princes requesting milder terms for their co-religionists. The amirs Salār and Bibars having usurped the whole of the sultan's authority, he retired in March 1309 to Kerak, whence he sent his abdication to Cairo; in consequence of which, on April 5, 1309, *Bibars Jāshengir* was proclaimed sultan, with the title *Malik al-Moẓaffar*. This prince was originally a freedman of Kalā'ūn, and was the first Circassian who ascended the throne of Egypt. Before the year was out the new sultan had been rendered unpopular by a famine, and Malik al-Nāṣir was easily able to induce the Syrian amirs to return to his allegiance, in consequence of which he re-entered Cairo as sovereign on March 5, 1310. He soon found the means to execute both Bibars and Salār, while other amirs who had been eminent under the former régime fled to the Mongols. The relations between their Ilkhan and the Egyptian sultan continued strained, and for many years each court commonly entertained refugees from the other kingdom. Finally in 1322 terms of peace and alliance were agreed on between the sultan and Abū Sa'īd the 9th Ilkhan. The sultan also entered into relations with the Mongols of the Golden Horde and in 1319 married a daughter of the reigning prince Uzbeg Khan (*see* MONGOLS: *Golden Horde*). Much of Malik al-Nāṣir's third administration was spent in raids into Nubia, where he endeavoured to set up a creature of his own as sovereign, in attempts at subduing the Bedouins of south-eastern Egypt, and in persecuting the Nosairīs, whose heresy became formidable about this time. Like other Egyptian sultans he made considerable use of the Assassins, 124 of whom were sent by him into Persia to execute Kara Sonkor, at one time governor of Damascus, and one of the murderers of Malik al-Ashraf; but they were all outwitted by the exile, who was finally poisoned by the Ilkhan in recompense for a similar service rendered by the Egyptian sultan. For a time Malik al-Nāṣir was recognized as suzerain in north Africa, the Arabian Irak, and Asia Minor, but he was unable to make any permanent conquests in any of these countries. He brought Medīna, which had previously been governed by independent sherīfs, to acknowledge his authority. His diplomatic relations were more extensive than those of any previous sultan, and included Bulgarian, Indian and Abyssinian potentates, as well as the pope, the king of Aragon and the king of France. He appears to have done his utmost to protect his Christian subjects, incurring thereby the reproaches of the more fanatical Muslims, especially in the year 1320 when owing to incendiarism in Cairo there was danger of a general massacre of the Christian population. His internal administration was marked by gross extravagance, which led to his viziers being forced to practise violent extortion for which they afterwards suffered. He paid considerable attention to sheep-breeding and agriculture, and by a canal which he had dug from Fuah to Alexandria not only assisted commerce but brought 100,000 feddans under cultivation. His taste for building and street improvement led to the beautifying of Cairo, and his example was followed by the governors of other great cities in the empire, notably Aleppo and Damascus. He paid exceptionally high prices for Mamelukes, many of whom were sold by their Mongol parents to his agents, and accustomed them to greater luxury than was usual under his predecessors. In 1315 he instituted a survey of Egypt, and of the 24 parts into which it was divided ten were assigned to the sultan and 14 to the amirs and the army. He took occasion to abolish a variety of vexatious imposts, and the new budget fell less heavily on the Christians than the old. Among the literary ornaments of his reign was the historian and geographer Ismā'īl Abulfeda (*q.v.*), to whom Malik al-Nāṣir restored the government of Hamath, which had belonged to his ancestors, and even gave the title sultan. He died on June 7, 1341.

With his death the decline of the Bahrī dynasty began. It lasted until 1381, when the heir of the dynasty was formally supplanted by the powerful Mameluke Barkūk, known as sultan under the title Malik al-Zāhir. But the 40 years before this event are marked by a succession of feeble and sometimes infant, sultans and by frequent revolutions in the palace and disorders in the provinces. Before the end the unity of the empire had become little more than superficial and its existence was threatened by Tartar hordes from further Asia.

Period of Burji Mamelukes.—After overcoming a brief reaction in favour of the older dynasty (1389–90) Barkūk entered into relations with the Ottoman sultan Bāyezīd I., and in 1394 led an army into Syria, partly as a measure preliminary to the extension of his influence further east, and partly to forestall the threatened Mongol invasion. Before the latter event occurred he died (June 20, 1399), and a young son of his, named *Faraj*, became sultan under the guardianship of two amirs. Incursions were immediately made by the Ottoman sultan into the territory of Egyptian vassals at Derendeh and Albistan (Albestin), and Malatia was besieged by his forces. Timur, who was at this time beginning his campaign against Bāyezīd, turned his attention first to Syria, and on Oct. 30, 1400, defeated the Syrian amirs near Aleppo, and soon got possession of the city and the citadel. He proceeded to take Hamah, Homs (Emesa) and other towns, and on Dec. 20 started for Damascus. An endeavour was made by the Egyptian sultan to relieve Damascus, but the news of an insurrection in Cairo caused him to retire and leave the place to its fate. In the first three months of 1401 the whole of northern Syria suffered from Timur's marauders. In the following year (Sept. 29, 1402) Timur who had in the interval inflicted a crushing defeat on the Ottoman sultan, sent to demand homage from Faraj, and his demand was readily granted, together with the delivery of the princes who had sought refuge from Timur in Egyptian territory. The death of Timur in Feb. 1405 restored Egyptian authority in Syria, which, however, became a rendezvous for all who were discontented with the rule of Faraj and his amirs, and two months after Timur's death was in open rebellion against Faraj. Although Faraj succeeded in defeating the rebels, he was com-

pelled by insubordination on the part of his Circassian Mamelukes to abdicate (Sept. 20, 1405), when his brother *Abd al-'aziz* was proclaimed with the title *Malik al-Manṣūr;* after two months this prince was deposed, and Faraj, who had been in hiding, recalled. Most of his reign was, however, occupied with revolts on the part of the Syrian amirs, to quell whom he repeatedly visited Syria; the leaders of the rebels were the amirs Newruz and Sheik Maḥmūdī, afterwards sultan. Owing to disturbances and misgovernment the population of Egypt and Syria is said to have shrunk to a third in his time, and he offended public sentiment not only by debauchery, but by having his image stamped on his coins. On May 23, 1412, after being defeated and shut up in Damascus, he was compelled by Sheik Maḥmūdī to abdicate, and an Abbasid caliph, Mosta'īn, was proclaimed sultan, only to be forced to abdicate on Nov. 6 of the same year in *Sheik's* favour, who took the title *Malik al-Mu'ayyad,* his colleague Newruz having been previously sent to Syria, where he was to be autocrat by the terms of their agreement. In the struggle which naturally followed between the two, Newruz was shut up in Damascus, defeated and slain. Sheik himself invaded Asia Minor and forced the Turkoman States to acknowledge his suzerainty. After the sultan's return they soon rebelled, but were again brought into subjection by Sheik's son Ibrāhīm; his victories excited the envy of his father, who is said to have poisoned him. Sheik himself died a few months after the decease of his son (Jan. 13, 1421). After a succession of brief sultanates the amir *Barsbai* was proclaimed in 1422. This sultan avenged the attacks on Alexandria repeatedly made by Cyprian ships, by sending a fleet which burned Limasol, and another which took Famagusta (Aug. 4, 1425), but failed in the endeavour to annex the island permanently. An expedition sent in the following year (1426) succeeded in taking captive the king of Cyprus, who was brought to Cairo and presently released for a ransom of 200,000 dinars, on condition of acknowledging the suzerainty of the Egyptian sultan and paying him an annual tribute. The sultan's exactions from merchants led to a naval demonstration on the part of the Venetians, who secured better terms for their trade, and to the seizure of Egyptian vessels by the king of Aragon and the prince of Catalonia. In a census made during Barsbai's reign, it was found that the total number of towns and villages in Egypt had sunk to 2,170, whereas in the 4th century A.H. it had stood at 10,000. Much of Barsbai's attention was occupied with raids into Asia Minor, where the Dhu 'l-Kadiri Turkomans frequently rebelled, and with wars against Kara Yelek, prince of Amid, and Shah Rokh, son of Timur. Barsbai died on June 7, 1438. In accordance with the custom of his predecessors he left the throne to a son still in his minority, *Abu'l-Mahāsin Yūsuf,* who took the title *Malik al-'Azīz,* but as usual after a few months he was displaced by the regent *Jakmak,* who on Sept. 9, 1438, was proclaimed sultan with the title *Malik al-Zāhir.* In the years 1442–44 this sultan sent three fleets against Rhodes, where the third effected a landing, but was unable to make any permanent conquest. In consequence of a lengthy illness Jakmak abdicated on Feb. 1, 1453, when his son *'Othman* was proclaimed sultan with the title *Malik al-Manṣūr.* Though not a minor, he had no greater success than the sons of the usurpers who preceded him, being dethroned after six weeks (March 15, 1453) in favour of the amir *Inal al-'Alā'ī,* who took the title *Malik al-Ashraf.* His reign was marked by friendly relations with the Ottoman sultan Mohammed II., whose capture of Constantinople (1453) was the cause of great rejoicings in Egypt, but also by violent excesses on the part of the Mamelukes, who dictated the sultan's policy. On his death on Feb. 26, 1461, his son *Aḥmad* was proclaimed sultan with the title *Malik al-Mu'ayyad,* but was compelled to abdicate on June 28, 1461, when the amir *Khoshkadam,* who had served as a general, was proclaimed sultan. Unlike the other Mameluke sovereigns, who were Turks or Circassians, this man had originally been a Greek slave.

The Turkish Conquest.—In his reign (1463) there began the struggle between the Egyptian and the Ottoman sultanates which finally led to the incorporation of Egypt in the Ottoman empire. The dispute began with a struggle over the succession in the principality of Karaman, where the two sultans favoured rival candidates, and the Ottoman sultan Mohammed II. supported the claim of his candidate with force of arms, obtaining as the price of his assistance several towns in which the suzerainty of the Egyptian sultan had been acknowledged. Open war did not, however, break out between the two States in Khoshkadam's time, who died on Oct. 9, 1467, when the Atābeg *Yelbai* was selected by the Mamelukes to succeed him, and was proclaimed sultan with the title of *Malik al-Zāhir.* Proving incompetent, he was deposed by a revolution of the Mamelukes on Dec. 4, 1467, when the Atābeg *Timurbogha* was proclaimed with the title *Malik al-Zāhir.* In a month, however, another palace revolution established as sultan the new Atābeg *Kait Bey* or *Kaietbai* (Jan. 31, 1468). During his sultanate relations with the Ottoman Turks became more strained, and Bayezid II. declared war against Egypt, seizing Adana, Tarsus and other places within Egyptian territory. In 1491, however, after the Egyptians had repeatedly defeated the Ottoman troops, Kait Bey made proposals of peace which were accepted, the keys of the towns which the Ottomans had seized being restored to the Egyptian sultan. Kait Bey endeavoured to assist his co-religionists in Spain who were threatened by King Ferdinand, by threatening the pope with reprisals on Syrian Christians, but without effect. He died on Aug. 8, 1496, and a succession of brief sultanates ended in the establishment of *Kānsūh al-Ghūri* (April 1501), under whom there broke out the war which ended in the incorporation of Egypt into the Ottoman empire. Kānsūh was charged by the Ottoman sultan Selim I. with giving the envoys of the Ṣafawid Isma'il passage through Syria on their way to Venice to form a confederacy against the Turks, and with harbouring various refugees. The actual declaration of war was not made by Selin till May 1515, when the Ottoman sultan had made all his preparations; and at the battle of Merj Dabik, on Aug. 24, 1515, Kānsūh was defeated by the Ottoman forces and fell fighting. Syria passed quickly into the possession of the Turks, whose advent was in many places welcome as meaning deliverance from the Mamelukes. In Cairo, when the news of the defeat and death of the Egyptian sultan arrived, the governor who had been left by Kānsūh, *Tūmānbey,* was proclaimed sultan (Oct. 17, 1516). On Jan. 20, 1517, Cairo was taken by the Ottomans, and Selim shortly after declared sultan of Egypt. Tūmānbey continued the struggle for some months, but was finally defeated, and after being captured and kept in prison 17 days, was executed on April 15, 1517.

(D. S. MA.; F. M. S.)

III. MODERN HISTORY

The Turkish Period.—The sultan, Selim, left with his viceroy, Khair Bey, a guard of 5,000 janissaries, but otherwise made few changes in the administration of the country. The register by which a great portion of the land was a fief of the Mamelukes was maintained, and it is said that a proposal made by the sultan's vizier to appropriate these estates was punished with death. The Mameluke amirs were to be retained in office as heads of 12 sanjaks into which Egypt was divided; and under the next sultan, Suleiman I., two chambers were created, called respectively the greater and the lesser divan, in which both the army and the ecclesiastical authorities were represented, to aid the pasha by their deliberations. Six regiments altogether were constituted by the conqueror, Selim, for the protection of Egypt; to these Suleiman added a seventh, of Circassians. In 1527 the first survey of Egypt under the Ottomans was made, in consequence of the official copy of the former registers, having perished by fire. Egyptian lands were divided in it into four classes—the sultan's domain, fiefs, land for the maintenance of the army, and lands settled on religious foundations.

It would seem that the constant changes in the Government caused the army to get out of control at an early period of the Ottoman occupation, and at the beginning of the 17th century mutinies became common. In 1604 the governor, Ibrahim Pasha, was murdered by the soldiers and his head set on the Bab Zuwēla; in 1609 they declared war on Mohammed Pasha. He, however, signally defeated them, and effected much-needed financial reforms. Meanwhile the prestige of the governors was threatened

in another direction; for the troubles that beset the metropolis of the Ottoman empire tended to weaken the respect of the Egyptians for its representatives at Cairo. In July 1623 there came an order from the Porte dismissing Mustafā Pasha and appointing 'Alī, Pasha governor in his place. The officers met and demanded from the newly-appointed governor's deputy the customary gratuity; when this was refused they sent letters to the Porte declaring that they wished to have Mustafā Pasha and not 'Alī Pasha as governor. 'Ali Pasha's efforts, on landing, to assert himself were unsuccessful, and soon after a rescript arrived from Constantinople, confirming Mustafā Pasha in the governorship. Similarly, in 1631, when the army took upon themselves to depose the governor, Mūsā Pasha, in indignation at his execution of Kītās Bey, an officer who was to have commanded an Egyptian force required for service in Persia, the Porte approved the conduct of the army and appointed one Khalīl Pasha as Mūsā's successor. Not only was the governor unsupported by the sultan against the troops, but each new governor regularly inflicted a fine upon his outgoing predecessor, under the name of money due to the treasury; and the outgoing governor was not allowed to leave Egypt till he had paid it. Besides the extortions to which this practice gave occasion the country suffered greatly from famine and pestilence. The latter, in the spring of 1619, is said to have carried off 635,000 persons, and in 1643 completely desolated 230 villages.

BY COURTESY OF THE NEAR EAST RELIEF

AN EGYPTIAN NEAR CAIRO

Rise of the Beys.—By the 18th century the importance of the pasha was quite superseded by that of the beys, and two offices, those of Sheikh al-Balad and Amīr-al-Ḥājj, which were held by these persons, represented the real headship of the community. In 1707 the Sheikh al-Balad, Qāsim Iywāz headed one of two Mameluke factions, the Qāsimites and the Fiqārites, between whom the seeds of enmity were sown by the pasha of the time, with the result that a fight took place between the factions outside Cairo, lasting 80 days. His son Ismā'īl, who succeeded him and held office for 16 years while the pashas were constantly being changed, reconciled the two factions of Mamelukes. Ismā'īl was assassinated in 1724, and the next two successors who fought their way into his place shared the same fate. Then came Ottoman Bey, who governed with wisdom and moderation, but was forced to fly from Egypt by the intrigues of two adventurers, Ibrāhīm and Riḍwān Bey. They, when their scheme had succeeded, began a massacre of beys and others thought to be opposed to them; they then proceeded to govern Egypt jointly, holding the two offices mentioned above in alternate years. More than one pasha failed to rid himself of them, but at last the murder of Ibrāhīm Bey took place in 1755; and his colleague, Riḍwān, perished in the disputes that followed upon it.

'Alī Bey.—'Alī Bey, a former protegé of Ibrāhīm's, set himself the task of avenging the death of his master, and spent eight years in purchasing Mamelukes and winning other adherents. He thereby excited the suspicions of the Sheikh al-Balad Khalīl Bey, who drove him out of Cairo, but was eventually overpowered, sent to Alexandria and finally strangled. The date of 'Alī Bey's victory was 1164 A.H. (A.D. 1750), and after it he was made Sheikh al-Balad. In that capacity he executed the murderer of his former master, Ibrāhīm; but the resentment which this act aroused among the beys caused him to leave his post and fly to Syria, where the governor of Acre, Ẓāhir b. Omar, obtained for him the goodwill of the Porte and reinstatement in his post as Sheikh al-Balad. In 1766, after the death of his supporter, the grand vizier, Rāghib Pasha, he was again compelled to fly from Egypt to Yemen, but in the following year his party at Cairo was strong enough to permit of his return. Resuming his office, he raised 18 of his friends to the rank of bey, among them Ibrāhīm and Murād, who were afterwards at the head of affairs, as well as Mohammed Abu'l-Dhahab, who was closely connected with the rest of 'Alī Bey's career. In 1769 the Porte called on him to furnish a force of 12,000 men to be employed in the Russian war. It was suggested, however, at Constantinople that 'Alī would employ this force when he collected it for securing his own independence, and a messenger was sent by the Porte to the pasha with orders for his execution. 'Alī, being apprised by his agents at the metropolis of the despatch of this messenger, ordered him to be waylaid and killed; the despatches were seized and read by 'Alī before an assembly of the beys, who were assured that the order for execution applied to all alike, and he urged them to fight for their lives. His proposals were received with enthusiasm by the beys whom he had created. Egypt was declared independent and the pasha given 48 hours to quit the country. Ẓāhir Pasha of Acre, to whom was sent official information of the step taken by 'Alī Bey, promised his aid and kept his word by compelling an army sent by the pasha of Damascus against Egypt to retreat. Within six months 'Alī Bey had subjugated the greater part of the Arabian peninsula and appointed as sherīf of Mecca a cousin of his own, who bestowed on him by an official proclamation the titles sultan of Egypt and khākān of the Two Seas. He then, in virtue of this authorization, struck coins in his own name (1185 A.H.) and ordered his name to be mentioned in public worship.

His next move turned out fatally, Abu'l-Dhahab was sent with a force of 30,000 men (A.D. 1771) to conquer Syria; and agents were sent to negotiate alliances with Venice and Russia. Abu'l-Dhahab's progress through Palestine and Syria was triumphant; but, after capturing Damascus, he entered into secret negotiations with the Porte, by which he undertook to restore Egypt to Ottoman suzerainty. He then proceeded to evacuate Syria, and marched with all the forces he could collect to Upper Egypt, occupying Assiut in April 1772. Ismā'īl Bey was sent by 'Alī Bey with a force of 3,000 to check his advance; but at Bāsātīn Ismā'īl with his troops joined Abu'l-Dhahab. 'Alī Bey received information to the effect that his friend Ẓāhir of Acre was willing to give him refuge, and left Cairo for Syria (April 8, 1772), one day before the entrance of Abu'l-Dhahab.

At Acre 'Alī's fortune seemed to be restored. A Russian vessel anchored outside the port, and supplied him with stores and ammunition, and a force of 3,000 Albanians. He sent one of his officers, 'Alī Bey al-Ṭanṭāwī, to recover the Syrian towns evacuated by Abu'l-Dhahab, and now in the possession of the Porte. He himself took Jaffa and Gaza, the former of which he gave to his friend Ẓāhir of Acre. In Feb. 1773 he started for Egypt at the head of an army of 8,000 men, and on April 19 met the army of Abu'l-Dhahab at Sālihia. 'Alī's forces were successful at the first engagement; but when the battle was renewed two days later he was deserted by some of his officers, and prevented by illness and wounds from himself taking the conduct of affairs. The result was a complete defeat for his army, after which he declined to leave his tent; he was captured after a brave resistance, and taken to Cairo, where he died seven days later.

After 'Alī Bey's death Egypt became once more a dependency of the Porte, governed by Abu'l-Dhahab as Sheikh al-Balad with the title pasha. He shortly afterwards received permission from the Porte to invade Syria, with the view of punishing 'Alī Bey's supporter Ẓāhir, and in the course of the campaign he died. One of his deputies, Ismā'īl Bey, now became Sheikh al-Balad, but was soon involved in a dispute with Ibrāhīm and Murād, two of the colleagues of 'Alī Bey who had deserted him at Sālihia. They after a time succeeded in driving Ismā'īl out of Egypt and establishing a joint rule (as Sheikh al-Balad and Amīr al-Ḥājj respectively) similar to that which had been tried previously. In 1786 an expedition was sent by the Porte to restore Ottoman supremacy in Egypt; and Ismā'īl Bey was again made Sheikh al-Balad and a new pasha installed as governor. In Jan. 1791 a terrible plague began to rage in Cairo and elsewhere in Egypt, to which Ismā'īl Bey and most of his family fell victims. Owing to the need for competent rulers Ibrāhīm and Murād Bey were sent for and reinstated in their dual government. These two persons were still in office when Bonaparte entered Egypt.

Literature.—Arabic literature being cosmopolitan, the list of authors connected with Egypt, which occupies pages 161–275 of Suyūṭī's work, *Ḥusn al-muḥādarah fi akhbāri Misr wal-Qāhirah* (Cairo, 1321 A.H.), contains the names of persons like Mutanabbī, who stayed there for a short time in the service of some patron; Abū Tammām, who lived there before he acquired fame as a poet; 'Umāra of Yemen, who came there at a mature age to spend some years in the service of Fāṭimite viziers; each of whom figures in lists of authors belonging to some other country also. So long as the centre of the Islamic world was not in Egypt, the best talent was attracted elsewhere; but after the fall of Baghdad, Cairo became the chief seat of Islamic learning, and this rank, chiefly owing to the university of Azhar, it has ever since continued to maintain. There is consequently a long and distinguished list of Arabic historians of Egypt, from Ibn 'Abd al-Ḥakam, in the 3rd Islamic century to 'Abd al-Raḥmān Jabartī, in the 13th. Of many of the Mameluke sultans there are special chronicles preserved in various European and oriental libraries. To these there should be added the Survey of Egypt, called *al-tuḥfah al-saniyyah* of Ibn Jī'ān, belonging to the time of Kait Bey; the treatise on the Egyptian constitution called *Zubdat Kashf al-Mamālik,* by Khalīl al-Ẓāhirī, of the same period; and the encyclopaedic work on the same subject called *Ṣubḥ al-Inshā*, by al-Qalqashandī, d. 821.

Arabic poetry is in the main encomiastic and personal, and from the beginning of the Omayyad period sovereigns and governors paid poets to celebrate their achievements; of those of importance who are connected with Egypt there is again a lengthy list from the 2nd to the 9th centuries. Poets distinguished for special lines are al-Ḥakīm b. Dāni'āl, d. 608, author of the Shadow-play; and al-Būsīrī (Mohammed b. Sa'īd), d. 694, author of the ode in praise of the prophet called Burdah. A list of poets of the 11th century is given by Khafājī in his *Raiḥānat al-alibbā.*

The needs of the Egyptian court produced a number of elegant letter-writers, of whom the most famous were 'Abd al-Raḥīm b. 'Alī al-Baisānī, ordinarily known as al-Qāḍi 'al-Fāḍil, d. 596, secretary of State to Saladin and other Ayyūbite sultans; 'Imād al-dīn al-Ispahānī, d. 597, also secretary of State and official chronicler; and Ibn 'Abd al-Ẓāhir, d. 692, secretary of State to Bibars I. and succeeding sultans; he was followed by his son Fatḥ al-dīn, to whom the title "Secret writer" was first given.

In the subject of law Egypt boasts that the Imām Shāfi'ī, founder of one of the schools, resided at Fosṭāṭ from 195 till his death in 204; his system, though displaced for a time by that invented by the Fāṭimites, and since the Turkish conquest by the Ḥanifite system, has always been popular in Egypt.

Among Egyptian mystics the most famous as authors are the poet Ibn al-Fāriḍ, d. 632, and Abd al-Wahhāb Shabrānī, d. 973. Abu'l-Ḥasan al-Shādhilī (d. 656) is celebrated as the founder of the Shādhilī order; but there were many others of note. The dictionary of physicians, compiled in the 7th century, enumerates nearly 60 men of science who resided in Egypt; the best-known among them are Sa'īd b. Biṭrīq, Moses Maimonides and Ibn Baiṭār. Of Egyptian miscellaneous writers two of the most celebrated are Ibn Daqīq al'-īd, d. 702, and Jalāl al-din Suyūṭī.

(D. S. Ma.; Me.)

The French Occupation.—Although in reality a move in Napoleon's great game of world domination, the French expedition to Egypt had, as its ostensible object, the reinstatement of the authority of the Sublime Porte, and the suppression of the Mamelukes. In the proclamation printed with the Arabic types brought from the Propaganda press, and issued shortly after the taking of Alexandria, Bonaparte declared that he reverenced the prophet Mohammed and the Koran far more than the Mamelukes reverenced either, and argued that all men were equal except so far as they were distinguished by their intellectual and moral excellences, of neither of which the Mamelukes had any great share. In future all posts in Egypt were to be open to all classes of the inhabitants; the conduct of affairs was to be committed to the men of talent, virtue and learning; and in proof of the statement that the French were sincere Muslims the overthrow of the papal authority in Rome was alleged. After the battle of Ambabah, at which the forces of both Murād Bey and Ibrāhīm Bey were dispersed, the populace readily plundered the houses of the beys, and a deputation was sent from al-Azhar to Bonaparte to ascertain his intentions; these proved to be a repetition of the terms of his proclamation, and, though the combination of loyalty to the French with loyalty to the sultan was unintelligible, a good understanding was at first established between the invaders and the Egyptians. The destruction of the French fleet, however, at the battle of the Nile, and the failure of the French forces sent to Upper Egypt (where they reached the first cataract) to obtain possession of the person of Murād Bey, shook the faith of the Egyptians in their invincibility; and in consequence of a series of unwelcome innovations, an insurrection broke out in Cairo on Oct. 22, 1798, of which the headquarters were in the Muslim university of Azhar. On this occasion the French general Dupuy, lieutenant-governor of Cairo, was killed. The prompt measures of Bonaparte, aided by the arrival from Alexandria of Gen. J. B. Kléber, quickly suppressed this rising; but the stabling of the French cavalry in the mosque of Azhar gave great and permanent offence. On Dec. 25 a proclamation was issued, reconstituting the two divans which had been created by the Turks; the special divan was to consist of 14 persons chosen by lot out of 60 government nominees, and was to meet daily. The general divan was to consist of functionaries, and to meet on emergencies.

Napoleon's ill-fated expedition to Syria followed: but in July 1799 he retrieved his fortunes by a crushing defeat of the Turkish army that had landed at Aboukir, aided by the British fleet commanded by Sir Sidney Smith. Shortly after his victory Bonaparte left Egypt, having appointed Kléber to govern in his absence, which he informed the sheikhs of Cairo was not to last more than three months. A double expedition shortly after Bonaparte's departure was sent by the Porte for the recovery of Egypt, one force being despatched by sea to Damietta, while another under Yūsuf Pasha took the land route from Damascus by al-Arish. Over the first some success was won, in consequence of which the Turks agreed to a convention (signed Jan. 24, 1800), by virtue of which the French were to quit Egypt. The Turkish troops advanced to Bilbeis, where they were received by the sheikhs from Cairo, and the Mamelukes also returned to that city from their hiding-places. Before the preparations for the departure of the French were completed, orders came to Sir Sidney Smith from the British Government, forbidding the carrying out of the convention unless the French army were treated as prisoners of war; and when these were communicated to Kléber he cancelled the orders previously given to the troops, and proceeded to put the country in a state of defence. In June, however, he was assassinated by a fanatic named Suleiman of Aleppo, said to have been incited to the deed by a Janissary refugee at Jerusalem. The command of the army then devolved on Gen. J. F. (Baron de) Menou (1750–1810), a man who had professed Islam, and achieved some popularity, counteracted, however, by his declaration of a French protectorate over Egypt, which was to count as a French colony.

French Evacuation.—In the first weeks of March 1801 the English, under Sir R. Abercromby, effected a landing at Aboukir, and proceeded to invest Alexandria, where on the 21st they were attacked by Menou; the French were repulsed, but the English commander was mortally wounded in the action. On the 25th fresh reinforcements arrived under Husain, the Kapudan Pasha, or high admiral; and a combined English and Turkish force was sent to take Rosetta. On May 30, Gen. A. D. Belliard, who had been left in charge at Cairo, was assailed on two sides by the British forces under Gen. John Hely Hutchinson (afterwards 2nd earl of Donoughmore), and the Turkish under Yūsuf Pasha; after negotiations Belliard agreed to evacuate Cairo and to sail with his 13,734 troops to France. On Aug. 30, Menou at Alexandria was compelled to accept similar conditions, and his force of 10,000 left for Europe in September. This was the termination of the French occupation of Egypt.

Soon after the evacuation of Egypt by the French, the country became the scene of more severe troubles, in consequence of the attempts of the Turks to destroy the power of the Mamelukes. In defiance of promises to the British Government, orders were trans-

mitted from Constantinople to Husain Pasha, the Turkish high admiral, to ensnare and put to death the principal beys. Invited to an entertainment, they were either attacked on board the flagship or fired upon in open boats, in the Bay of Aboukir. They offered an heroic resistance, but were overpowered, and some killed, some made prisoners; among the last was Osman Bey al-Bardīsī, who was severely wounded. Gen. Hutchinson, informed of this treachery, immediately assumed threatening measures against the Turks, and in consequence the killed, wounded and prisoners were given up to him. At the same time Yūsuf Pasha arrested all the beys in Cairo, but was shortly compelled by the British to release them. Such was the beginning of the disastrous struggle between the Mamelukes and the Turks.

In March 1803 the British evacuated Alexandria, and Mohammed Bey al-Alfī accompanied them to England to consult respecting the means to be adopted for restoring the former power of the Mamelukes. About six weeks after, the Arnaut (or Albanian) soldiers in the service of the Turkish governor, Mohammed Khosrev, tumultuously demanded their pay, and surrounded the house of the defterdār (or finance minister), who in vain appealed to the pasha to satisfy their claims. The latter opened fire from the artillery of his palace on the insurgent soldiery in the house of the defterdār, across the Ezbekia. Tāhir, the commander of the Albanians, then repaired to the citadel, gained admittance through an embrasure, and, having obtained possession of it, began to cannonade the pasha over the roofs of the intervening houses, and then descended with guns to the Ezbekia and laid close siege to the palace. On the following day Mohammed Khosrev made good his escape, with his women and servants and his regular troops, and fled to Damietta by the river. This revolt marks the beginning in Egypt of the breach between the Albanians and Turks, which ultimately led to the expulsion of the latter, and of the rise to power of the Albanian Mehemet Ali (Mohammed Ali, *q.v.*), who was destined to rule the country for nearly 40 years and be the cause of serious European complications.

Rise of Mehemet Ali.—Tāhir Pasha assumed the government, but in 23 days he was assassinated. A desperate conflict ensued between the Albanians and Turks; and the palace was set on fire and plundered. The masters of Egypt were now split into these two factions, animated with the fiercest animosity against each other. Mehemet Ali, then in command of an Albanian regiment, became the head of the former, but his party was the weaker, and he therefore entered into an alliance with the Mameluke leaders, Ibrahim Bey and 'Osmān Bey al-Bardīsī. The Mamelukes were reinstated in the citadel: and the allies marched against Khosrev Pasha, who having been joined by a considerable body of Turks, and being in possession of Damietta, was enabled to offer an obstinate resistance. After much loss on both sides, he was taken prisoner and brought to Cairo; but he was treated with respect. The victorious soldiery sacked the town of Damietta, and were guilty of the barbarities usual with them on such occasions.

A few days later, Ali Pasha Jazāirli landed at Alexandria with an imperial firmān constituting him pasha of Egypt, and threatened the beys, who now were virtual masters of Upper Egypt, as well as of the capital and nearly the whole of Lower Egypt. Mehemet Ali and al-Bardīsī therefore descended to Rosetta, which had fallen into the hands of a brother of Ali Pasha, captured the town and its commander, and returned to Cairo. The troubles of Egypt were now increased by an insufficient inundation, and great scarcity prevailed, aggravated by the taxation to which the beys were compelled to resort in order to pay the troops; while murder and rapine prevailed in the capital, the riotous soldiery being under little or no control. Meanwhile, Ali Pasha had been endeavouring to set the Albanians and the Mamelukes against each other, by intriguing with each separately. He failed, however, and his troops refusing to support him, he surrendered to the beys, while his army was compelled to retire to Syria. In the hands of the beys Ali Pasha again attempted treachery. This offered a fair pretext to the Mamelukes to rid themselves of a man proved to be a perfidious tyrant. He was sent under a guard of 45 men towards the Syrian frontier; and about a week after, news was received that in a skirmish with some of his own soldiers he had fallen mortally wounded.

The death of Ali Pasha produced only temporary tranquillity; in a few days (Feb. 12, 1804) the return of Mohammed Bey al-Alfī (called the Great) from England was the signal for fresh disturbances, which, by splitting the Mamelukes into two parties, accelerated their final overthrow. An ancient jealousy existed between al-Alfī and the other most powerful bey, al-Bardīsī, who took active measures to oppose his return. Husain Bey (a relative of al-Alfī) was assassinated by emissaries of al-Bardīsī, and Mehemet Ali, with his Albanians, gained possession of Giza, which had been occupied by al-Alfī's partisans. Al-Alfī himself on his way to Cairo encountered a party of Albanians, and with difficulty made his escape to the desert. A change in the fortune of al-Bardīsī, however, favoured his plans for the future. That chief, in order to satisfy the demands of the Albanians for their pay, gave orders to levy heavy contributions from the citizens of Cairo; and this new oppression roused them to rebellion. The Albanians, alarmed for their safety, assured the populace that they would not allow the order to be executed; and Mehemet Ali himself caused a proclamation to be made to that effect. Thus the Albanians became the favourites of the people, and took advantage of their opportunity. Seizing the citadel, they once more proclaimed Mohammed Khosrev pasha of Egypt. For one day and a half he enjoyed the title; the friends of the late Tāhir Pasha then accomplished his second degradation, and Cairo was again the scene of terrible enormities, the Albanians revelling in the houses of the Mameluke chiefs, whose harems met with no mercy at their hands. These events were the signal for the reappearance of al-Alfī.

The Albanians now invited Ahmed Pasha Khorshīd to assume the reins of government, and he without delay proceeded from Alexandria to Cairo. The forces of the partisans of al-Bardīsī had established a blockade of the city on the south, and were now ravaging the country on the north. Al-Alfī and Osman Bey had also declared against the pasha and advanced on Cairo, which was in a state of tumult and semi-starvation. At Shubra, however, a northern suburb, a pitched battle was fought in which the Mamelukes were defeated with heavy loss on both sides. This reverse in a measure united the two great Mameluke parties, though their chiefs remained at enmity. The Mamelukes gradually retreated towards Upper Egypt. Thither the pasha despatched three successive expeditions (one of which was commanded by Mehemet Ali) without decisive result.

At this period another calamity befell Egypt; about 3,000 Delīs (Kurdish troops) arrived in Cairo from Syria. These troops had been sent for by Khorshīd in order to strengthen himself against the Albanians; and the events of this portion of the history afford sad proof of their ferocity and brutal enormities, in which they far exceeded the ordinary Turkish soldiers and even the Albanians. Their arrival immediately recalled Mehemet Ali and his party from the war, and instead of aiding Khorshīd was the proximate cause of his overthrow.

Mehemet Ali Made Pasha.—Cairo was ripe for revolt; the pasha was hated for his tyranny and extortion, and execrated for the deeds of his troops, especially those of the Delīs: the ulemā prepared a formal statement of their wrongs and went with it (May 13, 1805) to Mehemet Ali and informed him that the people would no longer submit to Khorshīd. "Then whom will ye have?" said he. "We will have *thee*," they replied, "to govern us according to the laws; for we see in thy countenance that thou art possessed of justice and goodness." Mehemet Ali seemed to hesitate, and then complied, and was at once invested. On this, a bloody struggle began between the two pashas. Khorshīd was besieged by the Albanians in the citadel, from which he bombarded the town. The struggle went on, with intervals on Fridays, until a messenger from Constantinople brought a firmān confirming Mehemet Ali and ordering Khorshīd to go to Alexandria, there to await further orders; but this he refused to do, on the ground that he had been appointed by a *hatt-i-sherif*. The firing ceased on the following day, but the troubles of the people were rather increased than assuaged; murders and robberies were daily com-

mitted by the soldiery, the shops were all shut and some of the streets barricaded. While these scenes were being enacted, al-Alfī was besieging Damanhur, and the other beys were returning towards Cairo, Khorshīd having called them to his assistance: but Mehemet Ali forced them to retreat. At this point a squadron under the command of the Turkish high admiral arrived at Aboukir bay, with despatches confirming the firmān brought by the former envoy, and authorizing Mehemet Ali to continue to discharge the functions of governor. Khorshīd at first refused to yield; but at length, on condition that his troops should be paid, he evacuated the citadel and embarked for Rosetta.

Mehemet Ali now possessed the title of governor of Egypt, but beyond the walls of Cairo his authority was everywhere disputed by the beys, who were joined by the army of the silāhdār of Khorshīd; and many Albanians deserted from his ranks. To replenish his empty coffers he was also compelled to levy exactions, principally from the Copts. In these extremes he made an attempt to exterminate certain of the beys, who were encamped north of Cairo. On Aug. 17, 1805, having been induced by simulated treachery to enter the city, they marched along the principal street for some distance, with kettle-drums behind each company, and were received with apparent joy by the citizens. At the mosque called the Ashrafia they separated, one party proceeding to the Azhar and the other continuing along the main street, and through the gate called Bāb Zuwēla, where they turned up towards the citadel. Here they were fired on by some soldiers from the houses; and with this signal a terrible massacre began. Some sought refuge in the collegiate mosque Barkukia, while the remainder fought their way through their enemies and escaped over the city-wall. Two Mamelukes had in the meantime succeeded in giving the alarm to their comrades in the quarter of the Azhar, who escaped by an eastern gate. A horrible fate awaited those who had shut themselves up in the Barkukia. Having begged for quarter and surrendered, they were immediately stripped nearly naked, and about 50 were slaughtered on the spot; about the same number were dragged away, with every brutal aggravation of their pitiful condition, to Mehemet Ali, chained and left in the court of the pasha's house. On the following morning the heads of their comrades who had perished the day before were skinned and stuffed with straw before their eyes. One bey and two others paid their ransom and were released; the rest, without exception, were tortured and put to death in the course of the ensuing night. Thus ended Mehemet Ali's first massacre of his too confiding enemies.

In consequence of the remonstrances of the English, and a promise made by al-Alfī of 1,500 purses, the Porte consented to reinstate the beys of the 24 provinces, and to place al-Alfī at their head; but this measure met with the opposition of Mehemet Ali and the determined resistance of the majority of the Mamelukes, who, rather than have al-Alfī at their head, preferred their present condition; for the enmity of al-Bardīsī had not subsided, and he commanded the voice of most of the other beys. Al-Alfī was at the time besieging Damanhur, and he gained a signal victory over the pasha's troops; but the dissensions of the beys destroyed their last chance of a return to power. Al-Alfī and his partisans were unable to pay the sum promised to the Porte; Sālih Pasha, who had brought a Turkish force to Alexandria to depose Mehemet Ali, was placated by a payment of 4,000 purses to the Porte; Mehemet Ali was continued in his post, and the reinstatement of the beys was abandoned. Fortune continued to favour the pasha. In the following month al-Bardīsī died, aged 48 years; and soon after, a scarcity of provisions excited the troops of al-Alfī to revolt. That bey very reluctantly raised the siege of Damanhur, being in daily expectation of the arrival of an English army; and died suddenly on Jan. 30, 1807, at the age of 55. Thus was the pasha relieved of his two most formidable enemies; and shortly after he defeated Shāhīn Bey, with the loss to the latter of his artillery and baggage and 300 men killed or taken prisoners.

The British Expedition of 1807.—On March 17, 1807, a British fleet appeared off Alexandria, having on board nearly 5,000 troops, under the command of Gen. A. Mackenzie Fraser; and the place, being disaffected towards Mehemet Ali, opened its gates to them. Here they first heard of the death of al-Alfī, upon whose co-operation they had founded their chief hopes of success; and they immediately dispatched messengers to his successor and to the other beys, inviting them to Alexandria. Mehemet Ali countered by promising the beys to comply with all their demands if they would join him in expelling the invaders. To this they acceded. Meanwhile a detachment of Fraser's force under Gens. Wauchope and Meade, had been ambuscaded in Rosetta, and effected a retreat on Aboukir and Alexandria, after a very heavy loss of 185 killed and 281 wounded, Gen. Wauchope and three officers being among the former, and Gen. Meade and 19 officers among the latter. The heads of the slain were fixed on stakes on each side of the road crossing the Ezbekīa in Cairo. A second attack on Rosetta failed disastrously. On April 20, news having come in from the advanced guard at Hamād of large reinforcements to the besieged, Gen. Stewart was compelled to retreat; and the advanced guard, consisting of 733 men, was surrounded, and, after a gallant resistance, the survivors, who had expended all their ammunition, became prisoners of war. Gen. Stewart regained Alexandria with the remainder of his force, having lost, in killed, wounded and missing, nearly 900 men. Some hundreds of British heads were now exposed on stakes in Cairo, and the prisoners were marched between these mutilated remains of their countrymen. On Sept. 14 Gen. Fraser evacuated Alexandria.

Extermination of the Mamelukes.—Concessions to the beys then became the pasha's policy, and many of them took up their abode in Cairo, but tranquillity was not secured; several times they met the pasha's forces in battle and once gained a signal victory. Early in the year 1811, the preparations for an expedition against the Wahhābīs in Arabia being complete, all the Mameluke beys then in Cairo were invited to the ceremony of investing Mehemet Ali's favourite son, Tūsūn, with a pelisse and the command of the army. As on the former occasion, the unfortunate Mamelukes fell into the snare. On March 1, Shāhīn Bey and the other chiefs (one only excepted) repaired with their retinues to the citadel, and were courteously received by the pasha. Having taken coffee, they formed in procession, and, preceded and followed by the pasha's troops, slowly descended the steep and narrow road leading to the great gate of the citadel; but as soon as the Mamelukes arrived at the gate it was suddenly closed before them; and a heavy fire was opened on them from above and behind. Of the betrayed chiefs, many were laid low in a few moments; some, dismounting, and throwing off their outer robes, vainly sought, sword in hand, to return, and escape by some other gate. The few who regained the summit of the citadel experienced the same fate as the rest, for no quarter was given. Four hundred and seventy Mamelukes entered the citadel; and of these very few, if any, escaped. This massacre was the signal for an indiscriminate slaughter of the Mamelukes throughout Egypt, orders to this effect being transmitted to every governor; and in Cairo itself the houses of the beys were given over to the soldiery. A remnant of the Mamelukes fled to Nubia, and a tranquillity was restored to Egypt to which it had long been unaccustomed. In the year following the massacre the unfortunate exiles were attacked by Ibrahim Pasha, the eldest son of Mehemet Ali, in the fortified town of Ibrīm, in Nubia. Here the want of provisions forced them to evacuate the place; a few who surrendered were beheaded, and the rest went farther south and built the town of New Dongola (correctly Dunkulah), where the venerable Ibrahim Bey died in 1816, at the age of 80.

(X.; Me.)

Rule of Mehemet Ali.—Mehemet Ali was now undisputed master of Egypt, and his efforts henceforth were directed primarily to the maintenance of his practical independence. The suzerainty of the sultan he acknowledged, and at the reiterated commands of the Porte he despatched, in 1811, an army of 8,000 men, including 2,000 horse, under the command of his son Tūsūn, a youth of 16, against the Wahhābīs (*q.v.*). After two campaigns of varying fortune, Mehemet Ali took the field in person; he deposed and exiled the sherīf of Mecca, and after the death of the Wahhābī leader, Saud II., he concluded, in 1815, a treaty with Saud's son and successor, Abdullah. Hearing of the escape of Napoleon

from Elba—and fearing danger to Egypt from the plans of France or Great Britain—Mehemet Ali returned to Cairo by way of Kosseir and Kena. His return was hastened by reports that the Turks, whose cause he was upholding in Arabia, were treacherously planning an invasion of Egypt.

During Mehemet Ali's absence in Arabia his representative at Cairo had completed the confiscation, begun in 1808, of almost all the lands belonging to private individuals, who were forced to accept instead inadequate pensions. By this revolutionary method of land "nationalization" Mehemet Ali became proprietor of nearly all the soil of Egypt, an iniquitous measure against which the Egyptians had no remedy. The attempt which in this year (1815) the pasha made to reorganize his troops on European lines led, however, to a formidable mutiny in Cairo. This brought Tūsūn back to Egypt; but he died in 1816 at the early age of 20. Mehemet Ali, dissatisfied with the treaty concluded with the Wahhābīs, and with the non-fulfilment of certain of its clauses, determined to send another army to Arabia, and to include in it the soldiers who had recently proved unruly. This expedition, under his eldest son, Ibrahim Pasha, left in the autumn of 1816. The war was long and arduous, but in 1818 Ibrahim captured the Wahhābī capital of Deraiya. Abdullah, their chief, was made prisoner, and with his treasurer and secretary was sent to Constantinople, where, in spite of Ibrahim's promise of safety, and of Mehemet Ali's intercession in their favour, they were put to death. At the close of the year 1819, Ibrahim returned to Cairo, having subdued all present opposition in Arabia.

Meanwhile the pasha had turned his attention to the improvement of the manufactures of Egypt, and engaged very largely in commerce. He created for himself a monopoly in the chief products of the country, to the further impoverishment of the people, and set up and kept going for years factories which never paid. But some of his projects were sound, such as the excavation (1819–20) of the Mahmudiya canal, to establish a safe channel between Alexandria and the Nile. The sacrifice of life, however, was enormous (fully 20,000 workmen perished), and the labour of the unhappy fellahin was forced. Another notable fact in the economic progress of the country was the development of the cultivation of cotton in the Delta in 1822 and onwards. The cotton grown had been brought from the Sudan by Maho Bey, and the organization of the new industry—from which in a few years Mehemet Ali was enabled to extract considerable revenues—was entrusted to a Frenchman named Jumel.

In 1820 Mehemet Ali ordered the conquest of the eastern Sudan to be undertaken; it was his ambition to capture the valuable caravan trade then going towards the Red sea, and to secure the rich gold mines which he believed to exist in Sennār. He also saw in the campaign a means of getting rid of the disaffected troops, and of obtaining a sufficient number of captives to form the nucleus of the new army. Nubia, Sennār and Kordofan were reduced; Khartoum was founded, and in the following years the rule of the Egyptians was largely extended and control obtained of the Red sea ports Suakin and Massawa (*see* SUDAN, *History*).

In 1824 a native rebellion of a religious character broke out in Upper Egypt headed by one Aḥmad, an inhabitant of Es-Sālimiya, a village situated a few miles above Thebes. He proclaimed himself a prophet, and was soon followed by between 20,000 and 30,000 insurgents, mostly unarmed peasants. The insurrection was crushed by Mehemet Ali, and proved the last internal attempt to destroy the pasha's authority.

The fellahin, a patient, long-suffering race save when stirred by religious fanaticism, submitted to the kurbash, freely used by the Turkish and Bashi Bazuk tax-gatherers employed by Mehemet Ali to enforce his system of taxation, monopolies, corvée and conscription. Under this régime the resources of the country were impoverished, while the finances fell into complete and incomprehensible chaos. This is how Egypt in 1838 appeared to the British consul-general, Col. Campbell:—

"The Government (he wrote), possessing itself of the necessaries of life at prices fixed by itself, disposes of them at arbitrary prices. The fellāh is thus deprived of his harvest and falls into arrears with his taxes, and is harassed and bastinadoed to force him to pay his debts. This leads to deterioration of agriculture and lessens the production. The pasha having imposed high taxes has caused the high prices of the necessaries of life. It would be difficult for a foreigner now coming to Egypt to form a just idea of the actual state of the country as compared with its former state. In regard to the general rise in prices, all the ground cultivated under the Mamelukes was employed for producing food—wheat, barley, beans, etc.—in immense quantities. The people reared fowls, sheep, goats, etc., and the prices were one-sixth, or even one-tenth, of those at present. This continued until Mehemet Ali became viceroy in 1805. From that period until the establishment of monopolies prices have gradually increased; but the great increase has chiefly taken place since 1824, when the pasha established his regular army, navy and factories."

This picture of Egypt under Mehemet Ali is, nevertheless, not complete without regard being had to the beneficent side of his rule. Public order was rendered perfect; the Nile and the highways were secure to all travellers, Christian or Muslim; the Bedouin tribes were won over to peaceful pursuits, and genuine efforts were made to promote education and the study of medicine. To European merchants, on whom he was dependent for the sale of his exports, Mehemet Ali showed much favour, and under his influence the port of Alexandria again rose into importance. It was also under Mehemet Ali's encouragement that the overland transit of goods from Europe to India via Egypt was resumed.

Campaigns in Greece and Syria.—Mehemet Ali was fully conscious that the empire which he had so laboriously built up might at any time have to be defended by force of arms against his master, Sultan Mahmud II., and he was determined to anticipate the sultan in the creation of a fleet and an army on modern lines, partly as a measure of precaution, partly as an instrument for the realization of yet wider schemes of ambition. Before the outbreak of the War of Greek Independence in 1821 he had already expended much time and energy in organizing a fleet and in training, under the supervision of French instructors, native officers and artificers; though it was not till 1829 that the opening of a dockyard and arsenal at Alexandria enabled him to build and equip his own vessels. By 1823, moreover, he had succeeded in carrying out the reorganization of his army on European lines, the turbulent Turkish and Albanian elements being replaced by negroes and fellahin. His foresight was rewarded by the invitation of the sultan to help him in the task of subduing the Greek insurgents, offering as reward the pashaliks of the Morea and of Syria. Mehemet Ali had already, in 1821, been appointed governor of Crete, which he had occupied with a small Egyptian force. In the autumn of 1824 a fleet of 60 Egyptian warships carrying a large force of disciplined troops concentrated in Suda bay, and, in the following March, Ibrahim as commander-in-chief landed in the Morea. But for the action of European Powers the intervention of Mehemet Ali would have been decisive. His naval superiority wrested from the Greeks the command of the sea, on which the fate of the insurrection ultimately depended, while on land the Greek irregular bands were everywhere routed by Ibrahim's disciplined troops. The history of the events that led up to the battle of Navarino and the liberation of Greece is told elsewhere (*see* NAVARINO and GREEK INDEPENDENCE, WAR OF); the withdrawal of the Egyptians from the Morea was ultimately due to the action of Admiral Sir Edward Codrington, who early in Aug. 1828 appeared before Alexandria and induced the pasha to sign a convention undertaking to recall Ibrahim and his army.

Before the final establishment of the new kingdom of Greece, the Eastern question had, late in 1831, entered into a new and more perilous phase, owing to the revolt of Mehemet Ali against the sultan on pretext of chastising the ex-slave Abdullah, pasha of Acre, for refusing to send back Egyptian fugitives from the effects of Mehemet Ali's "reforms." For ten years from this date the relations of sultan and pasha remained in the forefront of the questions which agitated the diplomatic world. It was not only the very existence of the Ottoman empire that seemed to be at stake, but Egypt itself had become more than ever an object of attention, to British statesmen especially, and in the issue of the struggle were involved the interests of Great Britain in the two routes

to India by the Isthmus of Suez and the valley of the Euphrates. The victorious career of Ibrahim, who once more commanded in his father's name, beginning with the storming of Acre on May 27, 1832, and culminating in the rout and capture of Reshid Pasha at Konia on Dec. 21, was arrested by the intervention of Russia. As the result of endless discussions between the representatives of the Powers, the Porte and the pasha, the Convention of Kutaya was signed on May 14, 1833, by which the sultan agreed to bestow on Mehemet Ali the pashaliks of Syria, Damascus, Aleppo and Itcheli, together with the district of Adana.

Mehemet Ali now ruled over a virtually independent empire, subject only to a moderate tribute, stretching from the Sudan to the Taurus mountains. But in the spring of 1839, the sultan ordered his army, concentrated under Reshid in the border district of Bir on the Euphrates, to advance over the Syrian frontier. Ibrahim, seeing his flank menaced, attacked it at Nezib on June 24. Once more the Ottomans were utterly routed. Six days later, before the news reached Constantinople, Mahmud died. Once more the Ottoman empire lay at the feet of Mehemet Ali; but the Powers were now more prepared to meet a contingency which had been long foreseen. Their intervention was prompt; and the end was reached early in 1841. New firmans were issued which confined the pasha's authority to Egypt, the Sinai peninsula and certain places on the Arabian side of the Red sea, and to the Sudan. The most important of these documents are dated Feb. 13, 1841. The government of the pashalik of Egypt was made hereditary in the family of Mehemet Ali. (This provision has been observed. The successors of Mehemet Ali have been (1) Ibrahim, his eldest son; (2) Abbas, his grandson; (3) Said, his fourth son; (4) Ismail, son of Ibrahim; (5) Tewfik, eldest son of Ismail; (6) Abbas Hilmi, son of Tewfik; (7) Hasain Kāmil, second son of Ismail; and (8) Fuād, a younger son of Ismail.) Various restrictions were laid upon Mehemet Ali, emphasizing his position of vassalage. He was forbidden to maintain a fleet, and his army was not to exceed 18,000 men. The pasha was no longer a figure in European politics, but he continued to occupy himself with his improvements, real or imaginary, in Egypt. The condition of the country was deplorable; in 1842 a murrain of cattle was followed by a destructive Nile flood; in 1843 there was a plague of locusts, whole villages were depopulated. Meantime the uttermost farthing was wrung from the wretched fellahin, while they were forced to the building of magnificent public works by unpaid labour. In 1847 Mehemet Ali laid the foundation stone of the great barrage across the Nile at the beginning of the Delta. He was barely dissuaded from ordering the barrage to be built with stone from the pyramids. Towards the end of 1847 the aged pasha's mind began to give way, and by the following June he was no longer capable of administering the Government. In Sept. 1848 Ibrahim was acknowledged by the Porte as ruler of the pashalik, but he died in the November following. Mehemet Ali survived another eight months, dying on Aug. 2, 1849, aged 80. He had done great things in Egypt; the most permanent being the weakening of the tie binding the country to Turkey, the starting of the great cotton industry, the recognition of the advantages of European science, and the conquest of the Sudan. (F. R. C.; Me.)

Abbas I. and Said Pasha.—On Ibrahim's death in Nov. 1848 the government of Egypt fell to his nephew, Abbas I., the son of Tusun. Abbas put an end to the system of commercial monopolies, and during his reign the railway from Alexandria to Cairo was begun at the instigation of the British Government. Opposed to European ways, Abbas lived in great seclusion, and after a reign of less than six years he was murdered (July 1854) by two of his slaves. He was succeeded by his uncle, Said Pasha, the favourite son of Mehemet Ali, but a weakling. In his reign a land law of 1858 secured to the fellahin an acknowledgment of freehold as against the Crown. The pasha was much under French influence, and in 1856 was induced to grant to Ferdinand de Lesseps a concession for the construction of the Suez canal. Lord Palmerston was opposed to this project, and the British opposition delayed the ratification of the concession by the Porte for two years. To the British Said also made concessions—one to the Eastern Telegraph company, and another (1854) allowing the establishment of the Bank of Egypt. He also began the national debt by borrowing £3,293,000 from Messrs. Frühling and Göschen, the actual amount received by the pasha being £2,640,000. In Jan. 1863 Said Pasha died and was succeeded by his nephew, Ismail, a son of Ibrahim Pasha.

Reign of Ismail.—The reign of Ismail from 1863 to 1879 was for a while hailed as introducing a new era into modern Egypt. In spite of his vast schemes of reform and the *éclat* of his Europeanizing innovations, his oriental extravagance led to bankruptcy and European intervention in the internal affairs of Egypt. Yet in its earlier years much was done which seemed likely to give Ismail a more important place in history. In 1866 he received from the sultan (in consideration of his tribute being doubled) the right of primogeniture for his family: in 1867 the title of *khedive;* and in 1873 the recognition of virtually independent sovereignty. He re-established and improved the administrative system organized by Mehemet Ali, which had fallen into decay under Abbas's indolent rule; he caused a thorough remodelling of the customs system, which was in an anarchic state, to be made by English officials; in 1865 he established the Egyptian post office; he reorganized the military schools of his grandfather, and gave some support to the cause of education. Railways, telegraphs, lighthouses, the harbour works at Suez, the breakwater at Alexandria, were carried out by some of the best contractors of Europe. Most important of all, the Suez canal was opened in 1869. But the funds required for these public works, as well as the actual labour, were remorselessly extorted from a poverty-stricken population. At the same time thousands of lives were lost and large sums expended in extending Ismail's dominions in the Sudan and in futile conflicts with Abyssinia. In 1875 the impoverishment of the fellah had reached such a point that the ordinary resources of the country no longer sufficed for the most urgent necessities of administration; and the khedive Ismail, having repeatedly broken faith with his creditors, could not raise any more loans on the European market. The taxes were habitually collected many months in advance, and the colossal floating debt was increasing rapidly. In these circumstances Ismail had to realize his remaining assets, and among them sold 176,602 Suez Canal shares to the British Government for £3,976,582.

The crisis had come, and a series of international enquiries were now forced upon Ismail, each of which brought him more under European control. The establishment of the Mixed Tribunals in 1876, in place of the system of consular jurisdiction in civil actions, made some of the courts of justice international. The Caisse de la Dette, instituted in May 1876 as a result of a British financial mission (Stephen Cave and Sir John Stokes) which had been at work in the previous year, led to international control over a large portion of the revenue. Next came (in Nov. 1876) the mission of Mr. (afterwards Lord) Goschen and M. Joubert on behalf of the British and French bondholders, one result being the establishment of dual control, *i.e.*, an English official to superintend the revenue and a French official the expenditure of the country. Another result was the internationalization of the railways and the port of Alexandria. Another commission of enquiry, of which the principal members were Sir Rivers Wilson, Maj. Evelyn Baring (afterwards Lord Cromer) and MM. Kremer-Baravelli and de Blignières, extended international control to the enormous landed property of the khedive. Driven to desperation, Ismail made a virtue of necessity and accepted, in Sept. 1878, in lieu of the dual control, a constitutional ministry, under the presidency of Nubar Pasha, with Rivers Wilson as minister of finance and de Blignières as minister of public works. Before seven months had passed he found his constitutional position intolerable, got rid of his irksome cabinet by means of a secretly-organized military riot in Cairo, and reverted to his old autocratic methods of government. England and France appealed to the suzerain power, which was delighted to have an opportunity of asserting its authority. On June 26, 1879, Ismail suddenly received from the sultan a curt telegram, addressed to him as ex-khedive of Egypt, informing him that his son Tewfik was appointed his successor. Taken unawares, he made no attempt at resistance, and Tewfik was at once proclaimed khedive.

Events Leading to British Occupation.—After a short period of inaction, England and France, in Nov. 1879, re-established the dual control in the persons of Maj. Baring and M. de Blignières. For two years it governed Egypt, and initiated the work of progress that England was to continue alone. Of necessity it antagonized the classes which had long misgoverned the country for their own benefit. A movement of revolt slowly matured, largely military in its origin. Among its leaders was a fellah officer calling himself Ahmed Arabi the Egyptian. He was not a man of exceptional intelligence but solid and direct, influencing the masses by a rude kind of native eloquence. Behind him were a group of men, much abler than himself, who put him forward as the figurehead of a party professing to aim at protecting the Egyptians from the grasping tyranny of their Turkish and European oppressors. The Government, being too weak to suppress the agitation and disorder, had to make concessions, and each concession produced fresh demands. Arabi was first promoted, then made under-secretary for war, and ultimately a member of the cabinet. The danger of a serious rising brought the British and French fleets in May 1882 to Alexandria, and after a massacre (June 11) had been perpetrated by the Arab mob in that city, the British admiral bombarded the forts (July 11, 1882). The leaders of the national movement prepared to resist further aggression by force; and the sultan refused an invitation to suppress them.

At last the British Government determined to employ armed force, and invited France to co-operate. The French Government declined, and a similar invitation to Italy met with a similar refusal. England, therefore, having to act alone, landed troops at Ismailia under Sir Garnet Wolseley, who defeated Arabi in the battle of Tell-el-Kebir on Sept. 13, 1882. The khedive, who had taken refuge in Alexandria, returned to Cairo, and a ministry was formed under Sherif Pasha. Arabi was tried, and by arrangement pleaded guilty and was banished. The lives of his colleagues were also spared. This solution of the difficulty was brought about by Lord Dufferin, then British ambassador at Constantinople, who had been sent to Egypt as high commissioner to adjust affairs and report on the situation. One of his first acts, after preventing the application of capital punishment to the ring-leaders of the revolt, was to veto the project of protecting the khedive and his government by means of a Praetorian guard recruited from Asia Minor, Epirus, Austria and Switzerland, and to insist on the principle that Egypt must be governed in a truly liberal spirit. Passing in review all the departments of the administration, he laid down the general lines on which the country was to be restored to order and prosperity, and endowed, if possible, with the elements of self-government for future use.

Sir Evelyn Baring, Consul-general, 1884.—The laborious task of putting these general indications into a practical shape fell to Sir Evelyn Baring (Lord Cromer), who arrived as consul-general and diplomatic agent, in succession to Sir Edward Malet, in Jan. 1884. The position with which he was confronted was that, for the third time in little more than three years, the existing authority had been destroyed and a new one had to be created. But the power that had now to reorganize the country possessed in the British army of occupation a support sufficient to command respect. Without that support Sir Evelyn Baring could have done little or nothing; with it he did perhaps more than any other single man could have done. His difficulties arose in England as well as in Egypt. At first the aim of the British Government was to restore the power of the khedive, to keep him for some time in the right path by friendly advice, and to withdraw the British troops as soon as possible. As Lord Granville explained in a circular to the Powers, the position of England in Egypt imposed on her "the duty of giving advice with the object of securing that the order of things to be established shall be of a satisfactory character and possess the elements of stability and progress." But there was to be no embarking on a general scheme of reforms, which would increase unnecessarily the responsibilities of the protecting power and necessitate the indefinite prolongation of the military occupation. So far, therefore, as the British Government had a definite policy in Egypt, it was a *politique de replâtrage*. Even this policy was not strictly adhered to. Mr. Gladstone's cabinet had its hot fits and its cold fits, and it gave orders now to advance and now to retreat. In the long run circumstances proved too strong for it, and it had to undertake a great deal more than it originally intended. And all the while its agents in Egypt were faced by a growing volume of nationalist feeling, for which neither guidance nor safety valves were provided.

Of the numerous questions awaiting solution, the first to claim immediate attention was that of the Sudan. The British Government had begun by excluding it from the problem; but it was an integral part of the khedive's dominions, and caused, even in ordinary times, a deficit of £200,000 to the Egyptian treasury. At that moment it was in a state of open rebellion, stirred up by a religious fanatic who proclaimed himself a mahdi of Islam. An army of 10,000 men under an English officer, Col. William Hicks, otherwise Hicks Pasha, had been sent to suppress the revolt, and had been annihilated in a great battle fought on Nov. 5, 1883, near Obeid. The Egyptian Government wished to make a new attempt to recover the lost province, and the idea was certainly very popular among the governing class, but Sir Evelyn Baring vetoed the project on the ground that Egypt had neither soldiers nor money to carry it out. The efforts made to extricate the scattered garrisons surrounded by the Mahdi's forces, the mission of Gen. Gordon, the fall of Khartoum, and the Nile expedition under Lord Wolseley, are described separately. The practical result was that the khedive's authority was limited to the Nile valley north of Wadi Halfa.

Internal Reorganization.—With the internal difficulties Sir Evelyn Baring had been struggling bravely ever since his appointment. For two or three years it seemed doubtful whether he would succeed. All over Egypt there was a feeling of unrest. The introduction of English officials and English influence into all the administrative departments was resented by the native officials, and the action of the irrigation officers in preventing the customary abuses of the distribution of water was resented by the great landowners. Even the fellahin, who gained most by the reforms, were discontented, for the defeat of Arabi and the re-establishment of order had enabled the Christian money-lenders to return and insist on the payment of claims, which were supposed to have been extinguished by the rebellion. Worst of all, the Government was drifting rapidly towards insolvency; all departments were being starved, and even the salaries of poorly paid officials were in arrear. To free itself from its financial difficulties the Government adopted a heroic remedy by diverting into the Treasury certain revenues which should have been paid into the Caisse de la Dette for the benefit of the bondholders. Immediately the Powers protested against this infraction of the law of liquidation, and the Caisse applied for a writ to the Mixed Tribunals. The heroic remedy failed; but ultimately the British Government succeeded in negotiating the London Convention of March 1885, by which the Egyptian Government was enabled to raise a loan of £9,000,000 for an annual payment of £315,000. After paying out of the capital the sums required for the indemnities due for the burning of Alexandria and the deficits of the years 1882 and 1883, it still had a million sterling, and boldly invested it in the improvement of irrigation. The investment proved most remunerative, and helped very materially to save the country from bankruptcy. The danger of being again subjected to the evils of an international administration was very great, for the London Convention contained a stipulation to the effect that if Egypt could not pay her way at the end of two years, another international commission would be appointed.

To obviate this catastrophe the British reformers set to work most energetically. Already something in the way of retrenchment and reform had been accomplished. The public accounts had been put in order, and the abuses in the collection of the land tax removed. The constant drain of money and men for the Sudan had been stopped. A beginning had been made for creating a new army to replace the one that had been disbanded and to allow of a portion of the British garrison being withdrawn. In this work Sir Evelyn Wood had shown much sound judgment as well as great capacity for military organization, and had formed an efficient force out of very unpromising material. His colleague

in the department of public works, Sir Colin Scott-Moncrieff, had been not less active. By mitigating the hardships of the *corvée,* and improving the irrigation system, on which the prosperity of the country mainly depends, he had conferred enormous benefits on the fellahin, and had laid the foundation of permanent budgetary equilibrium for the future. Not less active was Sir Edgar Vincent, the financial adviser, who kept a firm hold on the purse-strings and ruthlessly cut down expenditure in all departments except that of irrigation. All this reforming activity engendered a certain amount of discontent and resistance; but the attitude of the British Government was thus defined by Lord Granville:

"It should be made clear to the Egyptian ministers and governors of provinces that the responsibility which for the time rests on England obliges H.M. Government to insist on the adoption of the policy which they recommend; and that it will be necessary that those ministers and governors who do not follow this course should cease to hold their offices."

There was not yet, however, any correlative movement towards the working principle which was officially formulated at a much later period: "Our task is not to rule the Egyptians, but as far as possible to teach the Egyptians to rule themselves. . . . European initiative suggests measures to be executed by Egyptian agency, while European supervision controls the manner in which they are executed." If that principle had been firmly laid down and clearly understood at the beginning, a good deal of needless friction would have been avoided.

International Problems.—The international difficulty remained. The British position in Egypt was anomalous, and might easily give rise to international complications. The sultan might well protest against the military occupation of a portion of his empire by foreign troops. It was no secret that France was ready to give him diplomatic support, and other Powers might adopt a similar attitude. Besides this, the British Government was anxious to terminate the occupation as soon as possible. With a view to regularizing the situation and accelerating the evacuation, Sir Henry Drummond Wolff was sent to Constantinople in Aug. 1885 on a special mission. On Oct. 24 of that year he concluded a preliminary convention by which an Ottoman and a British high commissioner, acting in concert with the khedive, should reorganize the Egyptian army, tranquillize the Sudan by pacific means, and consider what changes might be necessary in the civil administration. When the two commissioners were assured of the security of the frontier and the good working and stability of the Egyptian Government, they should present reports to their respective Governments, and these should consult as to the conclusion of a convention regulating the withdrawal of the English troops. In 1887 this was followed by a definitive convention, according to which the occupation should some to an end in three years, but England should have a right to prolong or renew it in the event of internal peace or external security being seriously threatened. The sultan authorized the signature of this convention, but under pressure of France and Russia he refused to ratify it.

The steadily increasing prosperity of the country during the years 1886 and 1887 removed the danger of national bankruptcy and international interference, and induced Sir Evelyn Baring to widen the area of administrative reforms. The new Egyptian army was so far improved that it gained successes over the forces of the Mahdi; the burden of the national debt was lightened by a successful conversion; the *corvée* was abolished (except in so far as it was necessary to call out men to guard the banks of the Nile in the season of high flood); the land tax was reduced 30% in the poorest provinces, and in spite of this and other measures for lightening the public burdens, the budgetary surplus constantly increased; the native tribunals were improved, and John Scott, an Indian judge of great experience and sound judgment, was appointed judicial adviser to the khedive. The very necessary reform of the native tribunals was then taken seriously in hand. The existing procedure was simplified and accelerated; the working of the courts was greatly improved by a carefully organized system of inspection and control; incompetent judges were eliminated and an excellent school of law was established. Later on the reforming activity was extended to prisons, public health, and education, and attained very satisfactory results.

Accession of Abbas.—In Jan. 1892 the khedive Tewfik, who had always maintained cordial relations with Sir Evelyn Baring, died suddenly, and was succeeded by his son, Abbas Hilmi, a young man without political experience. Aspiring to liberate himself at once from foreign control, he summarily dismissed the prime minister, Mustafa Pasha Fehmi (Jan. 15, 1893), whom he considered too amenable to English influence, and appointed in his place Fakhri Pasha, who was not a *persona grata* at the British Agency. This led to remonstrances and a compromise; but the young khedive long clung to his idea of liberating himself from all control, and secretly encouraged a Nationalist and anti-British agitation in the native press. Relations, however, between the British officials and their Egyptian colleagues gradually became more cordial, so that it was found possible at last to reform the local administration in the provinces according to the recommendations of Eldon Gorst, who had been appointed adviser to the ministry of the interior. Mustafa Fehmi was reinstated as prime minister at the end of 1895, and thereafter the Anglo-Egyptian condominium worked without serious friction.

Fashoda.—The success of the Anglo-Egyptian condominium, and the consequent economic and financial prosperity of Egypt proper, rendered it possible, during 1896–98, to recover from the Mahdists the Sudanese provinces and to delimit in that part of Africa, in accordance with Anglo-Egyptian interests, the respective spheres of influence of Great Britain and France. The arrangement was not effected without serious danger of a European conflict. French policy had aimed at an establishment in the upper Nile valley, which would link up the French possessions in West Africa with those at the entrance to the Red sea. With this object a small force under Maj. Marchand was sent from the French Congo into the Bahr-el-Ghazal; whilst a Franco-Abyssinian expedition was despatched from the eastward, to join hands with Maj. Marchand. The small force from the French Congo reached Fashoda on the Nile: but General (afterward Lord) Kitchener hastened up the river with a stronger Anglo-Egyptian escort, and persuaded Marchand to evacuate Fashoda and to retire by the Abyssinian route. By an agreement signed by Lord Salisbury and the French ambassador on March 21, 1899, France abandoned the basin of the Nile, and a line marking the respective spheres of influence of the two countries was drawn on the map from the northern frontier of the Congo Free State to the southern frontier of the Turkish province of Tripoli.

The administration of the Sudan was organized on the basis of an agreement between the British and Egyptian Governments signed on Jan. 19, 1899. According to that agreement the British and Egyptian flags were used together and the supreme military and civil command is vested in a governor-general, who is appointed by the khedive on the recommendation of the British Government, and who cannot be removed without the British Government's consent. Neither consular jurisdiction, nor that of the mixed tribunals, was permitted, the Sudan being made absolutely free of the international fetters which bound Egypt. Sir Reginald Wingate, the sirdar of the Egyptian army (in which post he succeeded Lord Kitchener at the close of 1899) was named governor-general, and in the work of regeneration of the country, the officials, British, Egyptian and Sudanese, had the cordial co-operation of the majority of the inhabitants.

Egypt in the 20th Century.—The growing prosperity of Egypt in the opening years of the 20th century was very marked, and is reflected in the annual reports on the country supplied to the British Foreign Office by Lord Cromer. Thus, in 1901 he was able to declare that "the foundations on which the well-being and material prosperity of a civilized community should rest have been laid. . . . The institution of slavery is virtually defunct. The *corvée* has been practically abolished. Law and order everywhere reign supreme. The *curbash* is no longer employed as an instrument of government." So little danger to internal peace was apprehended that during this year Arabi Pasha, who had been in exile in Ceylon since 1882, was permitted to return to Egypt. The machinery of government, despite its many imperfections

and anomalies, worked smoothly. Land increased in value as irrigation schemes were completed, and European capital was increasingly eager to find employment in the country. The bulk of the fellahin enjoyed a material prosperity to which they had been strangers for centuries.

The facilities enjoyed by the British and Egyptian Governments for securing the material development of Egypt were greatly enlarged in 1904, as the result of the understanding then come to between France and Great Britain. The natural irritation in France arising from the British occupation of the Nile valley, and the non-fulfilment of the pledge to withdraw the British garrison from Egypt, which had grown less acute with the passing of years, flamed out afresh at the time of the Fashoda crisis; but during 1903 a great change came over public opinion on both sides of the Channel, and a settlement was reached of many points in dispute between the two nations. On April 8, 1904, a declaration was signed by the representatives of France and Great Britain which virtually recognized the dominant position of France in Morocco and of Britain in Egypt.

Similar declarations and engagements were made by Germany, Austria and Italy. Annexed to the Anglo-French agreement was the text of a khedivial decree which, with the consent of the Powers came into operation on Jan. 1, 1905. The declaration was in effect a European recognition that Britain was the protecting power in Egypt. It put a period to a question which had long embittered the relations between England and France, and locally it caused the cessation of the systematic opposition of the French agents in Cairo to the British administration. Scarcely less important were the results of the khedivial decree. By it Egypt achieved in effect financial independence. The power of the Caisse de la Dette, which had virtually controlled the execution of the international agreements concerning the finances, was swept away, together with almost all the other financial fetters binding Egypt. For the first time since 1875 Egypt was free to control her own revenue. In return she pledged the greater part of the land tax to the service of the debt, and the functions of the Caisse were restricted to the receipt of the funds necessary for this service. Moreover, some £10,000,000, being accumulated surpluses in the hands of the Caisse after meeting the charges of the debt, were handed over to the Egyptian Treasury. The Egyptian Government was henceforth free to take full advantage of the financial prosperity of the country. In one respect only were the new arrangements open to criticism: they left untouched the extra-territoriality in criminal cases enjoyed by Europeans in Egypt in virtue of the treaties with Turkey, *i.e.*, the system of capitulations. Associated with the capitulations régime was the absence of any proper machinery for enacting laws applicable to the whole of the inhabitants of Egypt. No change could be made in any law applicable to Europeans without the unanimous consent of 15 foreign Powers—a state of affairs wholly incompatible with the condition of Egypt in the 20th century, "an oriental country which has assimilated a very considerable portion of European civilization and which is mainly governed by European methods."

Unrest and Denshawai.—While the removal of ancient jealousies among the European powers interested in Egypt helped to smooth the path pursued by the Egyptian administration under the guiding hand of Great Britain, the intrigues of the Turks and a revival of Muslim religious fervour threatened during 1905–06 to disturb the peace of the country. The Nationalist party, now under the leadership of Mustafa Kamil (1874–1908), was alive to the value of any weapon in its claim that Egypt was now ripe for self-government. The Nationalist press burst into an orgy of inflammatory writing, encouraged by many persons holding high positions both inside and outside Egypt, and created, by every process of misrepresentation, an anti-Christian and anti-European feeling among the mass of the people. After more than a quarter of a century, *i.e.*, since the accession of Tewfik, the tyranny of the Turkish system was apt to be forgotten, while the appeal to rally in support of their khalif found a response in the hearts of many Egyptians. The tension was increased, even if resentment was silenced, by the Denshawai incident in June 1906, when an affray between villagers and a few British officers was followed by judicial retribution of a severity which long rankled in the minds even of the fellahin.

The Taba Incident.—It was at this juncture that the Taba incident arose over the claim of the sultan of Turkey to jurisdiction in the Sinai peninsula. Mehemet Ali and his successors up to and including Tewfik had administered the Sinai peninsula and certain posts on the Arabian side of the Gulf of Akaba. The firman of investiture issued by the sultan on the occasion of the succession of Abbas Hilmi in 1892 differed, however, from the text of former firmans, and had to be rectified by a telegram (dated April 8, 1892) from the grand vizier, in which it was declared that the *status quo* was maintained in the Sinai peninsula. As officially stated by the British Government at the time, the eastern frontier of the Sinai peninsula was taken to be a line running in a south-easterly direction from Rafa, a place on the Mediterranean, east of El Arish, to the head of the Gulf of Akaba. So matters rested until, in 1905, in consequence of lawlessness among the Bedouins of the peninsula, a British official was appointed commandant and inspector of the peninsula and certain administrative measures taken. The report was spread by pan-Islamic agents that the intention of the Egyptian Government was to construct fortifications on the frontier near Akaba, to menace the railway which the Turks were building from Damascus to Mecca. In Jan. 1906 the sultan complained to the British ambassador at Constantinople of Egyptian encroachments on Turkish territory, and the local Turkish commandant seized Taba, a port near Akaba but on the western side of the gulf. A period of considerable tension ensued, and at a conference held between the khedive and Mukhtar Pasha, the Ottoman commissioner, the latter claimed that the peninsula of Sinai consisted only of the territory south of a straight line from Akaba to Suez. In other words the claim of the Porte was, to quote Lord Cromer: "to carry the Turkish frontier and strategical railways to Suez on the banks of the canal; or that if the Ras Mahommed line were adopted, the Turkish frontier would be advanced to the neighbourhood of Nekhl, *i.e.*, within easy striking distance of Egypt, and that . . . the Gulf of Akaba . . . would practically become a *mare clausum* in the possession of Turkey and a standing menace to the security of the trade route to the East."

Such proposals could not be entertained by Great Britain; and it was only after a virtual ultimatum that the sultan gave way and agreed (on May 14) that the line of demarcation should start at Rafa and run towards the south-east "in an approximately straight line as far as a point on the Gulf of Akaba at least 3 m. distant from Akaba." The Turkish troops were withdrawn from Taba, and the delimitation of the frontier was undertaken by a joint Turco-Egyptian commission. An agreement was signed on Oct. 1 finally settling the frontier line.

In April 1907, a few days after the appearance of his report for 1906, in which the "Nationalist" and pan-Islamic movements were declared to be detrimental to the welfare of Egypt, Lord Cromer resigned his post of British agent and consul-general. His resignation, dictated by reasons of health, was described by Sir Edward Grey as "the greatest personal loss which the public service of this country (Britain) could suffer." He left the country in a state of unexampled material prosperity, free from the majority of the international fetters with which it was bound when he took up his task in 1883, and with the legitimate expectation that the work he had done would endure. Lord Cromer was succeeded by Sir Eldon Gorst, who had served in Egypt 18 years under him, and was at the time of his appointment to Cairo an assistant under-secretary of State for foreign affairs.

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New Policy Under Gorst.—It fell to the lot of Gorst to carry out the policy of the new Liberal Government in England—a policy suggested by Cromer originally—of giving the Egyptian authorities a wide freedom in administration. A measure for increasing the powers of the provincial councils was promulgated in June 1908. The Denshawai prisoners had been released in the preceding January, and Mustapha Kamil's death in February had been followed by schisms in the Nationalist camp. Nevertheless the Nationalist movement made active headway. The legislative coun-

cil and the general assembly were demanding full self-government; and the hopes of the agitators were raised by the establishment of constitutional rule in Turkey in the summer of 1908. The instalment of political freedom which Gorst had secured was regarded as negligible; and the internal dissensions of the Nationalists tended to disappear in a common anti-British front. In Nov. 1908 Mustapha Fehmi resigned on the ground of ill-health, and with him there went his powerful and sustained influence in favour of co-operation with the British. The selection as his successor of Boutros Pasha, a Copt, aroused Muslim hostility; and the extreme section of the Nationalist party, secretly backed by the khedive, was effectively overpowering the moderate wing. In the assembly it soon proved its domination by rejecting (Feb. 1910) a measure for the extension of the Suez Canal company's concession. Two days later, the prime minister, who had introduced the measure, was assassinated by a young Nationalist fanatic. His place was taken by Mohammed Saïd Pasha, a protégé of the khedive; but the general assembly was not convoked again, and drastic measures were necessary to check anti-British demonstrations. In the last report which he lived to submit, Gorst deplored the failure of the programme of 1907, and warned the British Government that "the policy of ruling Egypt in co-operation with native ministers was incompatible with that of encouraging the development of so-called representative institutions." In July 1911 he surrendered his office, and died within a month.

Régime of Lord Kitchener.—Lord Kitchener arrived as occupant of the residency in Sept. 1911. His first pre-occupation was to impose order in the country, and to deal with the difficult situation created by the Italian declaration of war on Turkey and landing in Tripolitania. The excesses of nationalist extremism were repressed, and the use of Egypt or Egyptian forces against Italy by their nominal suzerain, the sultan, was quietly prevented. Islamic sentiment was none the less on edge, and early in 1912 a plot was discovered to kill the khedive, the prime minister and Lord Kitchener. Meanwhile a programme of administrative reform and constitutional progress was actively pursued. The peasantry were given a measure of protection from the money-lender, and the reform of the Waqf department, which was supposed to hold a wealth of Muslim pious foundations in trust, was undertaken. A new organic law of 1913 replaced the earlier statute of 1883, and a single legislative assembly was constituted in lieu of the two former bodies. It was composed of 66 members elected by indirect suffrage, and of 17 members nominated by the Government to represent minorities and interests which would otherwise have had no voice. It remained a consultative and deliberative body, although it had power to veto any increase in direct taxation; but it could delay legislation, record opinions on administrative business, and initiate measures of its own. The president and one vice-president were appointed by the Government. For the second vice-president the choice of the assembly fell on Saad Zaghlul Pasha, formerly minister of education and now the acknowledged leader of the nationalists. The whole scheme was distasteful to the khedive, and a palace intrigue led to the fall of Mohammed Saïd. He was succeeded by Hasain Rushdi Pasha, who remained in office until the end of 1918. The new assembly began its career by a session of fruitless bickering, and the hostility of the khedive became so undisguised that by 1914 Lord Kitchener would seem to have come to the conclusion that he must be either muzzled or removed.

The Protectorate.—When the World War broke out, Lord Kitchener was on leave in England, and the khedive was on a visit to Constantinople. The former became secretary of State for war, and never returned to Egypt. The latter was frankly involved with the enemies of England, and he, too, came back no more. The Egyptian Government immediately on the declaration of war, threw in its lot with the Allies. The legislative assembly was suspended and did not meet again. Ministers took action against German ships in Egyptian ports, and by the proclamation of martial law on Nov. 2, it became possible both to enforce administrative measures without reference to the assembly, and to take action affecting foreign subjects without first obtaining the assent of the Powers. The entry of Turkey into the war rendered the juridical position of Egypt, from the British point of view, an impossible anomaly; and accordingly a proclamation was issued on Dec. 18, 1914, by the British Foreign Office, with the following announcement:

"In view of the state of war arising out of the action of Turkey, Egypt is placed under the protection of His Majesty and will henceforth constitute a British protectorate. The suzerainty of Turkey over Egypt is thus terminated and His Majesty's Government will adopt all measures necessary for the defence of Egypt and protect its inhabitants and interests."

A further proclamation issued the following day announced that the khedive, Abbas Hilmi, who was in Constantinople, was deposed on the grounds of adherence to the King's enemies, and that his uncle, Prince Husein Kamel, had accepted the succession and would bear the title of sultan of Egypt. The new status was introduced without disturbance if without enthusiasm, and the new high commissioner, Sir Henry McMahon, took over the control of Egyptian foreign affairs. After the abortive Turkish attack on the Suez canal, the prestige of the sultan increased, but the failure in the Dardanelles produced some reaction and in 1915 his life was twice attempted. The Egyptian people, however, bore with patience the disabilities and unwelcome requisitions which the war entailed, and thus laid Great Britain under obligations, both moral and financial, for which too little credit was given.

On the other hand the withdrawal of British officials for service elsewhere opened a wider field for Nationalist propaganda, which found ready listeners among the younger men who had not known the pre-occupation conditions. A dissatisfied civil service regarded the growing number of British officials as a bar to promotion and the Nationalist ranks were reinforced by the students, whose prospect of obtaining State employment was diminished by foreign competition. A professed intention to train Egyptians to manage their own affairs seemed inconsistent with the constant increase of British officials, and their steady encroachment on administrative functions. Moreover, as their number grew, they became a separate community living aloof from Egyptians, and with loss of contact their moral influence diminished.

Succession of King Fuad.—At the end of 1916 Gen. Sir Reginald Wingate, sirdar and governor-general of the Sudan since Dec. 1899, replaced Sir H. McMahon as high commissioner. The declining health of Sultan Husein made a settlement of the succession urgent. His only son, Prince Kemal-ed-Din, declined the position of heir-apparent, which was then offered to the sixth son of Ismail, Prince Fuad, who had been educated at the military school at Turin. Sultan Husein died in Oct. 1917. The principles formulated by the President of the United States towards the close of the World War had a far-reaching effect on educated opinion in Egypt. Numerous disclaimers by British statesmen of any intention to occupy the country permanently were insistently recalled, and the acceptance of the principle of self-determination was represented as having given international sanction to the aspirations of Egyptians to govern themselves. When, in Nov. 1918, an Anglo-French declaration announced that the Allies contemplated the enfranchisement of the peoples oppressed by Turkish rule, Egyptians regarded their title to manage their own affairs to be even stronger than that of Syria, Mesopotamia or of Arabia, where an independent kingdom had already been established. No sooner was the Armistice signed than Zaghlul, as the head of a strong Nationalist committee, asked permission to go to London and submit Egypt's case for independence. The British Foreign Office rejected the proposal; and the reception in London of Egyptian Ministers though earnestly supported by Sir R. Wingate, was dismissed as equally impossible. Ministers thereupon resigned; Sir R. Wingate was summoned to London to make a personal report, and there was a steady drift of moderates into the nationalist camp. A *Wafd* or Nationalist delegation to proceed to London and Paris, was constituted on a Democratic basis. The prime minister resigned in final protest against his country being unrepresented at the Peace Conference: and the Wafd movement became so serious that martial law was invoked and Zaghlul and three of his most important adherents were arrested on March 8, 1919, and

deported to Malta.

Outbreak of March 1919.—The immediate effects of this measure revealed the gravity of the internal situation in Egypt. Anti-British demonstrations in Cairo necessitated military intervention. There were disturbances at Tanta and in the Delta provinces where British soldiers and civilians were attacked. Railway lines were torn up, telegraph wires cut and by the middle of March, Cairo was isolated. Foreign colonies were blockaded in Upper Egypt, and at Dairut station a British inspector of prisons, two officers and five other ranks were brutally murdered in the train by a fanatical crowd. Mobile columns were rapidly despatched to disturbed areas, communications were re-established and before the end of March the situation was well in hand. The Egyptian police behaved throughout in an exemplary manner. The Egyptian army which, all but a few units, was in the Sudan, remained unaffected. With these exceptions the agitation was supported by every class, including the Copts, whose solidarity with the Muslim was no doubt prompted by prudential considerations. If the movement was only partial among the peaceful unchanging fellaheen it was nevertheless perceptible that their experiences during the war had stirred a spirit of discontent even in the class which had benefited most from the British occupation. Recruiting for the Labour and Camel Corps had not been unpopular in the earlier volunteer stage. But when voluntary enlistment ceased to produce a sufficient number of men some administrative compulsion was exercised by unscrupulous mudirs, who, alleging British insistence, accepted bribes for exemptions and sent their enemies to serve. The requisition of domestic animals and of cereals had pressed hardly on the small farmer and had provided local officials with many an opportunity for abuses. The cost of food, clothing and fuel rose in an unprecedented manner and the average wages of the labouring class did not expand correspondingly. Meanwhile the producer of cotton and the privileged foreigner were notoriously accumulating fortunes.

When the outbreak became serious, Lord Allenby, the commander-in-chief in Egypt, who had left for Paris, was directed to return at once as special high commissioner during the absence of Sir R. Wingate. After the restoration of law and order a phase of passive resistance succeeded that of aggression. Lord Allenby, however, adopted a policy of conciliation, and a removal of the embargo on the free movement of Egyptians entailed the liberation (April 1919) of Zaghlul and his associates. They left Malta for Paris, where their hopes to obtain a hearing at the peace conference were disappointed; and the local unrest continued.

The Milner Mission.—The British Government now decided to send a mission to Egypt under the chairmanship of Lord Milner, "to enquire into the causes of the recent disorders, and to report on the existing situation in the country and the form of the Constitution which, under the protectorate will be best calculated to promote its peace and prosperity, the progressive development of self-governing institutions and the protection of foreign interests." It would have been well if the mission could have proceeded at once before the Nationalists had completed an organization which was now receiving encouragement from sections of the Arab university of El Azhar. But circumstances rendered its departure before the autumn difficult and arrangements for boycotting it were leisurely elaborated. In Dec. 1919 it reached Cairo, and special measures for the protection of its members had to be taken in view of an organized antagonism, in which even the Cairene ladies took a demonstrative part. Pickets of students watched their hotel, and individual members were followed into the provinces. A visit to Tanta provoked riots in that city. During the residence of the mission in Cairo, there were repeated assaults on British soldiers and no less than three attempts to assassinate Egyptian ministers with bombs. The chiefs of El Azhar now openly identified themselves with the Nationalists in a manifesto addressed to the high commissioner. Innumerable letters and resolutions were received denouncing the protectorate.

A declaration issued on Dec. 29, in which the real objects of the mission were clearly stated, had some reassuring influence. But the general boycott was rigidly maintained and relations with Egyptians were restricted to informal discussions with individuals who had the courage to be independent. As time went on, however, such conversations became general and the mission found no difficulty in estimating the current feeling in the country. The working of every department was thoroughly investigated, and before the departure of the mission, in March 1920, a large volume of material had been assembled, and certain proposals, unanimously adopted, were provisionally drafted pending the preparation of a final report in England.

Negotiations with Zaghlul.—Shortly after its return occasion was taken, through the good offices of Adly Pasha, to enter into relations with the Egyptian delegation then established in Paris, which, it could no longer be doubted, represented a majority of Egyptian opinion. Zaghlul, with seven other delegates, came to London in June; and after deliberations extending till the middle of August, in which Adly also took an unofficial conciliatory part, a memorandum which came to be known as the Milner-Zaghlul agreement, was drafted. It adopted the basis of settlement proposed by the special mission, a treaty of alliance in which Egypt contracted definite obligations in return for the recognition of independence, with certain additions such as the acceptance in principle of the rights of Egypt to foreign representation. Any reference to the Sudan was specifically excluded. As Zaghlul and his colleagues were not prepared to commit themselves to definite agreement without consulting their supporters, four members of the delegation proceeded to Cairo. On the return of the latter (Oct. 1920) they reported that the proposed settlement had been well received. At the same time they had been urged to invite modifications of certain points, including a restriction of the functions of the financial adviser and the official attached to the Ministry of Justice. Zaghlul insisted that his efforts to promote a settlement might be compromised if he could give no undertaking regarding the abolition of the protectorate. The delegates then left England and the mission sent in its report on Dec. 29, 1920. The inability of the British Government to act promptly on its recommendations has been the tragedy of Egypt's later history.

At the beginning of 1921 Adly Pasha had a strong following in Egypt and Zaghlul's influence appeared to be diminishing. On the other hand the resignation of Lord Milner was regarded as an indication that the British Government might not endorse the recommendations of the mission, while a reference in a speech from the new colonial secretary (Lord Curzon) to Egypt as included in the elastic circle of the British empire, evoked a number of protesting telegrams. When, however, the report was published in Arabic, the proposals were welcomed and the ascendancy of the Moderate party was re-established. The following invitation was then addressed to the sultan of Egypt:—

"His majesty's Government after a study of the proposals made by Lord Milner have arrived at the conclusion that the status of protectorate is not a satisfactory relation in which Egypt should continue to stand to Great Britain. While they have not reached final decisions with regard to Lord Milner's recommendations, they desire to confer regarding them with a delegation nominated by your highness, with a view, if possible, to substitute for the protectorate a relationship which would, while securing the special interests of Great Britain and enabling her to offer adequate guarantees to foreign Powers, meet the legitimate aspirations of Egypt and the Egyptian people."

Adly Pasha then formed a ministry with a programme designed to secure the co-operation of the Nationalists; but Zaghlul lost no time in attacking the new Government. His philippics, and the weakness of the administration in dealing with mob violence at Tanta, led to outbreaks in Cairo and Alexandria, directed in the latter city chiefly against the Greeks. A military court of enquiry attributed responsibility to the Zaghlulist party. Sixteen of the rioters found guilty were executed and a large number were condemned to lighter sentences.

Negotiations with Adly.—Six months had elapsed since the presentation of the Milner report before a delegation under the presidency of Adly, pledged to demand the abolition of the protectorate and the maintenance of the reserves formulated, proceeded to London in July 1921. In the ensuing conversations, all reference to the Sudan was avoided as it had been in negotiations

with the mission, but the negotiations broke down completely on the military issue. The British Government were unable to give the delegation an assurance that British troops would withdraw towards the canal zone as soon as conditions in Egypt were stabilized. Adly, while ready to accept the permanent establishment of a British military force to protect imperial communications, claimed that it should be restricted to a defined area in peace time, and that there should be no interference in the internal affairs of Egypt. When the impasse became final, Adly resigned: a successor could not be found; and disorder again broke out. Zaghlul, though badly received in Upper Egypt, continued to agitate in Lower Egypt, where demonstrations assumed a menacing character after the publication of the note to the sultan, and two British soldiers were shot. In view of their defiant attitude, Zaghlul and his chief supporters were ordered to retire to their country estates; as they proved recalcitrant, he and five others were deported by the British authorities.

Egypt Declared Independent.—The disturbances, which had taken a serious form in Cairo, were vigorously suppressed and by the end of the year (1921) conditions were favourable for a further endeavour to terminate a situation which could not be allowed to continue. Lord Allenby proceeded to London with his proposals and his resignation in his pocket; but he was back in Cairo within a month: and on Feb. 28, the day after his return, the following declaration was published:

"Whereas H.M. Government in accordance with their declared intentions desire to recognize Egypt as an independent sovereign State, and

"Whereas the relations between H.M. Government and Egypt are of vital importance to the British empire, the following principles are hereby declared:

"(1) The British protectorate over Egypt is terminated and Egypt is declared to be an independent sovereign State.

"(2) So soon as the Government of his highness shall pass an Act of Indemnity with application to all inhabitants of Egypt martial law as proclaimed on Nov. 2, 1914, shall be withdrawn.

"(3) The following matters are absolutely reserved to the discretion of H.M. Government until such time as it may be possible by free discussion and friendly accommodation on both sides to conclude agreements in regard thereto between H.M. Government and the Government of Egypt: (*a*) the security of the communications of the British empire in Egypt; (*b*) the defence of Egypt against all foreign aggression or interference direct or indirect; (*c*) the protection of foreign residents in Egypt and the protection of minorities; (*d*) the Sudan. Pending the conclusion of such agreements, the *status quo* in all these matters shall remain intact."

Although carefully protecting himself from acceptance of the terms of this declaration, Sarwat Pasha set to work to form a ministry with a programme contemplating a democratic constitution, ministerial responsibility and the revocation of martial law. The sultan assumed the title of king and proclaimed Egypt a monarchy. An Egyptian minister for foreign affairs was once more appointed. The British Government informed the Powers (March 15, 1922) that special relations between Great Britain and Egypt would always be maintained as an essential British interest. They could admit no question or discussion of those special relations, and any interference in the affairs of Egypt by any other Power would be regarded by them as an unfriendly act.

The Constitution, drafted by a representative commission, was completed by Oct. 1922. H.M. Government took exception to the ascription to King Fuad in the draft of the title of "king of Egypt and the Sudan" as well as to other clauses referring to the latter region. Acute differences also arose between the ministry and the king, whose views regarding the suitability of democratic institutions for Egypt seemed hardly consistent with his public utterances. Sarwat consequently resigned in November and Tewfik Nessim became prime minister for the second time. A further series of outrages on British subjects had meanwhile continued unchecked, culminating in the assassination in broad daylight of Prof. Newby Robson by three students. The Egyptian Government were informed that the continuance of these attacks would make impossible the abolition of martial law. Tewfik was anxious to promulgate the Constitution before announcing an Indemnity Act. But the king at first strenuously resisted a modification of his title, and a period of tension ensued. Tewfik Pasha resigned and an interregnum of five weeks followed, during which a recrudescence of murder and bomb-throwing rendered a severer application of martial law inevitable. Yehia Ibrahim Pasha finally formed an administration which assumed office in March 1923, and the Constitution was promulgated on April 19, 1923.

The New Constitution.—A constitutional monarchy was thereby established with two houses, a senate and a chamber of deputies, and a ministry responsible to the lower chamber. Deputies, 220 in number, were chosen by universal suffrage, under the old system of indirect election, for five years. The senate could not be dissolved. Two-fifths of its members were appointed by the Sovereign and three-fifths are elective, with a mandate for ten years. One half of each category was renewable every five years. A two-thirds' majority in each house was necessary for a revision of the Constitution. An Act of Indemnity prohibiting any process or plea calling in question acts under martial law was issued in July and that jurisdiction, continuously in force since Nov. 1914, was then terminated by a proclamation of the commander-in-chief and an exchange of notes between the British and Egyptian Governments. Yehia also carried through a law governing the retirement and compensation of foreign officials in the Egyptian service; and vigorous efforts to suppress the murder campaign met with some success.

Zaghlul was now permitted to return from exile; he was received with enthusiasm; and at the elections to the Chamber of Deputies in Jan. 1924, he was given an overwhelming majority of 188 supporters. In the senate he was equally strong. Yehia, who had deserved well of his country during the transitional period, resigned and Zaghlul formed a ministry. The almost simultaneous advent to power of a Labour Government in England revived Egyptian hopes that the Sudan policy would be reconsidered. But a declaration made (June 25) in the House of Lords by Lord Parmoor that the British Government did not intend to evacuate the Sudan evoked violent protests from Zaghlul. Nor was the statement in the House of Commons by J. Ramsay MacDonald a few days later more encouraging, though he expressed the hope that the Egyptian prime minister would come to England to discuss the issue. The latter, who was now completely master of the situation at Cairo, had repeatedly affirmed that he would only accept discussion on the basis of the incorporation of the Sudan in Egypt. In view of the unequivocal attitude of the British Government and parliament, he tendered his resignation, which was, however, not accepted. When about to start for Alexandria, where the court was established for the summer, he was shot at and wounded by a young Egyptian who appeared to be of unbalanced mind and not closely connected with any political movement. He recovered quickly and proceeded to Europe to recruit his health.

Meanwhile Nationalist propaganda had transferred its activity to the Sudan, and disturbances, of which there had been some premonition a few weeks earlier, broke out (Aug. 9–11) at Khartoum, the Atbara post and Port Sudan. A proposal from Cairo for an Egyptian-Sudanese commission of enquiry elicited the reply from the British Government that the governor-general was alone responsible for order in the Sudan. In certain other directions the position became more definite. The British Government announced that, having ceased to be a dependency of the sultan, Egypt could no longer be held liable for the tribute to Turkey. As the tribute had been made the security for two Turkish loans, the disclaimer of liability presented serious difficulties. It was proposed that a conference of interested Powers should study the question or that it should be referred to the International Court at The Hague.

The Crisis of 1924-25.—After more than one invitation from J. Ramsay MacDonald, a meeting between the British and Egyptian prime ministers eventually took place in London (Sept. 25–Oct. 3, 1924), but it was fruitless in results owing to the inordinate pretensions of Zaghlul who, when once Egyptian independence became an accomplished fact, repudiated any obligation to recipro-

cal concessions. He was informed by J. R. MacDonald that no British Government could divest itself of its interest in guarding the Suez canal, for which security must be provided in any agreement between Great Britain and Egypt. Effective co-operation might have been established by a treaty of alliance. The British force to be maintained in Egypt would neither interfere with the functions of its Government nor encroach upon its sovereignty. He adhered to the declaration made in the House of Commons that no arrangement which would jeopardise the administration and development of the Sudan could be contemplated. At the same time the special interest of Egypt in the water supply was recognized as well as certain financial claims against the Sudan Government. These interests Great Britain was prepared to secure. The contrast between the two points of view was irreconcilable, and Zaghlul's Government responded by replacing men of moderate opinions in the public service with uncompromising Nationalists. Zaghlul returned from London, engaged in an attack on the Palace and tendered a resignation which the king did not dare to accept. Events were marching steadily to a crisis.

The crisis came on Nov. 19, 1924, when Sir Lee Stack, the sirdar and governor-general of the Sudan, was shot in broad daylight while driving through the streets of Cairo. The assassination roused a storm of indignation in Great Britain. Rigorous measures were called for. The demands put forward by Lord Allenby (British note of Nov. 22) were tantamount to an ultimatum. They required:

1. An ample apology for the crime.
2. An enquiry into the authorship of the crime with the utmost energy and without respect of persons, and the condign punishment of the criminals, whoever and whatever their age might be.
3. The prohibition and vigorous suppression of all popular political demonstrations.
4. The payment forthwith to the British Government of a fine of £500,000.
5. The withdrawal from the Sudan within 24 hours of all Egyptian officers and the purely Egyptian units of the Egyptian army.
6. Notification to the competent department that the Sudan Government would increase the area to be irrigated at Gezira from 300,000 feddans to an unlimited figure as need might arise.
7. The withdrawal of all opposition in the respects to be specified later to the wishes of the British Government concerning the protection of foreign interests in Egypt.

If these demands were not immediately complied with, the British Government would at once take appropriate action to safeguard their interests in Egypt and the Sudan.

The Egyptian Government accepted the first four, but demurred to the last three of the demands, whereupon the British authorities took immediate action. Instructions were sent to the Sudan Government to effect the removal of all Egyptian officers and of the purely Egyptian units. The restriction of the irrigable area of the Gezira to 300,000 feddans would be regarded as no longer binding. At the same time the customs at Alexandria were occupied by a British force. Certain individuals under suspicion of conspiracy were arrested by the British but handed at once to the Egyptian authority. These vigorous measures inevitably led to the resignation of Zaghlul, who was replaced by Ahmed Pasha Ziwar, the president of the Senate, with a ministry of moderate views. They lost no time in negotiating a settlement with the British Government which secured the evacuation of the customs, after which they were joined by Ismail Sidky Pasha. A mutiny in a section of the Sudanese troops at Khartoum which broke out at this moment was rapidly suppressed. The Egyptian parliament was adjourned and finally dissolved at the end of 1924. An appeal which it had addressed to the League of Nations and to the parliaments of other countries for intervention remained without response.

A new Union party (*Ittihad*), formed under the inspiration of the Palace, had for its object to draw away from Zaghlul's party, the *Wafd,* many of those to whom his intransigence had become distasteful. On the reassembling of parliament, however (March 23, 1925), Zaghlul defeated the ministerial candidate for the presidency of the Chamber by a majority of 40, and it became evident that the Independents had repudiated their undertaking to separate themselves from the *Wafd*. In view of the support thus openly given to the leader whose policy had led up to the British ultimatum, the ministry recommended the king to dissolve the newly elected parliament. Eleven months were to elapse before it was re-elected: and in the interval a commission under the chairmanship of Ismail Sidky, in which the Liberal element predominated, was appointed to revise the electoral law so as to restrict the suffrage. The opposition appeared for the moment disconcerted and disarmed; and in May a number of persons were brought to trial for complicity in the murder of Sir Lee Stack. Seven of them were executed, and one sentenced to penal servitude for life.

Lord Lloyd's Tenure of Office.—Lord Allenby took advantage of the apparent lull to resign the high commissionership in May. He was succeeded in Oct. 1925 by Lord (formerly Sir George) Lloyd, who found the autocratic power of the Palace reviving in the absence, for health reasons, of the prime minister in Europe and in default of a parliament. The influence of Nashat Pasha, the head of the king's privy cabinet and his most trusted adviser, had become paramount. In promoting the formation of the *Ittihad* party his object had been to eliminate from power the Liberals, who were strenuously opposed to any extension of the royal prerogative. The chief result was to drive the Liberals into the arms of the Wafd, Zaghlul giving them satisfactory guarantees and losing no opportunity of impressing on the Liberals, as well as on the *Ittihad,* their dependence upon his support. The collapse of the latter was marked by the transfer of Nashat to a diplomatic post—the first indication of the influence exercised by Lord Lloyd. When at last a new parliament was elected in May 1926, it showed an overwhelming majority for the Nationalists, who were returned with some 150 candidates against about 30 Liberals, 5 Nationalists, 20 Independents and 10 Unionists.

The efforts of the police authorities and the support which they received from Ziwar had succeeded by the beginning of 1926 in bringing before the Egyptian courts the remainder of the culprits responsible for the political crimes which had occurred in Egypt since 1920. Among them were two members of Zaghlul's Government, Ahmed Maher, formerly minister of education, and Mahmud Nekrashi, under-secretary of the interior. To the consternation of the more moderate Egyptians and all foreigners, the trial at the end of May 1926 ended in their acquittal, but the verdict also involved, as a protest, the resignation of Judge Kershaw, the British member of the tribunal on the grounds that it had been given by his two Egyptian colleagues in defiance of the evidence brought before the court. On June 2 a note was presented to the Egyptian Government by Britain, declining to accept the verdict as establishing the innocence of the persons acquitted, and reserving liberty to ensure the safety of foreigners in Egypt.

Prior to the elections, Zaghlul Pasha had several times announced that it was not his intention to form a Government himself. It was clearly impossible, however, for Ziwar to carry on in face of the Wafd triumph: and he resigned just before the new parliament met. He was succeeded by Adly Pasha, with a coalition cabinet, while Zaghlul was re-elected president of the chamber. During the session which opened in Nov. 1926, the main political issues were the continuance of the contribution by Egypt to the defence force which had replaced the dismissed Egyptian garrison in the Sudan; the question of abrogating the capitulations; the treatment of foreign officials under the Egyptian Government, and a proposal that the village headman should be elected instead of, as before, appointed by Government. Outside the sphere of politics the chief events were the opening (Dec. 1926) of Port Fuad, opposite Port Said, which may in time become the southern harbour of Palestine; and the International Cotton Spinners' Congress held at Cairo in Jan. 1927, to consider the serious decline in the quantity and quality of the exports of Egyptian cotton.

By the spring of 1927 Adly's position was becoming impossible. His cabinet was disunited, his Government was constantly heckled by the Wafdists, who ostensibly owed it their support. In April he seized on a trivial excuse to resign, and Abdul Khalik Pasha Sarwat was summoned as prime minister. Although a Liberal, he was unable to change the constitution of the cabinet, which indeed

was more Wafdist than its predecessor. He was hardly in power before a minor crisis arose over a scheme for substantially strengthening the Egyptian army, to which the British Government objected. This difference being satisfactorily adjusted, a further effort was made to cement more friendly relations by the warmth with which King Fuad was received on his visiting England (July 4–26). Sarwat accompanied him; and the opportunity was taken by the foreign secretary (Sir Austen Chamberlain) to discuss informally all the outstanding issues between Britain and Egypt. The atmosphere was very different from that which had surrounded the earlier conversations with Zaghlul, and after much mutual give-and-take, a draft treaty of alliance between the two countries was hammered out, which Sarwat accepted during a second visit to London, and which ultimately met with the approval of the British and Dominion Governments. Before it could be forwarded officially to Cairo, Zaghlul died (Aug. 23, 1927), at the age of 74. The greatest national leader since Arabi, he had fought an unflinching battle for the independence of his country, and his death was the signal for a striking and genuine outburst of national grief. In his stead, the leadership of the Wafd was conferred on Mustapha Pasha Nahas, and the Wafd and Liberals combined in a declaration of their determination to remain united in following the principles of the dead leader.

The Draft Treaty of 1927.—The agreed draft, which reached Cairo late in Nov. 1927, provided for an alliance between Britain and Egypt. If Egypt were attacked, Britain would immediately come to her aid; and if Britain were menaced with or engaged in war, Egypt would furnish all facilities and assistance in her power. Egypt would not adopt in foreign countries an attitude hostile to the alliance; she would not oppose British policy abroad, or enter into any foreign agreement prejudicial to British interests. The Egyptian army would be trained on British methods, and any foreign instructors employed would be British subjects. The lines of communication in the British empire would be protected by such British forces in Egypt as Britain considered necessary: and after ten years the location of those forces would be reconsidered, any difference of opinion on the point being submitted to the League of Nations. Britain would use its influence to get the capitulations modified and to get Egypt admitted to the League of Nations. There were some detailed provisions regarding the Egyptian army, and for financial and judicial advisers. The lives and property of foreigners in Egypt were, if threatened, to be the subject of special consultation between the two Governments. The whole problem of the Sudan was left for future settlement.

On the receipt of the document Sarwat delayed action and sheltered himself behind a stream of requests for the interpretation of passages in the draft. Ultimately, under pressure from the British Foreign Office, he showed the draft to Nahas (Feb. 8, 1928), while still withholding it from his colleagues in the cabinet. With him clearly it was the Wafd, and the Wafd alone, which counted, and his dilatoriness had encouraged the Wafd to resume their old intransigent attitude. Nahas made no secret of his hostility to the treaty; as it did not provide for the complete evacuation of Egypt by the British army, it was not, he alleged, worth a moment's consideration. On March 4, Sarwat informed Lord Lloyd that the cabinet had refused to discuss the draft, and that he was accordingly resigning. Thus ended the most promising attempt since Lord Milner's conversations with Zaghlul, to get on to terms with the Nationalists. Nahas became premier and formed a Wafdist cabinet, containing only two Liberal members (March 16).

King Fuad's Coup.—To this rebuff the British Foreign Office replied by drawing attention to certain legislative proposals which it described as reckless, and prejudicial to the safety of foreigners in Egypt. After an ultimatum and the despatch of some warships from Malta, the chief offending measure, the Assemblies bill, was postponed until November. A crisis of an entirely different character, however, ensued immediately. Two Cairo newspapers, on June 24, published photographs of documents which, if authentic, would have seriously compromised Nahas and two other prominent Wafdists. Nahas denied their genuineness and the intrigue which they purported to disclose; but the king dismissed him and his cabinet on the following day. Mohammed Pasha Mahmud, one of the two Liberal members of Nahas's original cabinet, accepted office, and formed a ministry combining Liberals with the less extreme section of Wafdists. On July 19, 1928, King Fuad dissolved parliament which was not to assemble again for three years; he determined to carry on the Government by royal decree. The new prime minister announced his intention of acting as a benevolent dictator, and of clearing up the mess into which the public services had been thrown by the Wafd. The change was well received by the country, despite some strikes organized by way of protest. In Oct. 1928 the official enquiry into the charges against Nahas Pasha, concluded in a report that there was no case for a prosecution.

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(J. R. Ro.; Me.)

Egypt and Sudan Campaigns (1882–1899).—In Feb. 1879 a slight outbreak of discharged officers and soldiers occurred at Cairo, which led to the despatch of British and French ships to Alexandria. On June 26 Ismail Pasha was removed from Egypt, and Tewfik assumed the khediviate, becoming practically the *protégé* of the two western powers. On Feb. 1, 1881 a more serious disturbance arose at Cairo from the attempt to try three colonels, Ahmed Arabi, Ali Fehmy and Abd-el-Al, who had been arrested as the ringleaders of the military party. The prisoners were released by force, and proceeded to dictate terms to the khedive. Again British and French warships were despatched to Alexandria, and were quickly withdrawn, their presence having produced no apparent impression. It soon became clear that the khedive was powerless, and that the military party, headed by Arabi, threatened to dominate the country. The "dual note," communicated to the khedive on Jan. 6, 1881, contained an intimation that Great Britain and France were prepared to afford material support if necessary; but the fall of Gambetta's ministry produced a reaction, and both governments proceeded to minimize the meaning of their language. The khedive was practically compelled to form a government in which Arabi was minister of war and Mahmud Sami premier, and Arabi took steps to extend his influence throughout his army. The situation now became critical: for the third time ships were sent to Alexandria, and on May 25, 1882, the consuls-general of the two powers made a strong representation to Mahmud Sami which produced the resignation of the Egyptian ministry, but also a demand, to which the khedive yielded, by the military party for the reinstatement of Arabi. The attitude of the troops in Alexandria now became threatening; and on the 29th the British residents pointed out that they were "absolutely defenceless."

MILITARY OPERATIONS, 1882–1885

This warning was amply justified by the massacres of June 11, which took place almost under the guns of the ships in harbour. It was becoming clear that definite action would have to be taken, and by the end of June 26 warships, representing the navies of Great Britain, France, Germany, Italy, Austria, Russia, the United States, Spain, Greece and Turkey, lay off the port of Alexandria, and large numbers of refugees were embarked. The order received by Admiral Sir Beauchamp Seymour on July 3 was as follows:— "Prevent any attempt to bar channel into port. If work is resumed on earthworks, or fresh guns mounted, inform military commander that you have orders to prevent it; and if not immediately discontinued, destroy earthworks and silence batteries if they open fire, having given sufficient notice to population, shipping and foreign men-of-war."

On the 9th the admiral received a report that working parties had been seen in Fort Silsileh "parbuckling two smoothbore guns —apparently 32-pounders—towards their respective carriages and slides, which were facing in the direction of the harbour." Fort Silsileh was an old work at the extreme east of the defences of Alexandria, and its guns did not bear on the harbour. On the 10th an ultimatum was sent to Toulba Pasha, the military commandant, intimating that the bombardment would commence at sunrise on the following morning unless "the batteries on the isthmus of Ras-el-Tin and the southern shore of the harbour" were previously surrendered "for the purpose of disarming." The fleet prepared for action, and the bearer of the reply, which offered to dismount three guns in the batteries named, only succeeded in finding the flagship late at night. This proposal was rejected, and at 7 A.M. on July 11 the "Alexandra" opened fire and the action became general. The attacking force was disposed in three groups: a squadron outside the reef, to engage the Ras-el-Tin and the earthworks under weigh; another inside the harbour, to engage the Meks batteries; and two men-of-war to take up assigned stations outside the reef and to co-operate with the inshore squadron. The five gunboats were to keep out of fire at first and seek opportunities of engaging the Meks batteries. Meks fort was silenced by about 12:45 P.M., and a party landed and disabled the guns. As the fire delivered under weigh was not effective, the offshore squadron anchored at about 10:30 A.M., and succeeded in silencing Fort Ras-el-Tin at about 12:30 P.M., and Fort Adda, by the explosion of the main magazine, at 1:35 P.M. The gunboat "Condor," followed by three others, engaged Fort Marabout soon after 8 A.M. till 11 A.M., when they were recalled. The bombardment ceased at 5 P.M.; but a few rounds were fired on the morning of the 12th at the right battery in Ras-el-Tin lines.

The bombardment of the forts of Alexandria was illuminating as a gauge of the slight effect to be expected from the fire of ships—under favourable conditions—compared with that of guns on shore, even though indifferently mounted, with poorly trained gunners and antiquated ordnance. Seventy-five hits were obtained on the hulls of the ships, of which 30 were unquestionably due to the old smoothbores, which were not provided with sights. The British ships engaged fired 1,741 heavy projectiles and 1,457 light. The result was comparatively small. About eight rifled guns out of 36 and 19 smoothbores out of 120 were dismounted or disabled. A considerable portion of this injury was inflicted, after the works had been silenced, by the deliberate fire of the ships. In the afternoon of the 12th, fires, which were the work of incendiaries, began to break out in the best quarters of Alexandria; and the town was left to murder and pillage till the following day, when a party of bluejackets and marines was landed at about 3 P.M.

Military intervention being now imperatively demanded, a vote of credit for £2,300,000 was passed in the British House of Commons on July 27. Five days later the French Government failed to secure a similar vote, and Great Britain was left to deal with the Egyptian question alone. An expeditionary force was organized in two divisions, with a cavalry division, corps troops and a siege train, numbering in all about 25,000 men. An Indian contingent numbering about 7,000 combatants was prepared for despatch to Suez. Gen. Sir Garnet Wolseley was appointed commander-in-chief. The expeditionary force having assembled at Alexandria, the Suez Canal was seized and Ismailia occupied as the base for an advance on Cairo. Meanwhile the bulk of the expeditionary force was taken eastwards to Port Said, a naval demonstration being made at Abukir to deceive the enemy as to the object of the main movement in progress. The advance inland westwards towards Cairo now began. On Aug. 21 an advanced detachment moved from Ismailia occupying Nefiche, the junction with the Suez line. Reconnaissances showed that the enemy had dammed the sweet-water canal and blocked the railway at Tell-el-Mahuta, where entrenchments had been thrown up. But the advanced guard had now outrun its supplies, while a considerable force was distributed at intervals along the line Ismailia-Kassassin. The situation on the 27th tempted attack by an enterprising enemy, and Maj.-gen. Graham's force was in danger of being overwhelmed by vastly superior numbers from Tell-el-Kebir. On Aug. 28 and Sept. 9 the Egyptians attacked Kassassin, but were repulsed. Meanwhile strenuous efforts were made to bring up supplies and troops for an attack on Tell-el-Kebir, held by about 38,000 men with 60 guns. The Egyptian defences consisted of a long line of trench (two and a half miles) approximately at right angles to the railway and the sweet-water canal. At 11 P.M. on Sept. 12 the advance of about 15,000 men commenced; the 1st division, under Lieut.-gen. Willis, was on the right, and the 2nd division, under Lieut.-gen. Hamley, was on the left. Seven batteries of artillery were placed in the centre. The cavalry, under Maj.-gen. Drury Lowe, was on the right flank, and the Indian contingent, under Maj.-gen. Macpherson, starting one hour later, was ordered to move south of the sweet-water canal. The night was moonless, and the distance to be covered about 6¼ miles. The ground was perfectly open, slightly undulating and generally firm gravel. The conditions for a night march were thus ideal; but during the movement the wings closed towards each other, causing great risk of an outbreak of firing. The line was, however, rectified, and after a halt the final advance began. By a fortunate accident an isolated outwork was just missed in the darkness by the left flank of the 2nd Division; otherwise a premature alarm would have been given, which must have changed all the conditions of the operation. At dawn the Highland Brigade of the 2nd Division struck the enemy's trenches, and carried them after a brief struggle. The 1st Division attacked a few minutes later, and the cavalry swept round the left of the line of entrenchments, cutting down any fugitives who attempted resistance and reaching the enemy's camp in rear. The Indian contingent, on the south of the canal, co-operated, intercepting the Egyptians at the canal bridge. The opposition encountered at some points was severe, but by 6 A.M. all resistance was at an end. The British loss amounted to 58 killed, 379 wounded and 22 missing; nearly 2,000 Egyptians were killed, and more than 500 wounded were treated in hospital. An immediate pursuit was ordered, and the Indian contingent reached Zagazig, while the cavalry occupied Belbeis and pushed on to Cairo, 65m. from Tell-el-Kebir, next day. On the evening of the 14th the 10,000 troops occupying Abbasia barracks, and 5,000 in the citadel of Cairo, surrendered. The prompt following up of the victory at Tell-el-Kebir saved Cairo from the fate of Alexandria and brought the rebellion to an end—25 days from the landing at Ismailia to the occupation of Cairo. For the Egyptian troops elsewhere promptly surrendered.

The authority of the khedive and the maintenance of law and order now depended absolutely on the British forces left in occupation. Lord Dufferin, who had been sent to Cairo to draw up a project of constitutional reforms, advocated the re-establishment of a native army, not to exceed 5,000 to 6,000 men, with a proportion of British officers for purely defence purposes within the Delta; and Sir Evelyn Wood left England to undertake the organization of this force, with the title of *sirdar*. A gendarmerie of 4,400 was also formed, under Baker Pasha (Gen. Valentine Baker) as inspector-general.

In a despatch of Feb. 6, 1883, Lord Dufferin dealt with the Sudan, and stated that Egypt "could hardly be expected to acquiesce" in a policy of withdrawal from her southern territories. At the same time he pointed out that, "Unhappily, Egyptian administration in the Sudan had been almost uniformly unfortunate. The success of the present mahdi in raising the tribes and extending his influence over great tracts of country was a sufficient proof of the government's inability either to reconcile the inhabitants to its rule or to maintain order." Moreover, to restore tranquillity in the Sudan, "the first step necessary was the construction of a railway from Suakin to Berber, or what, perhaps, would be more advisable, to Shendi, on the Nile. The completion of this enterprise would at once change all the elements of the problem."

The immense responsibilities involved were most imperfectly understood by the British Government. Egyptian sovereignty in the Sudan dated from 1820, and in 1877 Gordon had become governor-general of the Sudan, where he laboured to destroy the slave trade and to establish just government. In Aug. 1879 he

returned to Cairo, and was succeeded by Raouf Pasha. Misrule and oppression again prevailed throughout the Sudan, while the slave traders, exasperated by Gordon's stern measures, were ready to revolt. The authority of Egypt was represented by scattered garrisons of armed men, badly officered, undisciplined and largely demoralized. In such conditions a leader only was required to ensure widespread and dangerous rebellion. A leader appeared in the person of Mohammed Ahmed, who, acquiring great reputation for sanctity, had actively fomented insurrection. In Aug. 1881 a small force sent by Raouf Pasha to arrest Mohammed Ahmed was destroyed, and the latter, proclaiming himself the mahdi, stood forth as the champion of revolt. Thus, at the time when the Egyptian army was broken up at Tell-el-Kebir, the Sudan was already in flames. These spread in face of the ineffective efforts of a rapidly changed succession of Egyptian governor-generals. An Egyptian force was improvised and despatched by the khedive to Khartoum via Suakin. In March 1883 Col. William Hicks, late of the Bombay army, found himself at Khartoum in command of nine European officers and about 10,000 troops of little military value. The reconquest of the Sudan having been determined upon, although Sir E. Malet reported that the Egyptian Government could not supply the necessary funds, and that there was great risk of failure, Hicks started from Khartoum on Sept. 9 for Kordofan.

Col. Hicks was fully aware of the unfitness of his rabble forces for the contemplated task, and on Aug. 5 he telegraphed: "I am convinced it would be best to keep the two rivers and province of Sennar, and wait for Kordofan to settle itself." Early in November the force from Khartoum was caught by the mahdists short of water at Kashgil, near El Obeid, and was almost totally destroyed, Col. Hicks, with all his European officers, perishing. Sinister rumours having reached Cairo, Sir E. Baring (Lord Cromer), who had succeeded Sir E. Malet, telegraphed to London that "if Col. Hicks's army is destroyed, the Egyptian Government will lose the whole of the Sudan, unless some assistance from the outside is given," and advised the withdrawal to some post on the Nile. On the following day Lord Granville replied: "We cannot lend English or Indian troops; if consulted, recommend abandonment of the Sudan within certain limits"; and on the 25th he added that "Her Majesty's Government can do nothing in the matter which would throw upon them the responsibilities for operations in the Sudan." In a despatch of Dec. 3 Baring forcibly argued against British intervention in the affairs of the Sudan; on Jan. 4, 1884 he was directed to insist upon the policy of evacuation, and on the 18th Gen. Gordon left London to assist in its execution.

The year 1883 brought a great accession of power to the mahdi, who had captured about 20,000 rifles, 19 guns and large stores of ammunition. On the Red Sea littoral Osman Digna, a slave dealer of Suakin, appointed *amir* of the Eastern Sudan, raised the local tribes, invested Sinkat and Tokar, and destroyed Egyptian reinforcements sent thither. On Dec. 23 Baker, followed by about 2,500 men, gendarmerie, blacks, Sudanese and Turks, with ten British officers, arrived at Suakin to prepare for the relief of Sinkat and Tokar. The tragedy of Kashgil was repeated on Feb. 4 when Gen. Baker's heterogeneous force, on the march to Tokar, was routed at El Teb by an inferior body of tribesmen. Of 3,715 men, 2,375 with 11 European officers were killed. Suakin was now in danger, and on Feb. 6 British bluejackets and marines were landed for the defence of the town.

Two expeditions in the Sudan led by British officers having thus ended in disaster, and Gordon with Lieut.-col. J. D. Stewart having reached Khartoum, the policy of British non-intervention could no longer be maintained. Public opinion in England was strongly impressed by the fact that the Egyptian garrisons of Tokar and Sinkat were perishing within striking distance of the Red Sea littoral. A British force about 4,400 strong, with 22 guns was rapidly concentrated at Suakin and placed under the orders of Maj.-gen. Sir G. Graham. News of the fall of Sinkat, where the starving garrison, under Tewfik Bey, made a gallant sortie and was cut to pieces, reached Suakin on Feb. 12. On the 24th Gen. Graham's force disembarked at Trinkitat and received information of the surrender of Tokar. At 8 A.M. on the 29th the force advanced towards Tokar in square, and came under fire at 11:20 A.M. from the enemy entrenched at El Teb. The tribesmen made desperate efforts to rush the square, but were repulsed, and the position was taken by 2 P.M. The cavalry, 10th and 19th Hussars, under Brig.-gen. Sir H. Stewart, became involved in a charge against an unbroken enemy, and suffered somewhat severely. The total British loss was 34 killed and 155 wounded; that of the tribesmen was estimated at 1,500 killed. On the following day Tokar was reached, and on March 2 the force began its return to Suakin, bringing away about 700 rescued people. On March 9 the whole force was back at Suakin, and on the evening of the 11th an advance to Tamai began, and the force bivouacked and formed a zariba in the evening. Information was brought by a native that the enemy had assembled in the Khor Ghob, a deep ravine not far from the zeriba. At about 8:30 A.M. on the 13th the advance began in echelon of brigade squares from the left. The left and leading square (2nd Brigade) moved towards the khor, approaching at a point where a little ravine joined it. The enemy showing in front, the leading face of the square was ordered to charge up to the edge of the khor. This opened the square, and a mass of tribesmen rushed in from the small ravine. The brigade was forced back in disorder, and the naval guns, which had been left behind, were temporarily captured. After a severe hand-to-hand struggle, in which the troops behaved with great gallantry, order was restored and the enemy repulsed, with the aid of the fire from the 1st Brigade square and from dismounted cavalry. The 1st Brigade square, having a sufficient field of fire, easily repelled all attempts to attack, and advancing as soon as the situation had been restored, occupied the village of Tamai. The British loss was 109 killed and 104 wounded; of the enemy nearly 2,000 were killed. On the following day the force returned to Suakin.

Two heavy blows had now been inflicted on the followers of Osman Digna, and the road to Berber could have been opened, as Graham suggested and Gordon urged. It was at first opposed by Sir E. Baring who, however, realized soon afterwards the gravity of the situation and telegraphed on March 16:—"It has now become of the utmost importance not only to open the road between Suakin and Berber, but to come to terms with the tribes between Berber and Khartoum." The Government refused to take this action and Graham's force was broken up, leaving one battalion to garrison Suakin.

The abrupt disappearance of the British troops encouraged the tribesmen led by Osman Digna. The first attempt at intervention in the affairs of the Sudan had been made too late to save Sinkat and Tokar. It resulted only in heavy slaughter of the tribesmen, which afforded no direct or indirect aid to Gordon or to the policy of evacuation. The public announcement of this policy increased Gordon's difficulties, and the situation at Khartoum grew steadily worse. On March 24 Sir E. Baring telegraphed:—"The question now is, how to get Gen. Gordon and Col. Stewart away from Khartoum. . . . Under present circumstances, I think an effort should be made to help Gen. Gordon from Suakin, if it is at all a possible military operation. . . . We all consider that, however difficult the operations from Suakin may be, they are more practicable than any operations from Korosko and along the Nile." A telegram from Gordon, received at Cairo on April 19, stated that "We have provisions for five months and are hemmed in. . . . Our position will be much strengthened when the Nile rises. . . . Sennar, Kassala and Dongola are quite safe for the present." At the same time he suggested "an appeal to the millionaires of America and England" to subscribe money for the cost of "2,000 or 3,000 nizams" (Turkish regulars) to be sent to Berber. A cloud now settled down upon Khartoum, and subsequent communications were few and irregular. The Foreign Office and Gordon appeared to be somewhat at cross purposes. The former hoped that the garrisons of the Sudan could be extricated without fighting. The latter, judging from some of his telegrams, believed that to accomplish this entailed the suppression of the mahdi's revolt, the strength of which he at first greatly under-estimated. On March 9 Gordon proposed, "if the immediate evacuation of Khartoum is determined upon irrespective of out-lying towns," to send down

the "Cairo *employés*" and the garrison to Berber, to resign his commission, and to proceed with the stores and the steamers to the equatorial provinces, which he would consider as placed under the king of the Belgians. On March 13 Lord Granville gave full power to Gordon to "evacuate Khartoum and save that garrison by conducting it himself to Berber without delay," and expressed a hope that he would not resign his commission.

By the end of March the growing danger to Gordon, with the grave national responsibility involved, began to be realized in Great Britain. Sir Henry Gordon, however, who was in personal communication with Mr. Gladstone, considered that his brother was in no peril, and for some time disbelieved in the need for a relief expedition. Meanwhile it was at least necessary to evolve some plan of action, and on April 8 Lord Wolseley, the adjutant-general, drew up a memorandum detailing the measures required for placing 6,500 British troops "in the neighbourhood of Shendi." The controversial "battle" of the routes began much earlier, and was continued for some months. Practically the choice lay between the Nile and the Suakin-Berber road. The first involved a distance of 1,650m. from Cairo along a river strewn with cataracts, which obstructed navigation to all but small boats, except during the period of high water. So great was this obstruction that the Nile had never been a regular trade route to the Sudan. The second entailed a desert march of about 250m., of which one section, Obak-Bir Mahoba (52m.), was waterless, and the rest had an indifferent water supply (except at Ariab, about half-way to Berber), but capable of development. From Berber the Nile is followed (210m.) to Khartoum. This was an ancient trade route with the Sudan, and had been used without difficulty by the reinforcements sent to Hicks Pasha in 1883. The authorities in Egypt were unanimous in favour of it. From the first Maj.-gen. Sir A. Clarke, then inspector-general of fortifications, strongly urged this plan, and proposed to begin at once a metre gauge railway from Suakin. Preliminary arrangements were made, and on June 14 the Government sanctioned certain measures of preparation at Suakin. On the other side were the adjutant-general and a small number of officers who had taken part in the Red River expedition of 1870 in Canada (*q.v.*). Wolseley's memorandum had been based on the hypothesis that Khartoum could not hold out beyond Nov. 15, and that the expedition should reach Berber by Oct. 20. Steamers were to be employed in such reaches as proved practicable, but the force was to be conveyed in special whale-boats, by which "the difficulty of transport is reduced to very narrow limits." The question of routes continued to be argued and on July 29 a committee of three officers who had served in the Red River expedition reported:—"We believe that a brigade can easily be conveyed in small boats from Cairo to Dongola in the time stated by Lord Wolseley; and, further, that should it be necessary to send a still larger force by water to Khartoum, that operation will present no insuperable difficulties."

This inconclusive report, and the baseless idea that the adoption of the Nile route would involve no chance of bloodshed, which the Government was anxious to avoid, seem to have decided the question. Wolseley was appointed to take over the command in Egypt for the purposes of the expedition, and on Sept. 9 he arrived at Cairo, where the plan of operations was somewhat modified. A camel corps of 1,100 men selected from 28 regiments at home was added, and the "fighting force to be placed in line somewhere in the neighbourhood of Shendi" was fixed at 5,400. The construction of whale-boats began at once, the first batch arrived at Wadi Halfa on Oct. 14, and on the 25th the first boat was hauled through the second cataract. The mounted forces proceeded up the banks, and the first half-battalion embarked at Gemai, 870m. from Khartoum, on Nov. 5, ten days before the date to which it had been assumed Gen. Gordon could hold out. In a straggling procession the boats worked their way up to Korti, piloted by Canadian *voyageurs*. By Christmas day 2,220 men had reached Korti, of whom about 800 only had been conveyed by the whale-boats, the last of which did not arrive till Jan. 27. Beyond Korti lay the very difficult section of the river to Abu Hamed, which was quite unknown. A letter from Gordon, dated Nov. 4 and received on Nov. 17, stated that his steamers would await the expedition at Metemma, and added, "We can hold out 40 days with ease; after that it will be difficult."

It was clear at Korti that something must be done at once; and on Dec. 13 a camel force under Gen. Sir H. Stewart was despatched to occupy Jakdul wells, 96m. on the desert route to Metemma. Stewart returned on Jan. 5, 1885, and started again on the 8th, with orders to establish a fort at Abu Klea and to occupy Metemma. The desert column, 1,800 men, with 2,880 camels in poor condition and 153 horses, found the enemy in possession of Abu Klea wells on the 16th, and was desperately attacked on the 17th. The want of homogeneity of the force, and the unaccustomed tactics imposed upon the cavalry, somewhat hampered the defence, and the square was broken at the left rear corner. Driven back upon the camels in the centre, the troops fought hand to hand with the greatest gallantry. Order was quickly restored, and the attack was repulsed, with a loss of 74 killed and 94 wounded. At least 1,100 of the enemy were killed. After occupying the wells the column started again next evening. The wrong road was taken, and great confusion occurred during the night, but at dawn this was rectified; and after forming a rough fort under fire, by which Stewart was fatally wounded, the advance was resumed. Repulsing a fresh attack, the desert column, now greatly exhausted, on the 21st reached Metemma, which was found too strong to assault. On this day Gordon's four steamers arrived; and on the morning of the 24th Sir C. Wilson, on whom the command had devolved, with 20 British soldiers and about 280 Sudanese, started in the "Bordein" and "Telehawiyeh" for Khartoum. The "Bordein" grounded twice, by which 24 hours were lost. On the 28th Khartoum was sighted, and it soon became clear that the town was in the hands of the enemy. After reconnoitring farther, the steamers turned and proceeded down stream under a heavy fire, the Sudanese crews showing signs of disaffection. Both steamers were wrecked on the way back, but Wilson's party was rescued. Khartoum had been taken and Gordon killed on the morning of Jan. 26, having thus held out 34 days beyond the date when he had expected the end. The desert column, now in a precarious situation, increased by the breakdown of its transport, extricated itself by a return to Korti, while the river column was still 350m. below Khartoum when on Feb. 24 it received orders to retire. On Feb. 11, Wolseley, who had previously refused the offer of an active demonstration from Suakin, accepted the proposal of the Government to make a railway from there to Berber, as a means of supply.

Every effort was now concentrated upon sending an expeditionary force to Suakin, and before the end of March about 13,000 men, including a brigade from India and a field battery from New South Wales, with nearly 7,000 camels and 1,000 mules, were there assembled. Gen. Graham was placed in command of this force, with orders to break down the power of Osman Digna and to press the construction of the railway towards Berber. On March 19, Graham reconnoitred as far as Hashin and there next day inflicted a sharp reverse on the enemy, despite the natural difficulties of fighting in the dense mimosa scrub. On the 22nd a detachment with a large camel convoy started from Suakin for Tamai, but at a halt six miles out was attacked. Although caught partly unprepared, they repulsed the enemy, after a severe fight, before Graham's prompt aid arrived. After the repulse of a few lesser attacks, the railway was pushed on without interruption, reaching Otao on the 30th. On the night of May 6 a combined movement was made from Suakin and Otao, which resulted in the surprise and break-up of a force of the enemy and the seizure of a large number of sheep and goats. The moral effect of this operation was marked.

Meanwhile many communications had passed between the War Office and Wolseley, who at first believed that Berber could be taken before the summer. But by March 6 he had come to the opinion that it would be "impossible . . . to undertake any offensive operations until about the end of the summer, and only then with large reinforcements." A cloud having arisen on the frontiers of Afghanistan, the withdrawal of the troops from the Sudan was ordered in May. On June 22, before the British rearguard had left Dongola, the mahdi died. The withdrawal of

the Suakin force began on May 17, and the friendly tribes, deprived of support, were compelled to make terms with Osman Digna.

MILITARY OPERATIONS, 1885 TO 1896

The operations against mahdism during the 11 years from the end of the Nile expedition and the withdrawal from the Sudan to the commencement of the Dongola campaign will be more easily understood if, instead of narrating them in one chronological sequence, the operations in each province are considered separately. On the death of the mahdi he was succeeded by the principal khalifa, Abdullah el Ta'aisha, a Baggara Arab, who for the next 13 years ruled the Sudan with despotic power. He was cruel, vicious, unscrupulous and strong, and the country groaned beneath his oppression. He removed all possible rivals, concentrated at Omdurman a strong military force composed of men of his own tribe, and maintained the ascendancy of that tribe over all others. As the British troops retired to Upper Egypt, his followers seized the evacuated country, and the khalifa cherished the idea, already formulated by the mahdi, of the conquest of Egypt, but for some years he was too much occupied in quelling risings, massacring the Egyptians in the Sudan, and fighting Abyssinia, to move seriously in the matter.

Upper Egypt.—Mohammed el Kheir, dervish amir of Dongola, advanced towards the frontier in the autumn of 1885. After a month of small encounters, Sir Frederick Stephenson, commanding the British army of occupation in Egypt, concentrated the mixed British and Egyptian frontier field force at Firket, and attacked the main body of the enemy at Ginnis on Dec. 30, 1885, completely defeating it. It was here the new Egyptian army received its baptism of fire and acquitted itself creditably. Although checked, the dervishes were not discouraged, and continued to press upon the frontier in frequent raids. In April 1886 the frontier was drawn back to Wadi Halfa, a fortified camp at the northern end of the desolate defile, Batn-el-Hagar, through which the Nile tumbles amid black, rocky hills in a succession of rapids, and debouches on a wide plain. The protection of the frontier was now left in the hands of the Egyptian army, a British force remaining for two years longer at Aswân, 200m. to the north, as a reserve in case of emergency.

It was not until May 1889 that an invasion of the frontier on a large scale was again attempted. At this time the power and prestige of the khalifa were at their height; the rebellions in Darfur and Kordofan had been stamped out, the anti-mahdi was dead, and even the dervish defeat by the Abyssinians had been converted by the death of King John and the capture of his body into a success. It was therefore an opportune time to try to sweep the Turks and the British into the sea. On June 22 the amir Wad en Nejumi was at Sarras with over 6,000 fighting men and 8,000 followers. On July 2 Col. Wodehouse headed off and routed a part of this force at Argin. The sirdar, Gen. Grenfell, who had arrived to take the command in person, concentrated the Egyptian troops, with a squadron of the 20th Hussars, at Toski, and thence, on Aug. 3 gained a decisive victory with slight loss. The dervish army was practically destroyed and no further serious attempts were made to disturb the frontier, of which the most southerly outpost was at once advanced to Sarras.

The Eastern Sudan.—In 1884 Col. Chermside, governor of the Red sea littoral, entered into arrangements with King John of Abyssinia for the relief of the beleaguered Egyptian garrisons. Gera, Amadib, Senhit and Gallabat were, in consequence, duly succoured by the Abyssinians in 1885. Unfortunately famine compelled the garrison of Kassala to capitulate on July 30, and Osman Digna entrenched himself at Kufit with 10,000 men to oppose the Abyssinian general, Ras Alula. On Sept. 23 Ras Alula attacked him there with an equal number of men and routed him with great slaughter. Instead of marching on to Kassala, Ras Alula, who at this time was much offended by the transfer of Massawa by the Egyptians to Italy, made a triumphant entry into Asmara, and refused to make any further efforts to extricate Egyptian garrisons from the grip of the khalifa. Meanwhile Osman Digna, who had fled from Kufit to Kassala, wreaked his vengeance upon the unhappy captives at Kassala.

In the neighbourhood of Suakin there were many tribes disaffected to the khalifa's cause, and in the autumn of 1886 Col. H. Kitchener, who was at the time governor of the Red Sea littoral, judiciously arranged a combination of them to overthrow Osman Digna, with the result that his stronghold at Tamai was captured on Oct. 7. But at the end of 1887 Osman Digna again advanced towards Suakin, and although routed by the "Friendlies," he collected a large force again in 1888 and besieged Suakin. In December the sirdar arrived with reinforcements from Cairo, on the 20th sallied out and dislodged the dervishes from their trenches at Gemaiza, and the country was again fairly quiet for a time. In Jan. 1891 Osman Digna showed signs of increased activity, and Col. Holled Smith, then governor of the Red Sea littoral, advanced and on Feb. 19 fought the decisive action of Afafit, occupied Tokar, and drove Osman Digna back to Temrin with a loss of 700 men, including all his chief amirs. This action proved the final blow to the dervish power in the neighbourhood of Suakin, for although raiding continued on a small scale, the tribes were growing tired of the khalifa's rule and refused to support Osman Digna.

In the spring of the same year an agreement was made between England and Italy by which the Italian forces in Eritrea were at liberty, if they were able, to capture and occupy Kassala, which lay close to the western boundary of their new colony, on condition that they should ultimately restore it to Egypt. Three years passed before they availed themselves of this agreement. In 1893 the dervishes, 12,000 strong, under Ahmed Ali, invaded Eritrea, and were met on Dec. 29 at Agordat by Col. Arimondi with 2,000 men of a native force. Ahmed Ali's force was completely routed and himself killed, and in the following July Col. Baratieri, with 2,500 men, made a fine forced march from Agordat, surprised and captured Kassala and continued to hold it for three years and a half.

The Abyssinian Frontier.—In June 1886 *Ras* Adal invaded Gallabat and defeated the dervishes. In the following year dervish raids into Abyssinian territory led *Ras* Adal to collect a vast army for the invasion of the Sudan, but he was anticipated by the amir Abu Angar, a very skilful leader, who entered Abyssinia, defeated *Ras* Adal in the plain of Debra Sin after a prolonged battle, and marched on Gondar, the ancient capital, which he sacked before returning to Gallabat. King John, the negus of Abyssinia, burning to avenge this defeat, marched in 1889 to Gallabat where the khalifa's forces fortified the town and the camp. On March 9 the Abyssinians made a terrific onslaught, stormed and burnt the town, and took thousands of prisoners. But a stray bullet mortally wounded King John, and the Abyssinians decided to retire. That night, the greater part of the army having gone ahead with the prisoners, a party of Arabs pursued the rearguard, routed them, and captured the king's body, which was sent to Omdurman to confirm the story of victory sent to the khalifa. Internal strife prevented the new negus of Abyssinia from prosecuting the war, which thus, in spite of the Abyssinian success, resulted in the increased prestige of the khalifa. From this time, however, the dervishes ceased to trouble the Abyssinians.

Darfur and Kordofan.—On the outbreak of the mahdi's rebellion Slatin Bey was governor of the province, and mahdism spread over Darfur in spite of Slatin's efforts to stay it. He fought no fewer than 27 actions in various parts of his province, but his own troops became infected with the new faith and deserted him. He was obliged to surrender in Dec. 1883, and was a prisoner until he escaped from Omdurman in 1895. After successive wars between rival amirs, in 1888, the Darfurian chiefs allied themselves with Abu Gemaiza, sheikh of the Masalit Arabs, who had proclaimed himself "Khalifa Osman," and was known as the anti-mahdi. The revolt assumed large proportions, and became the more dangerous to Abdullah, the khalifa, by reason of its religious character. Abu Gemaiza won two important victories, but instead of following them up, he retired to Dar Tama to augment his army, to which thousands flocked as the news of his achievements spread far and wide. He again advanced in Feb. 1889, but was seized with smallpox. After his death, and the subsequent defeat of his army, the movement collapsed.

The Bahr-el-Ghazal.—The first outbreak in favour of mahdism in the Bahr-el-Ghazal took place in Aug. 1882, and although crushed by Lupton Bey, a fresh outbreak a year later forced him to retire to Dem Suliman, where he was completely cut off from Khartoum. After gallantly fighting for 18 months he was compelled by the defection of his troops to surrender to Karamalla, the dervish amir of the province, and he died at Omdurman in 1888. In 1890 the Shilluks in the neighbourhood of Fashoda rose against the khalifa, and the dervish amir of Gallabat, Zeki Tumal, was engaged for two years in suppressing the rebellion. In 1892 he was recalled by the khalifa to invade Eritrea (Italian), and on reporting it to be impossible he was summoned to Omdurman and put to death. The country then relapsed into its original barbarous condition, and dervish influence was nominal only.

Equatoria.—In the Equatorial Province, which extended from the Albert Nyanza to Lado, Emin Bey, who had a force of 1,300 Egyptian troops and 3,000 irregulars, distributed among many stations, held out, hoping for reinforcements. In April 1885, however, Karamalla arrived near Lado, the capital, and sent to inform Emin of the fall of Khartoum. Emin and Capt. Casati, an Italian, moved south to Wadelai, and opened friendly relations with the king of Unyoro. Emin determined to remain rather than leave the country and to "hold together, as long as possible, the remnant of the last ten years." His troops were in a mutinous state, wishing to go north rather than south, and unsuccessfully endeavoured to carry him with them by force.

His communications to Europe through Zanzibar led to the relief expedition under Stanley, which went to his rescue by way of the Congo in 1887, and eventually met with Emin and Casati at Nsabé, on the Albert Nyanza, on April 29, 1888. Stanley went back in May to pick up his belated rearguard, leaving Mounteney Jephson and a small escort to accompany Emin round his province. But a revolt broke out, headed by Fadl-el-Maula, governor of Fabbo, and Emin and Jephson were made prisoners by the Egyptian mutineers. In the meantime, the arrival of Stanley at Lake Albert had caused rumours, which quickly spread to Omdurman, of a great invading white pasha, with the result that in July the khalifa sent up the river three steamers and six barges, containing 4,000 troops, to oppose this new-comer. In October the mahdist commander took Rejaf and sent messengers to Dufile to summon Emin to surrender. The mutineers then released Emin and Jephson—who rejoined Stanley and reached Zanzibar safely —and turned to repulse the dervishes, eventually driving them back to Rejaf. They did not, however, follow up their victory. In 1893 Fadl-el-Maula Bey and many of his men took service with the Congo State expedition. The bey was killed fighting the dervishes and the remnant of his men were found by Capt. Thruston from Uganda in March 1894 at Mahagi, on the Albert Nyanza, whither they had drifted in search of supplies. They were enlisted by Thruston and brought back under the British flag to Uganda. In consequence of the Franco-Congolese Treaty of 1894, Maj. Cunningham and Lieut. Vandeleur were sent from Uganda to Dufile, where they planted the British flag on Jan. 15, 1895.

SUDAN CAMPAIGNS, 1896–1900

Accounts of the wonderful progress which Egypt had made during British occupation, notably Sir Alfred Milner's *England in Egypt* (1892), together with the revelation of the character of the khalifa's despotism in the Sudan and the miserable condition of his misgoverned people made by Father Ohrwalder and Slatin Bey after their escape from captivity at Omdurman, stirred public opinion in Great Britain, and brought the question of the recovery of the Sudan into prominence. A change of ministry took place in 1895, and Lord Salisbury's cabinet, which had consistently assailed the Egyptian policy of the old, was not unwilling to consider whether the flourishing and settled condition of Egypt, with a capable little army ready to hand, warranted an attempt to recover gradually the Sudan provinces abandoned by Egypt in 1885 on the advice of Mr. Gladstone's Government. Such being the condition of public and official sentiment, the crushing defeat of the Italians by the Abyssinians at the battle of Adowa on March 1, 1896, and the critical state of Kassala—held by Italy at British suggestion, and now closely invested by the dervishes—made it not only desirable but necessary to take immediate action.

On March 14, 1896, Maj.-gen. Sir H. Kitchener, who had succeeded Sir Francis Grenfell as sirdar of the Egyptian army, received orders to reoccupy Akasha, 50m. S. of Sarras, and to carry the railway on there. Subsequent operations were to depend upon the amount of resistance he encountered. The advance to Akasha, occupied on March 20, was followed by and contributed to an easing of the pressure at Kassala, for Osman Digna took part of his investing force for an abortive move toward Suakin. Concentrating at Akasha on June 6 Kitchener moved to the attack of Firket 16m. away, where the amir Hamuda was encamped. The attack was made in two columns: one marching along the river-bank, approached Firket from the north; while the other making a detour through the desert, approached it from the south. The co-operation of the two columns was admirably timed, and on the morning of the 7th the dervish camp was surrounded, and, after a sharp fight half their force was destroyed and the rest dispersed. The dash and discipline of the Egyptian troops in this victory were a good augury for the future. The railway was then pushed forward to Kosha and in September Kitchener made a fresh spring. Dongola was bombarded by the gunboats and captured by the army on the 23rd. The pursuit was pressed until the dervish Dongola army had practically ceased to exist. With the province recovered for Egypt, the work of consolidation began, and preparations were made for a farther advance.

The railway up the right bank of the Nile was continued to Kerma, in order to evade the difficulties of the 3rd cataract; but the sirdar had conceived the bold project of cutting off the great angle of the Nile from Wadi Halfa to Abu Hamed, involving nearly 600m. of navigation and including the 4th cataract, by constructing a railway across the Nubian desert, and so bringing his base at Wadi Halfa within a few hours of his force, when it should have advanced to Abu Hamed, instead of ten days. Early in 1897 this new line of railway was commenced from Wadi Halfa across the great Nubian desert 230m. to Abu Hamed. By July it had advanced 130m. into the desert towards Abu Hamed, when it became necessary, before it was carried farther, to secure that terminus by an advance from Merawi.

In the meantime the khalifa was not idle. He brought to Omdurman the army of the west under Mahmud—some 10,000 men; entrusted the line of the Atbara to Osman Digna; constructed defences in the Shabluka gorge; and personally superintended the organization and drill of the forces gathered at Omdurman, and the collection of a vast reserve of supplies. On July 29 Maj.-gen. Hunter, with a flying column, marched up the Nile from near Merawi to Abu Hamed, 133m. distant. He arrived on Aug. 7 and captured it by storm. By the end of the month the gunboats had surmounted the 4th cataract and reached Abu Hamed. Berber was next occupied, and a reconnoitring raid made thence on Adarama. The railway reached Abu Hamed on Nov. 4, and was pushed rapidly forward along the right bank of the Nile towards Berber.

The forces of the khalifa remaining quiet, the sirdar visited Kassala and negotiated with the willing Italians for its restoration to Egypt. An Egyptian force from Suakin took it formally over on Christmas day 1897. On his return to Berber the sirdar received information of an intended advance of the khalifa northward. He at once ordered a concentration of Egyptian troops towards Berber, and telegraphed to Cairo for a British brigade. Disagreement among the khalifa's generals postponed the dervish advance and gave Kitchener much-needed time. But at the end of February, Mahmud crossed the Nile to Shendi with some 12,000 fighting men, and with Osman Digna advanced along the right bank of the Nile to Aliab, where he struck across the desert to Nakheila, on the Atbara, intending to turn Kitchener's left flank at Berber. The sirdar took up a position at Ras el Hudi, on the Atbara. His force consisted of Gatacre's British brigade and Hunter's Egyptian division, with cavalry, a camel corps and artillery. The dervish army reached Nakheila on March 20, and entrenched themselves. It was ascertained from prisoners that Mahmud's army

was short of provisions and Kitchener therefore did not hurry. He sent his flotilla up the Nile and captured Shendi, the dervish depôt, on March 27. On April 4 he advanced and, taking the precaution to construct a strong zariba on the night of the 7th he marched to the attack of Mahmud's zariba, which, after an hour's bombardment in the morning was stormed with complete success. Mahmud was captured with several hundred of his men, and 3,000 were killed. The sirdar lost 80 killed.

Preparations were now made for the attack on the khalifa's force at Omdurman, and the railway carried on to the Atbara. Reinforcements were forwarded from Cairo, including a second British brigade; and on Aug. 24 nearly 26,000 men were concentrated for the advance at Wad Hamad. Kitchener's advance up the west bank of the Nile met with no opposition; and on Sept. 1 the army bivouacked in zariba at Egeiga within four miles of Omdurman. Here, on the next morning the khalifa's army, 40,000 strong, attacked the zariba, but was repulsed. Kitchener then moved out and marched towards Omdurman, when he was again twice fiercely attacked on the right flank and rear, MacDonald's brigade bearing the brunt. MacDonald distinguished himself by his tactics, and completely repulsed the enemy. The 21st Lancers gallantly charged a body of 2,000 dervishes which was unexpectedly met in a khor on the left flank, and drove them westward. The khalifa was now in full retreat, and the sirdar, sending his cavalry in pursuit, marched into Omdurman. The dervish loss was over 10,000 killed, as many wounded, and 5,000 prisoners. The British and Egyptian casualties together were under 500. The European prisoners found in Omdurman were released and a short service held in memory of Gen. Gordon, near the place where he met his death.

The results of the battle of Omdurman were the practical destruction of the khalifa's army, the extinction of mahdism in the Sudan, and the recovery of nearly all the country formerly under Egyptian authority. The khalifa fled to Kordofan. The British troops were quickly sent down stream to Cairo, and the sirdar, shortly afterwards created Lord Kitchener of Khartoum, was free to turn his attention to restoring order in the country.

He had first, however, to deal with a serious development—the arrival of a French expedition at Fashoda, on the White Nile, some 600m. above Khartoum. He started for the south on Sept. 10 with five gunboats and a small force, and on the 19th arrived at Fashoda, to find the French Capt. Marchand, with 120 Senegalese soldiers, entrenched there and the French flag flying. He arranged with Marchand to leave the political question to be settled by diplomacy, and contented himself with hoisting the British and Egyptian flags to the south of the French flag, leaving a gunboat and a Sudanese battalion to guard them. The French expedition had experienced great difficulties on its way, and at Fashoda had been attacked by a dervish force on Aug. 25, and was anticipating another when Kitchener arrived and probably saved it from destruction. The Fashoda incident was the subject of important diplomatic negotiations, which at one time approached an acute phase; but ultimately the French position was found to be untenable, and on Dec. 11 Marchand and his men returned to France by the Sobat, Abyssinia and Jibuti. In the following March the spheres of interest of Great Britain and France in the Nile basin were defined by a declaration making an addition to Article IV. of the Niger convention of the previous year.

During the sirdar's absence from Omdurman Col. Hunter commanded an expedition up the Blue Nile, establishing garrisons, and Col. Parsons had marched with 1,400 men from Kassala to capture Gedaref. He encountered 4,000 dervishes outside the town, and after a desperate fight, defeated them. At Gedaref he was assailed by Ahmed Fedil, but the latter moved south on the approach of reinforcements, only to be caught and cut up in crossing the Blue Nile at Dakheila. Early in 1899 a reconnaissance in force under Col. Walter Kitchener was despatched against the khalifa, but found him strongly posted in Kordofan. However, towards the end of the year when, order having been established throughout the rest of the Sudan, it was decided to extend it to Kordofan.

A strong expedition in October failed to pin the khalifa, but next month a flying column of 3,700 men under Col. Wingate was concentrated at Faki Kohi. On reaching Gedid the khalifa was ascertained to be at Om Debreikat. Wingate marched at midnight of the 24th, and was resting his troops on high ground in front of the khalifa's position, when at daybreak the dervishes attacked. They were repulsed with great slaughter, and Wingate advancing, carried the camp. The khalifa, unable to rally his men, gathered many of his principal amirs around him, and they met their death unflinchingly from the bullets of the advancing Sudanese infantry. Three thousand men and 29 amirs of importance, including the khalifa's eldest son and intended successor, surrendered. The dervish loss in the two actions was estimated at 1,000 killed and wounded, while the Egyptian casualties were only 4 killed and 29 wounded. Thus ended the power of the khalifa and of mahdism.

On Jan. 19, 1900, Osman Digna, who had been so great a supporter of mahdism in the Eastern Sudan, and had always shown great discretion in securing the safety of his own person, was surrounded and captured among the hills beyond Tokar. The reconquest of Dongola and the Sudan provinces during the three years from March 1896 to Dec. 1898, considering the enormous extent and difficulties of the country, was achieved at an unprecedentedly small cost, while the main item of expenditure—the railway—has remained a permanent benefit to the country. The figures were:—

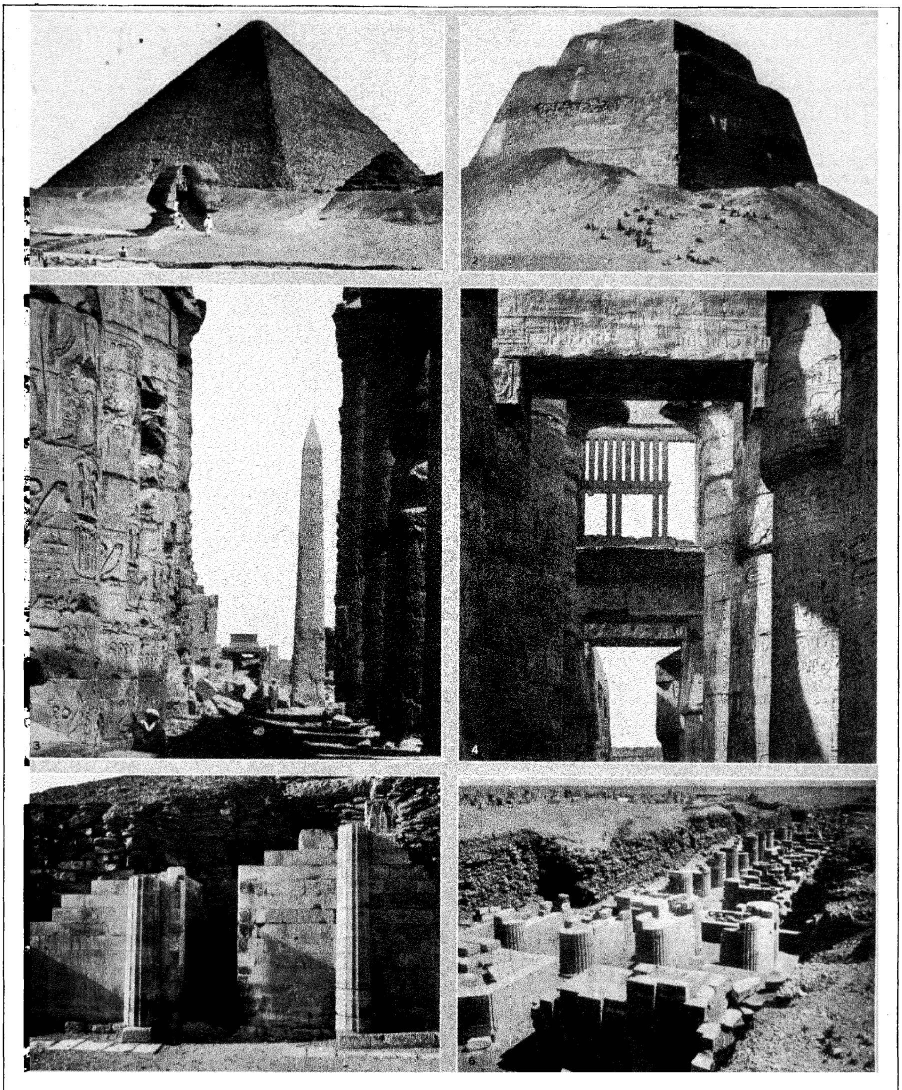
Railways	£E. 1,181,372
Telegraphs	21,825
Gunboats	154,934
Military	996,223
Total	£E. 2,354,354

Towards this expense the British Government gave a grant-in-aid of £800,000, and the balance was born by the Egyptian treasury. (X.)

EGYPTIAN ARCHITECTURE. The architecture of ancient Egypt is a primary contribution to world architecture. Its methods of construction were so essentially simple and its material for monumental work so imperishable, that its survival is unique. The modern designer has much to learn from the severity and grandeur of its masses, its treatments of broad planes and the sculpturesque qualities of its highest manifestations. Some of its monumental work was rock-cut, but most of it was built with enormous masses of stone or granite, set with the utmost nicety and care and worked to the finest possible surface. Egyptian architecture was perfectly suited to its natural environment—the sandy desert adjacent to the Nile. It was of the simplest possible form: the arch or vault was not used, except with crude brick, in subsidiary positions and constructed in a manner that produced the minimum of risk. It is clear, however, that the principle of the true arch was understood. There is no other instance in the world's history of a prevailing type of structure persisting, comparatively unchanged, for such a long period of time. Emerging, probably from the East, over 3,000 years before our era, its principal forms have stamped themselves indelibly on the consciousness of mankind. Even the dominance of Rome failed to make any permanent impression; and it was only when Rome ceased to exploit a province that had no political significance that these forms became extinct.

Pyramids and Mastabas.—The vast superstructures which the early kings erected to enclose their tombs are characteristically Egyptian. Though they belong more to engineering than architecture, there is no doubt about the impressiveness and grandeur of the largest examples. In the stepped pyramid of Medum, the result is truly architectonic. The slopes are so steep that they nearly resemble walls and have real monumental quality. At Sakkara, near Cairo, the oldest or stepped pyramid has a resemblance to the ziggurat form of Mesopotamia. Both forms though representing different ideals, are believed to be attempts to make mountains rise from plains. [1]The lower stage of the Medum pyramid is finished and the intention may have been one unbroken square cone. It is probable that the Sakkara pyra-

[1](W. R. Lethaby, quoting from Zeus, vol. iii., by A. B. Cook, in the *Builder* magazine, for April 6, 1928.)



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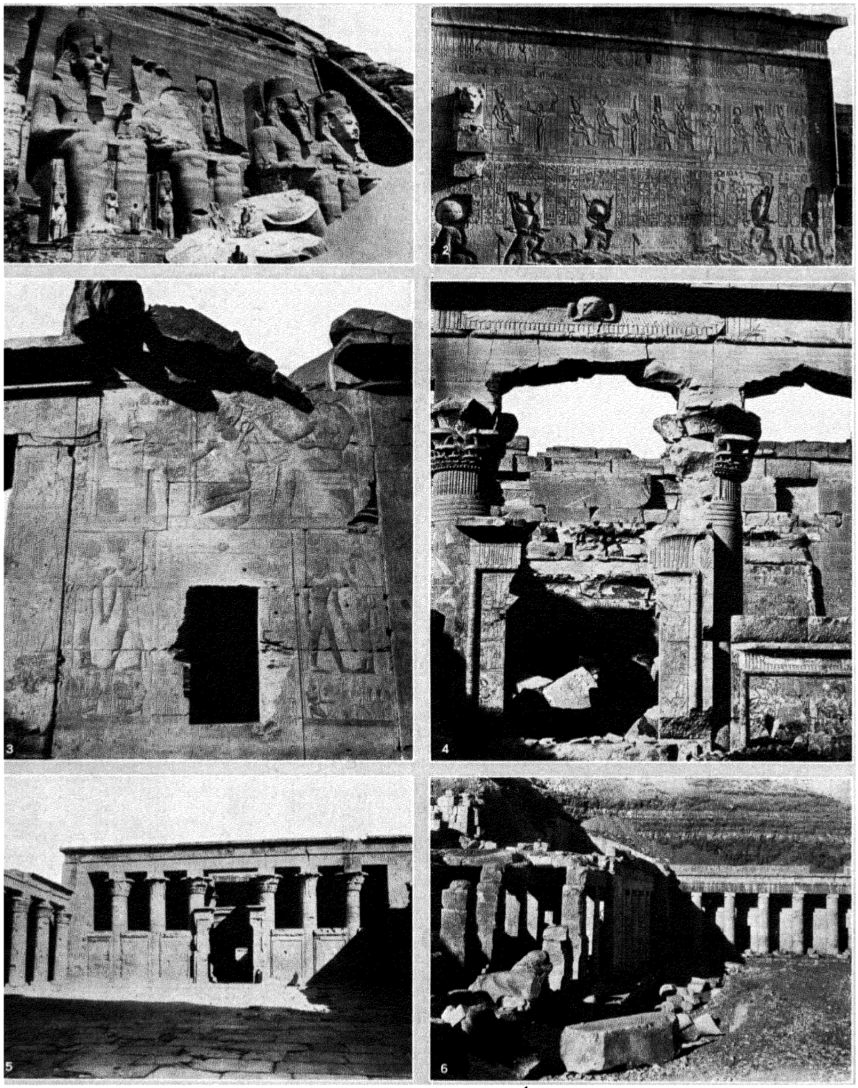
EXAMPLES OF EGYPTIAN ARCHITECTURE

1. Sphinx and Great Pyramid of Cheops at Gizeh 4th dynasty, *c.* 2900 B.C. 2. Pyramid of Medum, 40 m. south of Cairo. Built by Snefru, 3rd dynasty. 3. Great Temple of Amen Ra, Karnak, Middle Egypt, obelisk of Thotmes III. 4. Great Temple, Karnak, showing clerestory. Built by Seti I. and Rameses II. 5. Chapel, Sakkara, near Gizeh, 3rd dynasty, *c.* 3000 B.C. Fluted columns resemble Greek Doric. 6. Sakkara; colonnade at one end of pyramid enclosure, *c.* 3000 B.C.

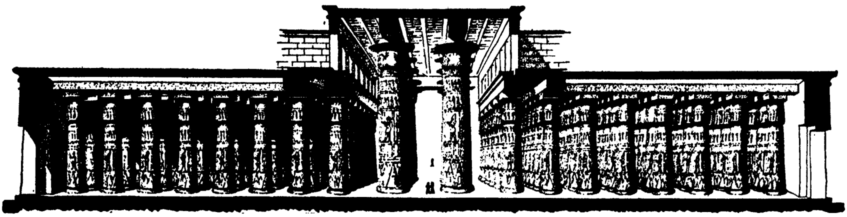
EGYPTIAN ARCHITECTURE



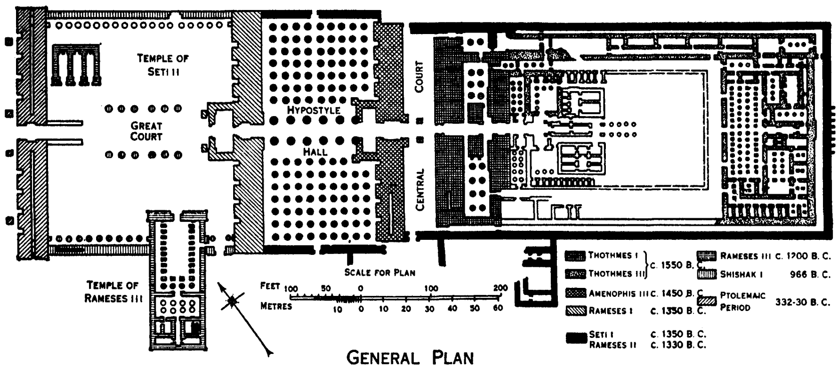
BY COURTESY OF (1, 2, 4, 5) THE TRUSTEES OF THE BRITISH MUSEUM, (3, 6) THE EGYPT EXPLORATION SOCIETY

DETAILS OF EGYPTIAN TEMPLES

1. Front of Great Temple, Abu Simbel, formed by Rameses II., *c.* 1270 B.C. 2. South wall, Temple of Hathor, Denderah, built by Cleopatra VI., 40 B.C. 3. Carvings and inscription on Temple of Seti I., at Abydos, *c.* 1300 B.C. 4. Temple, Kalabsheh, Upper Egypt. Capitals, Roman period, 1st century A.D. 5. Outer court of Great Temple, Edfu, completed 58 B.C. 6. Temple of Hatshepsut, Dair al-Bahri, Thebes; architect Senmut, *c.* 1500 B.C.



SECTIONAL VIEW OF HYPOSTYLE HALL



GENERAL PLAN OF THE GREAT TEMPLE

BY PERMISSION FROM SIR BANISTER FLETCHER, "HISTORY OF ARCHITECTURE ON THE COMPARATIVE METHOD," EIGHTH EDITION, 1928 (BATSFORD)

mid is unfinished and that the steps represent under-construction. It is clear that the pyramids at Ghizeh were finished with smooth limestone casing, which exists in places. The pure conical form is evident now from a distance, though the existing surfaces, for the most part, consist of rough steps of large size. The various passages and chambers in the interior of the great pyramid show amazing skill and ability in the handling of material. There is no parallel to work of this magnitude and finish at such an early age. Taking the most conservative estimate, it can hardly be later than 2900 B.C. The pyramids were, for the most part, the tombs of the kings of the fourth dynasty. Mastabas were built structures of rectangular form with sloping walls containing tomb chambers. Their lowness prevents them from being really impressive, but the mastaba is the earlier form for those of royal or noble rank. The stepped pyramid may be a succession of mastabas, one on the top of the other. The mastabas in the great cemeteries of Sakkara are important because of their internal decoration.

Rock-cut Tombs and Monuments.—In some rock-cut tombs of the 12th dynasty (*c.* 2000 B.C.) at Beni-Hassan, in Middle Egypt, pillars are finely used and some of the ceilings are curved. One of these tombs has a front with a strong resemblance—though on the surface only—to Greek Doric work of some 1,500 years later. The grandest expression of rock-cut treatment is that of the two 19th dynasty temples at Abu Simbel in Nubia, on the Upper Nile, which are both works of Rameses II., one of the greatest builders of all time. In the great temple the front is a sloping plane of sandstone rock relieved by four giant seated figures, 70 ft. high, as guardians, deeply cut out of the rock against a background which is nearly vertical. In the smaller temple, the natural slope, worked to a true surface, forms the front and the figures are deeply incised, forming long panels. The 18th dynasty temple of Queen Hatshepsut, at Deir-el-Bahari, Thebes, is also rock-cut, as the natural rock, rising to a great height out of the desert, forms a background to a long built front of piers carrying a continuous lintel treated with the utmost simplicity. As a result,

the architectural forms carry weight and seem part of the cliff face behind them: any ornament would have destroyed this effect. Complete balance is thereby secured by the great forecourt treatments of the approach, which very successfully counteract any crushing effect from the cliff by introducing an immense base area.

Temples.—The free standing temple is the ultimate expression of Egyptian form and is, in the truest sense, monumental. A great deal is made of the approach. An avenue formed by two rows of sphinxes facing inwards—and in one case 330 yd. long—is associated with an outer portal called the propylon. This feature consists of two towers with sloping walls, connected by a smaller gateway. Beyond this is the outer court of the temple proper which is enclosed by walls or colonnades. At the temple entrance is another pylon gateway, resembling the propylon in its treatment. The temple itself is a series of halls which gradually diminish in size and height until the inner sanctuary is reached; one main axial line controls the whole. The arrangement indicated is a typical one based on several examples of the 18th and 19th dynasties at Karnak, in Middle Egypt. The grandest part of this complete arrangement was its first or "hypostyle" hall, containing a forest of columns cut through by a central avenue of large columns on the main axis. The hypostyle hall of the great 19th dynasty temple at Karnak is one of the architectural achievements of the world. Substantial fragments of it remain but as all its roofing slabs have gone it is difficult to realize its true effect. Of tremendous scale, containing 134 columns, its internal dimensions are 329 ft. by 170 ft., while the columns of its central avenue are 70 ft. high. We have more complete knowledge about the lighting of this hall than we have about the lighting of any Greek temple. The extra height of the central avenue enabled a clerestory, or vertical arrangement of top lighting, to be formed. This consisted of large rectangular openings filled with pierced stone trellises, raised above the normal roof level. We see here distinct prototypes of the Roman basilicas and of the mediaeval cathedral churches which followed on from them.

The great temple at Edfu—which, though of "Ptolemaic" or Graeco-Roman times, contains all the unchanging elements of Egyptian architectural form—is very well preserved. The dignity of unbroken wall surface built to a slight slope and of immense mass in association with pylons in almost perfect preservation, can be seen there to perfection. The effect of the whole is rendered much more impressive by the all-over decoration of incised figures arranged in tiers. Taken as a whole, perhaps the most impressive building in Egypt at the present day is the 19th dynasty temple of Seti I. at Abydos, which is of peculiar plan, as its arrangement was dependent on nine shrines placed in a row, one of them dedicated to Seti himself. It is in a remarkable state of preservation and an adequate idea can be formed of the value of rooms of great size containing their ceilings, doorways and decorative treatments, almost intact. No building illustrates more clearly what Egyptian architectural form really meant in these comparatively simple elements of expression. It is a lesson in the use of form and in the richness that can be obtained by an all-over method of decorating with delicate relief and colour controlled by simple lines. These facts should give it peculiar value to modern designers and decorators. The Ptolemaic temple of Hathor at Denderah, though coarse in detail, is also a valuable example because of its completeness. This building practically exists now as it was built, so that the effect of a stone flat-roofed structure can be realized both externally and internally.

Columns, Pillars, Obelisks and Domestic Work.—Columns and pillars have an important function in all early styles and Egyptian architecture is no exception. The character of the Egyptian column was distinctive and peculiar in most of its many forms, persisting for some 3,000 years. It usually suggests natural growth, as a grouped collection of budding or flowering stalks, bound together at the base and near the top of the shaft; and it is decorated to enforce this suggestion. Circular columns discovered recently at Sakkara, by Firth, show a remarkable approximation to pure Greek Doric ones of the fifth century B.C.; and as the Egyptian ones are ascribed to the third dynasty and must have been executed about 3000 B.C., they are of great significance in the history of art. The pillar is essentially a square and not a round support. Plain square pillars can be seen in the "granite temple" at Ghizeh but many-sided ones, cut out of square, are more usual. This principle is sometimes carried so far that the effect of circular columns is obtained, as in the tomb at Beni Hassan, already cited. Some pillars at the temple of Seti I., Abydos, have shallow flutings, with a plain inscribed strip on each of the four cardinal faces. Egyptian pillars are more suggestive of Indian forms than of the Aegean or Greek ones. They often have fine sculpturesque quality and could be used appropriately in the concrete constructions of to-day.

The obelisk is an Egyptian form of commemorative pillar which has survived into Renaissance and modern times. It is akin to the inscribed pillars of the Sumerians in Chaldea and had, probably, some special religious significance. It is peculiarly suited to its surroundings as used in Egypt and has great monumental value in certain positions. The earliest examples date from the 11th dynasty. Senmut used obelisks in the temple at Deir el Bahari.

Domestic buildings have, of course, completely disappeared, but we know from painted representations that some of them were treated with great delicacy and fine decorative quality, suggestive of a kind of pole and curtain construction. There is a slight but graceful cornice of the prevailing type and, obviously, a flat roof. This form of structure may well have influenced Pompeian decoration.

Ornament.—It is customary to regard Egyptian building as destitute of any but the simplest mouldings; what is known as the "gorge"—or overhanging hollow moulding—with a plain roll member beneath it which was also carried down the external angles of the walls and doorways, being accepted as practically the only mouldings used. It is true that these, based on natural forms, were universal and were used for every kind of cornice and crowning member. Nevertheless, there is a considerable feeling of moulded form in many of the columns. Apart from mouldings the ornamental form of many of the spreading capitals is most pronounced and constitutes a definite emphasis which amounts, in places, to richness. Of other architectural enrichment there is really only one form but it is a most effective one—the winged solar disc, which was used over doorways and pylons in the hollow of the cornice.

Sculpture.—The sculpture of ancient Egypt is justly famous for its qualities of extreme simplicity and grandeur and some of the finest examples are truly architectonic. In this category are the maneless lions of red granite, now in the British Museum, belonging to the reign of Tutankhamen in the 18th dynasty. The nobility of animal form in repose has never been conveyed with greater truth and absence of superfluous detail. The seated figures at Abu Simbel are even more pronouncedly architectonic and show the same mastery. The celebrated sphinx, of doubtful date, near the pyramids of Ghizeh, is a colossal *tour-de-force* of sculpture, which, from its size, constitutes a monument; in a lesser degree the seated colossi of the Theban plain are in the same category. Less successful, because coarser in detail, are the pillared supports in the form of human figures in the Ramesseum at Thebes and the human-headed capitals with four faces from the Hathor columns in the temple at Denderah. The avenue of ram-headed sphinxes at Karnak is an example of emphasis by reiteration, and must have impressed those approaching the temple with a feeling of mystery and awe; but like all other things in Egyptian sculpture, they were rendered with monumental calm.

Surface Decoration.—If pronounced sculpture in the round was of considerable architectonic value, it was overshadowed in that respect by the relief sculpture and incised work which were the prevailing forms of wall decoration in all periods. To decorate walls with any completeness, there must be subject material and, like other races of the early world, the Egyptians were at no loss in this respect. With a thoroughness which has never been excelled, they carved on their wall surfaces the intricate systems connected with their worship of the dead as well as the ceremonies and observances of their life on earth. At its best, it is neither

sculpture nor painted decoration, but both of these combined. Nowhere is it seen to greater advantage than, as at Abydos, in the smooth limestone which was capable of taking the most delicate relief. In the dry climate of Egypt, parts of the painted finish seem as fresh to-day as when they were executed. The method is one of incision as well as relief in which the grades of sharpness in definition were treated with amazing skill. Even in granite this system prevailed, combined with the simpler incised work of symbols and hieroglyphics, the schematic material being grouped by means of incised lines and delicate bands. The decoration travels round doorways and enhances their value by a skillful arrangement of shallow panels emphasizing posts and lintels. Nothing could be more complete and, in its way, more successful. The Hindu decorated by serried ranks of figures in relief; the Assyrian by delicate reliefs in fine stone or alabaster; the Greek by a restrained scheme of friezes; but nothing at once so comprehensive and so architectonic as the finest Egyptian decoration has ever been produced. It is an all-over principle which even includes columns without interfering with their sense of structural stability.

At a certain brief period in Egyptian art—that of the ill-fated Akhenaton (Ikhnaton, *q.v.*) of the 18th dynasty—an extraordinary development in painted plaster decoration occurred, which was contemporary with and doubtless influenced by somewhat similar work in late Minoan Crete. The floors of Akhenaton's palace at Tel-el-Amarna were covered with this plaster, for the most part representing Nilotic plants and birds arranged in large panels with an astonishing richness and variety of detail. *See* EGYPT, ART AND ARCHAEOLOGY.

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EGYPTIAN LANGUAGE. The documents for the history of the Egyptian language begin with the primitive inscriptions of the 1st dynasty (not later than 3,300 B.C.) and end with the latest Coptic compositions of about the 14th century A.D. The bulk of the hieroglyphic inscriptions are written in a more or less artificial literary language; but in business documents, letters, popular tales, etc., the scribes often approached more closely to the living form of the tongue, and thus reveal its progressive changes. The stages of the language may be distinguished as follows:

Old Egyptian.—In this, the language of the Old Kingdom, we have (*a*) inscriptions of the 1st dynasty, too brief and concise to throw much light on the language of that time; and the great collections of spells and ritual texts found inscribed in the Pyramids of the 5th and 6th dynasties, which must even then have been of high antiquity, though they contain later additions made in the same style; (*b*) a few historical texts and an abundance of short inscriptions representing the language of the 4th, 5th and 6th dynasties. The ordinary *literary language* of the later monuments, sometimes termed classical or Middle Egyptian, is modelled on Old-Middle Egyptian, but often much affected by contemporary speech.

Middle and New Egyptian.—These represent the vulgar speech of the Middle and New Kingdoms respectively. The former is found chiefly in tales, letters, etc., written in hieratic on papyri of the 13th dynasty to the end of the Middle Kingdom; also in some inscriptions of the 18th dynasty. New Egyptian is seen in hieratic papyri from the end of the 18th to the 21st dynasties. The spelling of New Egyptian is full of false etymologies, otiose signs, etc., the old orthography being quite unable to adapt itself neatly to the profoundly modified language; nevertheless, this clumsy spelling is expressive, and the very mistakes are instructive as to the pronunciation.

Demotic (*q.v.*).—Demotic Egyptian seems to represent approximately the vulgar speech of the Saite period during which the demotic writing was formed. With progressive changes, this form of the language is found in documents reaching down to the fall of paganism in the 4th century A.D. and a century longer at Philae.

Coptic (*q.v.*).—This was the vulgar speech of about the 3rd-5th centuries and was written in Greek characters; several dialects being easily distinguished in it.

The above stages of the Egyptian language are not abruptly defined. Progress is traceable from dynasty to dynasty or from century to century but the gap between Middle Egyptian and Old Egyptian is wide. New Egyptian shades off almost imperceptibly into demotic, and gaps which now exist in the development may be filled by further discovery. Coptic is the only stage of the language in which the spelling gives a clear idea of the pronunciation. It is therefore the mainstay of the scholar in investigating or restoring the word-forms of the ancient language. Greek transcriptions of Egyptian names and words are valuable as evidence for the vocalization of Egyptian. Such are found from the 6th century B.C. in the inscription of Abu Simbel, from the 5th in Herodotus, etc., and abound in Ptolemaic and later documents from the beginning of the 3rd century B.C. onwards. At first sight they may seem inaccurate, but on closer examination the Graecizing is seen to follow definite rules, especially in the Ptolemaic period. Aramaic transcriptions of the 4th and 5th centuries B.C., and earlier ones in biblical Hebrew, are very useful for revealing the true condition of the consonantal skeletons of words, but cuneiform gives us valuable examples of vocalization as early as the 25th, 19th and 18th dynasties reaching to the 15th century B.C.

It must not be supposed that the pronunciation of Old Egyptian can be restored from Coptic. In the latter speech, Old Egyptian verbal forms are mostly replaced by periphrases; though the strong roots are often preserved entire, the weaker consonants and the *y* have largely or entirely disappeared, so that the language appears as one of biliteral rather than triliteral roots. Coptic is strongly impregnated with Greek words adopted late; moreover, a certain number of Semitic loan-words flowed into Egyptian at all ages, and especially from the 16th century B.C. onwards, displacing earlier words. Demotic grammar ought soon to be thoroughly comprehensible in its forms, and the study of Late Egyptian should not stand far behind that of demotic. On the other hand, Middle Egyptian, and still more Old Egyptian, which is separated from Middle Egyptian by a wide gap, will perhaps always be to us little more than consonantal skeletons, the flesh and blood of their vocalization being for the most part irretrievably lost.

In common with the Semitic languages, the Berber languages of North Africa, and the Cushite language of north-east Africa, Egyptian of all periods possesses grammatical gender, expressing masculine and feminine. Remarkable resemblances have been observed in the grammatical structure of the Berber and Cushite groups with Semitic (*cf.* H. Zimmern,, *Vergleichende Grammatik d. semitischen Sprachen,* Berlin, 1898, especially pronouns and verbs). Their connection with Semitic and Egyptian remains at present an obscure though probable hypothesis. On the other hand, Egyptian in its oldest form is clearly related to Semitic. In it triliteral roots enormously preponderate; the roots consist of consonants and semi-consonants only, inflexion being effected by internal vowel change and the addition of certain consonants or vowels at the beginning or end. In the verb there is a precise analogue of the Semitic perfect. In nouns the feminine is formed by the addition of *t*, the adjective by the addition of *y*, instrumental nouns and some others (participial, etc.) by prefixing *m*, and both numerals and personal pronouns show obvious relationship. Although the vocabularies in general are widely different, Egyptian either was originally a characteristic member of the Semitic family of languages, greatly modified in its African surroundings or was the result of fusion between an African and a Semitic tongue or tongues.

The verb in the earliest known form of Egyptian had displaced the Semitic imperfect, and the perfect largely by new suffix-tenses derived from a participle with pronoun such as *sdm-f* "hearing he (is)," = "he hears," *sdm n-f* "heard (is) to him" = he has heard. The few forms were past and present but with all the vagueness of the Semitic forms and more. Coptic presents a remarkable contrast to Egyptian in the preciseness of its periphrastic conjugation. There are two present tenses, an imperfect, two perfects, a pluperfect; a present and three futures besides future per-

fect; there are also conjunctive and optative forms. The negatives of some of these are expressed by special prefixes. The gradual growth of these new forms can be traced through all the stages of Egyptian. Throughout the history of the language we note an increasing tendency to periphrasis; but there was no great advance towards *precision* before demotic. In demotic there are distinguishable a present tense, imperfect, perfect, frequentative, future, future perfect, conjunctive and optative; also present, past and future negative, etc. The passive was extinct before demotic; demotic and Coptic express it by an impersonal "they" *e.g.*, "they struck him" stands for "he was struck."

In other departments besides the verb, the Egyptian language was far better adapted to practical ends during and after the period of the Deltaic dynasties (22nd–30th) than before. It was both simplified and enriched. The inflections rapidly disappeared and little was left of the distinctions between masculine and feminine, singular, dual and plural—except in the pronouns. The dual number had been given up entirely at an earlier date. The pronouns, both personal and demonstrative, retained their forms very fully. As prefixes, suffixes and articles, they, together with some auxiliary verbs, provided the principal mechanism of the renovated language. An abundant supply of useful adverbs was gradually accumulated, as well as conjunctions, so far as the functions of the latter were not already performed by the verbal prefixes. These improvements in the language correspond to the constant intercourse of all classes of Egyptians with foreigners from Europe and Asia. Probably the best stage of Egyptian speech was that which immediately preceded Coptic. Though Coptic is here and there more exactly expressive than the best demotic, it was spoilt by too much Greek, duplicating and too often expelling native expressions that were already adequate for its very simple requirements; moreover, it is clumsily pleonastic.

See HIEROGLYPHICS. For modern Egyptian literature *see* ARABIC LITERATURE.

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EHRENBERG, CHRISTIAN GOTTFRIED (1795–1876), German naturalist, was born at Delitzsch in Saxony on April 19, 1795. After studying at Leipzig and Berlin, where he took the degree of doctor of medicine in 1818, he was appointed professor of medicine in the university of Berlin (1827). Meanwhile in 1820 he was engaged in a scientific exploration conducted by General von Minutoli in Egypt. They travelled in the Libyan desert, the Nile valley and the northern coasts of the Red Sea, and subsequently in Syria, Arabia and Abyssinia. Some results of these travels and of the important collections that had been made were reported on by Humboldt in 1826; and afterwards Ehrenberg produced *Symbolae physicae* (2 vols. 1828–1834), in which many particulars of the mammals, birds, insects, etc., were made public. In 1829 he accompanied Humboldt through eastern Russia to the Chinese frontier. On his return he undertook microscopical researches of the infusorial earths used for polishing and other economic purposes; and of the microscopic organisms of chalk formations, and of the modern marine and freshwater accumulations. Ehrenberg showed that considerable masses of rock were composed of minute forms of animals or plants. He demonstrated also that marine phosphorescence was due to organisms. He died in Berlin on June 27, 1876.

He wrote also *Die Infusionsthierchen als vollkommene Organismen* (2 vols., Leipzig, 1838); *Mikrogeologie* (2 vols., Leipzig, 1854); and "Fortsetzung der mikrogeologischen Studien," in *Abhandl. der k. Akad. der Wissenschaft* (1875). *See* Lane, *Christian Gottfried Ehrenberg, ein Vertreter deutscher Naturforschung* (1895).

EHRENBREITSTEIN, a town of Germany, in the Prussian Rhine province, on the right bank of the Rhine, facing Coblenz, with which it is connected by a railway bridge and a bridge of boats, on the main line of railway Frankfort-on-Main-Cologne. Pop. (1925) 2,925. Above the town, facing the mouth of the Mosel, on a rock 400 ft. high, lies the magnificent fortress of Ehrenbreitstein. The sides towards the Rhine and the south and south-east are precipitous, and the south side, on which is the winding approach, is strongly defended. The central fort or citadel is flanked by a double line of works with three tiers of casemate batteries. The works towards the north and north-east end in a separate outlying fort. The site of the castle is said to have been occupied by a Roman fort built in the time of the emperor Julian. In the 11th century the castle was held by a noble named Erembert, from whom it is said to have derived its name. In the 12th century it came into the possession of Archbishop Hillin (de Fallemagne) of Trier, who strengthened the defences in 1153. These were again extended by Archbishop Henry II. (de Fénétrange) in 1286, and by Archbishop John II. of Baden in 1481. In 1631 it was surrendered by the archbishop elector Philip Christopher von Soetern to the French, but was recovered by the Imperialists in 1637 and given to the archbishop elector of Cologne. It was restored to the elector of Trier in 1650, but was not strongly fortified until 1672. Between this date and 1815, the castle suffered many vicissitudes; it afterwards was reconstructed.

EHRENFELS, CHRISTIAN FREIHERR VON (1859–), Austrian philosopher, was born on June 20, 1859, at Rodaun. Since 1896 he has been professor at Prague. The influence of Brentano and Meinong is apparent in his *System der Werttheorie*, 2 vols. (1897–98) and *Grundbegriffe der Ethik* (1907). His *Sexualethik* (1907) was followed by other works on sex problems. Ehrenfels was also the author of three dramas: *Mélusine* (1887), the allegorical *Hildegard* (1895) and *Der Kampf des Prometheus* (1895).

EHRLICH, PAUL (1854–1915), German bacteriologist, was born in Silesia of Jewish parentage. He studied medicine and was early drawn to research on aniline dyes, at the same time winning distinction as a bacteriologist. In 1907 he discovered the dye, known as "trypan red," which, when injected into the blood of animals infected with trypanosomes effected the destruction of these organisms. This led him to try to treat other diseases by chemical injections and culminated in his famous discovery in connection with venereal diseases. It was announced in 1910 that he had prepared an arsenical compound, known as salvarsan or "606," which was a cure for syphilis. The name was given because it was the 606th compound that he had tried for the purpose. Ehrlich also did important work on problems of immunity. In 1908 he shared with Metchnikov the Nobel prize for medicine.

See *Paul Ehrlich: eine Darstellung seines wissenschaftlichen Wirkens* (1914).

EHUD, in the Old Testament, a "judge" who delivered Israel from the Moabites (Judges iii. 12–30), by assassinating Eglon, king of Moab, and raising the tribe of Ephraim to seize and hold the fords against the fleeing Moabite garrisons. He is called the son of Gera, a Benjamite, but since Gera and Ehud are tribal names, it has been supposed that this notice is not original. *See* further BENJAMIN, JUDGES.

EIBENSTOCK, a town of Germany, in the republic of Saxony, near the Mulde, on the borders of Bohemia, 17 m. by rail S.S.E. of Zwickau. Pop. (1925) 9,210. It is a principal seat of the tambour embroidery, introduced in 1775 by Clara Angermann, and possesses manufactories of curtains, lace and pasteboard, and tin and iron works. It has also a large cattle market. Eibenstock, together with Schwarzenberg, was acquired by purchase in 1533 by Saxony and was granted municipal rights in 1534.

EICHENDORFF, JOSEPH, FREIHERR VON (1788–1857), German poet and romance-writer, was born at Lubowitz, near Ratibor, in Silesia, on March 10, 1788. He studied law at Halle and Heidelberg from 1805 to 1808. After a visit to Paris he went to Vienna, where he resided until 1813, when he joined the Prussian army as a volunteer in the famous Lützow corps. In 1816 he was appointed to a judicial office at Breslau. He subsequently held similar offices at Danzig, Königsberg and Berlin. Retiring from the public service in 1844, he lived successively in Danzig, Vienna, Dresden and Berlin. He died at Neisse on Nov. 26, 1857. Eichendorff was one of the most distinguished of the later members of the German romantic school. His genius was essentially lyrical. Thus he is most successful in his shorter romances and dramas, where constructive power is in least demand. His first work, written in 1811, was a romance, *Ahnung und Gegenwart*

(1815). This was followed at short intervals by others, the most famous of which is the delightful *Aus dem Leben eines Taugenichts* (1826), which has often been reprinted. Of his dramas may be mentioned *Ezzelin von Romano* (1828), and *Der letzte Held von Marienburg* (1830), both tragedies, and a comedy, *Die Freier* (1833). He also translated several of Calderon's religious dramas (*Geistliche Schauspiele,* 2 vols. 1846–52). It is, however, through his lyrics (*Gedichte,* first collected 1837) that Eichendorff is best known. He is perhaps the greatest lyric poet of the second phase of the Romantic movement. No one has given more beautiful expression than he to the poetry of a wandering life; often, again, his lyrics are exquisite word pictures interpreting the mystic meaning of the moods of nature, as in *Nachts,* or the mystery which haunts the twilight forests and feudal castles of Germany, as in the dramatic lyric *Waldesgespräch* or *Auf einer Burg.* Many of his verses were set to music by Schubert and Schumann.

In his later years Eichendorff published several works on literary history and criticism.

Eichendorff's *Sämtliche Werke* appeared in 6 vols. (1864); a critical edition is that by W. Kosch and A. Sauer (1911 etc.). C. H. von Eichendorff's biographical introduction to the *Sämtliche Werke;* also H. Keiter, *Joseph von Eichendorff* (Cologne, 1887); H. Brandenburg (*Joseph von Eichendorff, sein Leben und sein Schaffen* [Munich 1922]).

EICHHORN, HERMANN VON (1848–1918), German field-marshal, was born at Breslau on Feb. 13, 1848. He took part as a young officer, in the campaigns of 1866 and 1870–71. In 1913 he was appointed inspector-general of the VII. Army inspection at Saarbrucken. At the outbreak of the World War he was incapacitated by an accident, but took part in the battle of Soissons in Jan. 1915. In that month he was appointed to the command of the X. Army, which fought in the battle of the Masurian lakes in February. In August he took Kovno and afterwards the fortresses of Grodno and Olita, and continued his victorious advance into Russia. From 1916 to 1918 Eichhorn was in command of the army group known by his name in Courland. In Dec. 1917 he was raised to the rank of general field-marshal and sent to the Ukraine as chief-in-command of the German troops on the eastern front. He was assassinated at Kiev on July 30, 1918.

EICHHORN, JOHANN GOTTFRIED (1752–1827), German theologian, was born at Dörrenzimmern on Oct. 16, 1752. Eichhorn has been called "the founder of modern Old Testament criticism." He first properly recognized its scope and problems. It was Eichhorn's conclusion that "most of the writings of the Hebrews have passed through several hands," and took for granted that all the so-called supernatural facts relating to the Old and New Testaments were explicable on natural principles. He estimated them from the standpoint of the ancient world, and by the superstitious beliefs which were then generally in vogue, and did not perceive in them any religious ideas of much importance for modern times. He regarded many books of the Old Testament as spurious, questioned the genuineness of 2 *Peter* and *Jude,* denied the Pauline authorship of *Timothy* and *Titus,* and suggested that the canonical gospels were based upon various translations and editions of a primary Aramaic gospel.

His principal works were—*Geschichte des Ostindischen Handels vor Mohammed* (Gotha, 1775); *Allgemeine Bibliothek der biblischen Literatur* (10 vols., Leipzig, 1787–1801); *Einleitung in das Alte Testament* (3 vols., Leipzig, 1780–83); *Einleitung in das Neue Testament* (1804–12); *Einleitung in die apokryphischen Bücher des Alten Testaments* (Gött., 1795); *Commentarius in apocalypsin Joannis* (2 vols., Gött., 1791); *Die Hebr. Propheten* (3 vols., Gött., 1816–19); *Allgemeine Geschichte der Cultur und Literatur des neuern Europa* (2 vols., Gött., 1796–99); *Literärgeschichte* (2 vols., Gött., 1799–1814); *Geschichte der Literatur von ihrem Anfange bis auf die neuesten Zeiten* (5 vols., Gött., 1805–12); *Übersicht der Französischen Revolution* (2 vols., Gött., 1797); *Weltgeschichte* (3rd ed., 5 vols., Gött., 1819–20); *Geschichte der drei letzten Jahrhunderte* (3rd ed., 6 vols., Hanover, 1817–18); *Urgeschichte des erlauchten Hauses der Welfen* (Hanover, 1817).

See R. W. Mackay, *The Tübingen School and its Antecedents* (1863); O. Pfleiderer, *Development of Theology* (1890), T. K. Cheyne, *Founders of Old Testament Criticism* (1893).

EICHHORN, KARL FRIEDRICH (1781–1854), German jurist, son of the preceding, born at Jena on Nov. 20, 1781, was professor of law at Frankfurt-on-Oder, Berlin, and Göttingen successively. He died at Cologne on July 4, 1854. Eichhorn is regarded as one of the principal authorities on German constitutional law. His chief work is *Deutsche Staats- und Rechtsgeschichte* (Göttingen, 1808–1823, 5th ed. 1843–1844). In company with Savigny and J. F. L. Göschen he founded the *Zeitschrift für geschichtliche Rechtswissenschaft.*

See Schulte, *Karl Friedrich Eichhorn, sein Leben und Wirken* (1884).

EICHSTÄTT, a town and episcopal see of Germany, in the republic of Bavaria; in the valley of the Altmühl, 35 m. S. of Nuremberg, on the railway to Ingolstadt and Munich. Pop. (1925) 8,006. The cathedral of St. Wilibald (first bishop of Eichstätt), —with the tomb of the saint and numerous pictures and relics,— the church of St. Walpurgis, sister of Wilibald, whose remains rest in the choir, and the Capuchin church, a copy of the Holy Sepulchre are the chief churches. Of its secular buildings the most noticeable are the town hall and the Leuchtenberg palace, once the residence of the prince bishops and later of the dukes of Leuchtenberg (now occupied by the court of justice of the district). The Wilibaldsburg, built on a neighbouring hill in the 14th century by Bishop Bertold of Hohenzollern, was long the residence of the prince bishops of Eichstätt, and now contains an historical museum. The industries of the town include bootmaking, brewing and the production of lithographic stones.

Eichstätt (Lat. *Aureatum* or *Rubilocus*) was originally a Roman station which, after the foundation of the bishopric by Boniface in 745, developed considerably and was walled in 908. The bishops of Eichstätt were princes of the Empire, under the archbishops of Mainz, and ruled over large territories in the Circle of Franconia. In 1802 the see was secularized and incorporated in Bavaria. In 1817 it was given, with the duchy of Leuchtenberg, as a mediatized domain under the Bavarian crown, by the king of Bavaria to his son-in-law Eugène de Beauharnais, ex-viceroy of Italy, henceforth styled duke of Leuchtenberg. In 1855 it reverted to the Bavarian crown.

EICHWALD, KARL EDUARD VON (1795–1876), Russian geologist and physician, was born at Mitau, Courland, on July 4, 1795. He became doctor of medicine and professor of zoology in Kazan in 1823; four years later professor of zoology and comparative anatomy at Vilna; in 1838 professor of zoology, mineralogy and medicine at St. Petersburg; and finally professor of palaeontology in the institute of mines in that city. He travelled much in the Russian empire. He died at St. Petersburg on Nov. 10, 1876. His published works include *Reise auf dem Caspischen Meere und in den Caucasus,* 2 vols. (Stuttgart and Tübingen, 1834–1838); *Die Urwelt Russlands* (St. Petersburg, 1840–1845); *Lethaea Rossica, ou paléontologie de la Russie,* 3 vols. (Stuttgart, 1852–1868), with Atlases.

EIDER, a river of north Germany in Schleswig-Holstein. It rises to the south of Kiel, in Lake Redder, flows first northward, nearly as far as Kiel, then bends westward and flows across the low peninsula in a sluggish, winding course of about 117 m. Tönning stands at the head of its long shallow estuary. It is navigable up to Rendsburg, and is embanked through the marshes across which it runs in its lower course. Since the reign of Charlemagne, the Eider (originally *Ägyr Dör*—Neptune's gate) was known as *Romani terminus imperii* and was recognized as the boundary of the Empire in 1027 by the emperor Conrad II., the founder of the Salian dynasty. In the controversy arising out of the Schleswig-Holstein question, which culminated in the war of Austria and Prussia against Denmark in 1864, the Eider gave its name to the "Eider Danes," the *intransigeant* Danish party which maintained that Schleswig (Sønderjylland, South Jutland) was by nature and historical tradition an integral part of Denmark. The Eider canal (*Eider-Kanal*), which was constructed between 1777 and 1784, leaves the Eider at the point where the river turns to the west and enters the Bay of Kiel at Holtenau. It was hampered by six sluices, but was used annually by some 4,000 vessels, and until its conversion in 1887–95 into the Kaiser Wilhelm canal afforded the only direct connection between the North sea and the Baltic. (*See* KIEL CANAL.)

EIDER, *Somateria mollissima*, a large marine duck, famous for its down. The common eider nests on low rocky islets near the coast, and in Iceland and Norway has long been afforded every encouragement and protection. Despite its clumsy appearance, the eider flies fast and dives admirably. The male in breeding dress is velvet-black beneath and white above. In the "eclipse" plumage, he resembles the female, which is dark reddish-brown, barred with black. The nest is lined with the down from the mother's breast and contains a variable number of eggs. By removing both down and eggs at intervals of a few days, the owners of the "eider-fold" make the birds deposit both during the whole season, though they are careful to allow every bird to hatch a clutch of eggs ultimately. The eider breeds from the Farne Islands to Spitzbergen. When the female is disturbed at the nest, she trails off in front of the intruder as if wounded. In America the allied *S. dresseri* nests from the coasts of Newfoundland northwards and also in Greenland; north of the Danish settlements there, however, it is replaced by the king-eider (*S. spectabilis*), a very beautiful bird which also nests in Spitzbergen. On the west coast of North America occur *S. v-nigra* and two other eiders, the spectacled eider and steller's eider, the last a bird of the high Arctic and sub-Arctic coasts of the northern hemisphere. The extinct Labrador duck (*S. labradoria*) also belongs to this group.

EIDETIC IMAGES are subjective visual phenomena which assume a perceptual character and which resemble negative or positive after-images in that they are "seen" in the literal sense of the word. An eidetic individual is not only able to *imagine* an absent object but also to *see* it, either when he closes his eyes or looks at some surface which serves as convenient background for his eidetic image. An object may be eidetically seen either immediately after it has been removed from sight or after a considerable period of time (minutes, days, years) has elapsed since the removal; there are also spontaneous eidetic images. As regards form, colour, size, position in space, richness of details and other characteristics, the eidetic image may, in various ways, differ from the object which it represents. The individual who possesses eidetic images, *i.e.*, "images of hallucinatory clearness," is in general a "normal and healthy" person; in other words, most hallucinations, pseudo-hallucinations and related phenomena are not to be referred to as eidetic images, although clinically it may be difficult to distinguish between the two. Urbantschitsch's investigations (1907) suggested a pathological basis for eidetic phenomena. O. Kroh (1917) discovered that eidetic images were frequently found in normal children. E. R. Jaensch's experiments brought out the fact that eidetic images are distinctly different from negative after-images and memory-images although their behaviour is in many respects similar. In fact, E. R. Jaensch asserts that eidetic images represent two extremes; they are either pronounced after-images or *visible* memory-images. Jaensch also maintains that most individuals during childhood pass through an eidetic "phase." The frequency of the eidetic disposition, however, varies considerably in different geographic regions. In certain regions 80–100% of the children are reported eidetic. The experimental work as done by the Marburg school has led to the conclusion that the presence of eidetic imagery in an eidetic individual implies the existence of closely correlated "typical" characteristics in his physical make-up in the perceptions, after-images and memory-images of this individual, and in his intellectual and emotional life. Thus the eidetic type is a biotype, *i.e.*, a definite "psychophysical reaction system." W. Jaensch assumes two eidetic subtypes: the T-type (referring to tetany) and the B-type (referring to Basedow's syndrome).

Eidetic images exist in many individuals and they can be subjected to laboratory methods. Aside from Germany, experimental work on the eidetic disposition has been done in England (G. W. Allport), France (Quercy), Italy (Kiesow) and in different regions of the United States (Klüver). Phenomena corresponding to eidetic images in the visual field are supposed to exist in other sense-fields as well. H. Henning maintains that images do not exist at all in the field of the lower senses. Here all past sensory experiences are revived eidetically.

See E. R. Jaensch: *Die Eidetik* (Leipzig, 1925); E. R. Jaensch and others, *Ueber den Aufbau der Wahrnehmungswelt* (Leipzig, 1927); H. Klüver, "Studies on the Eidetic Type and on Eidetic Imagery," *Psychol. Bull.*, No. 25 (1928). (H. Kl.)

EIFEL, a district of Germany, between the Rhine, the Moselle and the frontier of Luxemburg. It is a hilly region, most elevated in the eastern part (Hohe Eifel), where there are several points above 2,000 ft. above sea-level. In the west is the Schneifels; and the southern part, where the most picturesque scenery and chief geological interest is found is called the Vorder Eifel.

The Eifel is an ancient massif of folded Devonian rocks and upon its margins, near Hillesheim and towards Bitburg and Trier, Triassic sandstones, marls and limestones rest unconformably. On the southern border, at Wittlich, terrestrial deposits of the Permian Rothliegende also occur. Lower Devonian slates and sandstones form the greater part of the region; but folded amongst these, in troughs running from south-west to north-east lie the Middle Devonian fossiliferous limestones, and occasionally, *e.g.*, near Büdesheim, small patches of Upper Devonian. Upon these peneplaned Devonian strata stand numerous small volcanic cones of Tertiary age, many of which, though now extinct, are still very perfect in form. Emission of carbon dioxide and heated waters still occurs in many places. The eruptions probably ceased in Quaternary times for the lavas of Papenkaule are clearly posterior to the excavation of the valley of the Kyll, and a lava flow has forced the Uess to seek a new course. The volcanic rocks occur both as tuffs and as lava-flows. They are chiefly leucite and nepheline rocks, such as leucitite, leucitophyre and nephelinite, but basalt and trachyte also occur. The leucite lavas of Niedermendig contain haüyne in abundance. The most extensive and continuous area of volcanic rocks is that surrounding Laacher See and extending eastwards to Neuwied and Coblenz and even beyond the Rhine.

The numerous so-called crater-lakes or *maare* present several features of interest. They do not, as a rule, lie in true craters at the summit of cones, but rather in hollows formed by explosions. The most remarkable group is that of Daun, where the three depressions of Gemünd, Weinfeld and Schalkenmehren have been hollowed out in Lower Devonian strata. The first of these shows no sign of either lavas or scoriae, but volcanic rocks occur on the margins of the other two. The two largest lakes in the Eifel region, however, are Laacher See and Pulvermaar.

EIGHT HOURS DAY: *see* Hours of Labour.

EILDON HILLS, three conical volcanic hills in Roxburghshire, Scotland, 1 m. S. by E. of Melrose. They were once known as Eldune—the *Eldunum* of Simeon of Durham (*fl.* 1130)—probably from the Gaelic *aill*, "rock," and *dun*, "hill"; or a corruption of the Cymric *moeldun*, "bald hill." The northern peak is 1,327 ft. high, the central 1,385 ft. and the southern 1,216 ft. According to General William Roy (1726–1790) the Roman station of Trimontium—so called, according to this theory, from the triple Eildon heights—was Old Melrose; other authorities incline to place the station on the northern shore of Solway Firth. The Eildons have been the subject of much legendary lore. The Eildon Tree Stone, a large moss-covered boulder, lying on the high road as it bends towards the west within 2 m. of Melrose, marks the spot where the Fairy Queen led Thomas of Erceldoune into her realms in the heart of the hills.

EILENBURG, a town of Germany, in the Prussian province of Saxony, on an island formed by the Mulde, 31 m. E. from Halle, at the junction of the railways Halle-Cottbus and Leipzig-Eilenburg. Pop. (1925) 18,156. The industries of the town include the manufacture of chemicals, cotton, cigars, celluloid and agricultural implements, etc., and trade in cattle. In the neighbourhood is the iron foundry of Erwinhof. The castle (Ilburg) is mentioned in records of the reigns of Henry the Fowler as an important outpost against the Sorbs and Wends. The town itself, originally called Mildenau, is of great antiquity. It is first mentioned as a town in 981, when it belonged to the house of Wettin and was the chief town of the East Mark. In 1386 it was incorporated in the margraviate of Meissen. In 1815 it passed to Prussia.

EINBECK or **EIMBECK,** a town of Germany, in the Prussian province of Hanover, on the Ilm, 50 m. by rail S. of Hanover. Pop. (1925) 9,683. It is an old-fashioned town with many quaint old wooden houses, notable among them the "Northeimhaus." The industries include brewing, weaving and horsehair-spinning, and the manufacture of cycles, carpets, sugar, chemicals and soap.

Einbeck grew up round the monastery of St. Alexander (founded 1080), famous for its relic of the True Blood. It is first recorded as a town in 1274, and in the 14th century was the seat of the princes of Grubenhagen, a branch of the ducal house of Brunswick. The town later joined the Hanseatic League. In the 15th century it became famous for its beer ("Eimbecker"). In 1540 the Reformation was introduced by Duke Philip of Brunswick-Saltzderhelden (d. 1551), with the death of whose son Philip II. (1596) the Grubenhagen line became extinct.

EINDHOVEN, in the province of North Brabant, Holland, and a railway junction 8 m. W. by S. of Helmond. Pop. (1900) 4,730; (1927) 65,888. Like Tilburg and Helmond it has developed into a flourishing industrial centre, with textile, tobacco and radio factories. It is the centre of the electric bulb industry.

EINHARD (*c.* 770–840), the friend and biographer of Charlemagne. He is also called Einhartus, Ainhardus or Heinhardus, in early manuscripts, and in 10th century mss. Agenardus, Eginhardus, or Eginhartus.

According to the statement of Walafrid Strabo, Einhard was born of a noble family in the Main valley. His birth has been fixed at about 770. He was educated in the monastery of Fulda, where he was certainly residing in 788 and in 791. He was transferred, not later than 796, from Fulda to the palace of Charlemagne by abbot Baugulf, and soon rose in the emperor's service. He was one of the palace scholars, and was entrusted with the charge of the public buildings, receiving the name of Bezaleel (Exodus xxxi. 2 and xxxv. 30–35) owing to his artistic skill. He also supervised the erection of the palace buildings at Aix, and in 806 was sent by Charlemagne on a mission to Rome. When Louis became sole emperor in 814 he retained his father's minister, made him tutor to his son, Lothair, afterwards the emperor Lothair I., and showed him many other marks of favour. Einhard married Emma, or Imma, a sister of Bernharius, bishop of Worms, and a tradition of the 12th century represented this lady as a daughter of Charlemagne, inventing a romantic story for which there is no foundation. In 815 Louis I. bestowed on Einhard and his wife the domains of Michelstadt and Mulinheim in the Odenwald, and in a document of the same year, he is referred to as abbot. After this time he is mentioned as head of several monasteries. In 818 he had given his estate at Michelstadt to the abbey of Lorsch, but he retained Mulinheim, where *c.* 827 he founded an abbey and erected a church, where he deposited some relics of St. Peter and St. Marcellinus, which he had procured from Rome. To Mulinheim, afterwards called Seligenstadt, he finally retired in 830. He died on March 14, 840, his epitaph being written by Hrabanus Maurus. Einhard was a man of very short stature, a feature on which Alcuin wrote an epigram. He was on intimate terms with Alcuin, was well versed in Latin literature, and knew some Greek.

His most famous work is his *Vita Karoli Magni,* to which a prologue was added by Walafrid Strabo. Written in imitation of the *De vitis Caesarum* of Suetonius, this is the best contemporary account of the life of Charlemagne, being written by one who was intimate with the emperor and his court. It is an admirably simple and direct narrative; its only fault is that it is too brief. It was written before 821, and was first printed at Cologne in 1521. Other works by Einhard are: *Epistolae,* important for the history of the times: *Historia translationis beatorum Christi martyrum Marcellini et Petri,* which gives a curious account of how the bones of these martyrs were stolen and conveyed to Seligenstadt, and what miracles they wrought; and *De adoranda cruce.* It has been asserted that Einhard was the author of some of the Frankish annals, and especially of part of the annals of Lorsch (*Annales Laurissenses majores*), and part of the annals of Fulda (*Annales Fuldenses*).

Editions of his works are by A. Teulet, *Einhardi omnia quae extant opera* (Paris, 1840–43), with a French translation; P. Jaffé, in the *Bibliotheca rerum Germanicarum,* Band iv. (Berlin, 1867); G. H. Pertz in the *Monumenta Germaniae historica* (Hanover, 1826 *seq.*), and J. P. Migne in the *Patrologia Latina,* tomes 97 and 104 (Paris, 1866). The *De adoranda cruce* was first published by E. Dümmler in the *Neues Archiv der Gesellschaft für ältere deutsche Geschichtskunde,* Band xi. (Hanover, 1886). There are Eng. translations of the *Life of Charlemagne* by A. J. Grant in the King's Classics Series (1905) and by H. W. Garrod (1915), of the *Letters* by H. Prebel 1913, and of the *Hist. of the Translation of . . . Marcellinus and Peter* by B. Wendell (1926). *See* A. Potthast, *Bibliotheca historica* (Berlin, 1896), W. Wattenbach, *Deutschlands Geschichtsquellen,* Band i. (Berlin, 1904) and M. Buchner, *Einhards Künstler- und Gelehrtenleben* (Bonn, 1922).

EINHORN, DAVID (1809–1879), leader of the Jewish reform movement in the United States of America, was born in Bavaria. He was a supporter of the principles of Abraham Geiger (*q.v.*), and while still in Germany advocated the introduction of prayers in the vernacular, the exclusion of nationalistic hopes from the synagogue service, and other ritual modifications. In 1855 he migrated to America, where he became the acknowledged leader of reform, and laid the foundation of the régime under which the mass of American Jews (excepting the newly arrived Russians) now worship. In 1858 he published his revised prayer book, which has formed the model for all subsequent revisions. In 1861 he strongly supported the anti-slavery party, and was forced to leave Baltimore where he then ministered. He continued his work first in Philadelphia and later in New York. (I. A.)

EINSIEDELN, the most populous town in the Swiss canton of Schwyz, on the right bank of the Alpbach (an affluent of the Sihl). It is 2,908 ft. above sea-level, and 25 m. S.E. of Zürich. It communicates directly with Schwyz over the Hacken pass (4,649 ft.) or the Holzegg pass (4,616 ft.). In 1920 the population was 8,228, all (save 99) Romanists and (save 60) German-speaking. The town is dependent on the Benedictine abbey that rises slightly above it to the east. The abbey was founded about 934, on the site of a hermit's cell. In 1274 the reigning abbot was made a prince of the Holy Roman Empire. Originally under the protection of the counts of Rapperswil (to which town on the lake of Zürich the old pilgrims' way still leads over the Etzel pass, 3,146 ft., with its chapel and inn), this position passed by marriage in 1295 to the Laufenburg Habsburgs, but from 1386 was permanently occupied by Schwyz. Throngs of pilgrims resorted to Einsiedeln in the middle ages. The existing buildings date from the 18th century and the treasury and library contain many precious objects, despite the sack by the French in 1798. Zwingli was the parish priest of Einsiedeln 1516–18, while near the town Paracelsus (1493–1541) was born.

EINSTEIN, ALBERT (1879–), German-Swiss physicist, was born of Jewish parents at Ulm, Württemberg, May 14, 1879. His boyhood was spent at Munich where his father, who owned electro-technical works, had settled. The family migrated to Italy in 1894, whilst Albert Einstein went to a cantonal school at Aarau in Switzerland. He attended lectures while supporting himself by teaching mathematics and physics at the polytechnic school at Zürich until 1900 and finally, after a year as tutor at Schaffhausen, was appointed examiner of patents at the patent office at Berne, where, having become a Swiss citizen, he remained until 1909. It was during this period that he took his Ph.D. degree at the University of Zürich and published his first papers on physical subjects. These were so highly thought of that in 1909 he was appointed extraordinary professor of theoretical physics at the University of Zürich. In 1911 he accepted the chair of physics in Prague, only to be induced to return to his own polytechnic school at Zürich as full professor in the following year. In 1913 his pre-eminence had become so evident that a special position was created for him in Berlin, director of the Kaiser-Wilhelm Physical Institute. He was elected a member of the Royal Prussian Academy of Sciences and given a stipend sufficient to enable him to devote all his time to research without any restrictions or routine duties. He was elected a foreign member of the Royal Society in 1921, having also been made previously a member of the Amsterdam and Copenhagen Academies, while the universities of Geneva, Manchester, Rostock and Princeton conferred honorary degrees on him. In 1925 he

received the Copley Medal of the Royal Society and in 1926 the gold medal of the Royal Astronomical Society in recognition of his theory of relativity. He received a Nobel Prize in 1921.

Einstein's work is so important and has proved fertile in so many various branches of physics that it is not possible to do more than enumerate a few of the most salient papers. The work by which he is best known, the theory of relativity, was begun in 1905 with the publication of the restricted principle with its consequences (*see* RELATIVITY; SPACE-TIME). Though considered fantastic by many, it had secured fairly general acceptance in Germany in 1912. The restricted theory was followed by the generalized theory in 1915. But Einstein's work has been by no means confined to such abstract questions. One of his earliest publications gave the complete theory and formulae of the phenomenon known as Brownian motion, which had puzzled physicists for nearly 80 years. Sooner, probably, than anybody else he realized the far-reaching implications of the theory propounded by Planck, and Einstein spent much of his time on the problems which could be explained by the quantum theory. A series of papers in 1905, 1906, 1909 and 1911 developed his "light-quantum" hypothesis which assumes that radiation when propagated has a "quantum-like" structure. In dealing with the transformation of these light quanta Einstein developed his Law of the Photoelectric effect. His paper on the variation of the specific heat with temperature, which appeared in 1907, was the first extension of Planck's fundamental hypothesis, and its verification in essentials is one of the most convincing arguments in its favour. In 1917 Einstein published a paper in which he deduced the Law of Radiation using the generalized Bohr atom instead of Planck's linear oscillator. Numerous other papers on molecular physics, including an experimental research on magnetism, appeared in the *Proceedings* of the Russian Academy of Science, the *Physikalische Zeitschrift*, the Proceedings of the German Physical Society, the *Annalen der Physik*, and elsewhere. In this *Encyclopædia* he has written the article SPACE-TIME.

In 1929 Einstein published two short papers on what he terms a unified field theory which represents an attempt to find a mathematical expression of formal simplicity to represent comprehensively the laws of gravitation and electro-magnetism.

EINTHOVEN, WILLEM (1860–1927), Dutch physiologist, was born on May 22, 1860, at Samarang, in Java, and was educated at Utrecht under Donders. In 1885 he was made professor of physiology at Leyden, where he remained until his death, on Sept. 29, 1927. In 1924 he was awarded the Nobel prize for physiology and medicine for his discovery of the mechanism of the electro-cardiogram. He was also renowned for his application of the string-galvanometer in the investigation of the mechanism of the electrical phenomena of the human heart.

EISENACH, a town of Germany, in Thuringia; lies at the north-west foot of the Thuringian forest, at the confluence of the Nesse and Hörsel, 32 m. by rail W. from Erfurt. Pop. (1925) 43,869. Interesting buildings include the formal ducal palace built in 1742; the late-Gothic St. Georgenkirche; the Nikolaikirche, built about 1150 and restored in 1887; the Klemda, a small castle dating from 1260; the Lutherhaus, in which the reformer stayed with the Cotta family in 1498; the house in which Sebastian Bach was born, and that (now a museum) in which Fritz Reuter lived (1863–1874). Eisenach has a school of forestry, a school of design, a Gymnasium containing the Thuringian museum and a Wagner museum. The most important industries of the town are worsted-spinning, carriage and wagon building, and the making of colours and pottery. Among others are the manufacture of cigars, cement pipes, iron-ware and machines, alabaster ware, shoes, leather, etc., cabinet-making, brewing, granite quarrying and working.

The natural beauty of the district attracts summer visitors. Magnificently situated on a precipitous hill, 600 ft. above the town to the south, is the historic Wartburg (*q.v.*), the ancient castle of the landgraves of Thuringia, famous as the scene of the contest of Minnesingers immortalized in Wagner's Tannhäuser, and as the place where Luther, on his return from the diet of Worms in 1521, was kept in hiding and made his translation of the Bible.

Eisenach (*Isenacum*) was founded in 1070 by Louis II. the Springer, landgrave of Thuringia. The Klemda, mentioned above, was built by Sophia (d. 1284), daughter of the landgrave Louis IV., and wife of Duke Henry II. of Brabant, to defend the town against Henry III., margrave of Meissen, during the succession contest that followed the extinction of the male line of the Thuringian landgraves in 1247. The principality of Eisenach fell to the Saxon house of Wettin in 1440, and in the partition of 1485 formed part of the territories given to the Ernestine line. It was a separate Saxon duchy from 1596 to 1638, from 1640 to 1644, and again from 1662 to 1741, when it finally fell to Saxe-Weimar. The town of Eisenach, by reason of its associations, has been a favourite centre for religious propaganda.

EISENBERG (*Isenberg*), a town of Germany, in the republic of Thuringia on a plateau between the rivers Saale and Elster 20 m. S.W. from Zeitz. Pop. (1925) 11,304. It possesses an old castle and several churches. Its principal industries are metal working and the manufacture of machines, photographic plates, toys, ovens, furniture, pianos, porcelain and sausages.

EISENERZ, an old mining town in Styria, Austria. It lies in a deep valley, tributary to that of the Enns and is dominated by imposing peaks, one of which, the Erzberg (5,030 ft.), to the south is connected with the town by a rack railway which descends to Vordernberg on the south side of the Erzberg. On this mountain is quarried in the summer months the rich iron ore to which the town owes its prosperity. Nearly one million tons of ore, with a 35 per cent iron content, are raised annually, part of this output being handled in the iron and steel foundries of Vordernberg and Eisenerz. The Gothic church of St. Oswald, founded in the 13th century and rebuilt in the 16th, is an interesting example of a mediaeval fortified church. Pop. (1920) 8,600.

EISENSTEIN, FERDINAND GOTTHOLD (1823–1852), German mathematician, was born in Berlin on April 16, 1823. He was educated at Berlin university, where he became *privatdozent*, subsequently professor of mathematics. He was the author of a number of papers published in *Crelle's Journal* on the theory of numbers and elliptic functions (*q.v.*). In his memoir, *Neue Theoreme der höheren Arithmetik* Eisenstein developed the theory of complex numbers (*q.v.*). He extended the work of Gauss in ternary quadratic forms from two to three indeterminates. He only dealt with cases of an uneven determinant; his results were extended later by Henry Smith to cases of an even determinant. Eisenstein dealt with the theory of binary quadratic forms and discovered the first covariant used in analysis. He discussed doubly infinite products using analytical methods, this was used later by Weierstrass in representing some of his functions. In his work on the representation of numbers by sums of squares, Eisenstein showed that the general theorem was limited to eight squares; he gave the solutions for three and five squares; this work was extended later by Henry Smith.

Eisenstein was a member of the Berlin academy. He died in Berlin on Oct. 11, 1852.

EISLEBEN, a town of Germany, in the Prussian province of Saxony, 24 m. W. by N. from Halle. Pop. (1925) 23,758. The earliest record of Eisleben (Lat. *Islebia*) is dated 974. In 1045, at which time it belonged to the counts of Mansfield, it received the right to hold markets, coin money, and levy tolls. In the 18th century, Eisleben fell to Saxony, and, in the partition of Saxony by the congress of Vienna in 1815, was assigned to Prussia. It is divided into an old and a new town (Alstadt and Neustadt). The church of St. Peter and St. Paul (Peter-Paulkirche), contains the font in which Luther was baptized; the royal gymnasium (classical school), was founded by Luther shortly before his death in 1546. The house in which Luther was born was burned in 1689, but was rebuilt in 1693 as a free school for orphans. This school fell into decay, but was restored in 1817 by King Frederick William III. of Prussia, who, in 1819, transferred it to a new building behind the old house. The house in which Luther died was restored towards the end of the 19th century, and his death chamber is still preserved. In the neighbour-

hood potash is obtained and manufactures include machinery, furniture and cigars. It is also a centre for plant breeding.

EISLER, RUDOLF (1873–), German philosopher, was born on Jan. 7, 1873, at Vienna, and was educated at Leipzig, where he continued to reside. The influence of Kant and the 19th century idealistic thinkers, and the spiritualistic dynamism of his metaphysics colour his works, the chief of which are: *De Weiterbildung der Kantschen Aprioritätslehre* (1895); *Grundlagen der Phil. des Geisteslebens* (1908); *Geschichte des Monismus* (1910); *Geist und Körper* (1912; 2nd ed., 1925); *Der Zweck* (1924). Eisler has also translated various philosophical works and compiled *Wörterbuch der philos. Begriffe* (1899; 4th ed., 1927); *Philosophen-lexicon* (1912) and *Handwörterbuch der Philosophie* (1913; 2nd ed., 1922).

EISNER, KURT (1867–1919), Bavarian politician and writer, was born in Berlin on May 14, 1867. He became a journalist, and was frequently imprisoned because of the socialist tendency of his writings. He was successively on the editorial staff of *Vorwärts* in Berlin (1898–1905) and of socialist newspapers at Nuremberg and Munich. After the outbreak of the World War he turned against his old allies, the Social Democrats, and attacked them for supporting the war. Convicted of treason in Jan. 1918, he was released on account of his candidature for the Reichstag, and was in time to organize the mass meeting which was held at Munich on Nov. 7, 1918, and resulted in the overthrow of the Bavarian monarchy. A Bavarian revolutionary and socialist government, with Eisner as its president, was established. He was opposed to the re-establishment of the federal system of the German Reich and to the election of a National Constituent Assembly. His revelations regarding Germany's responsibility for the War increased his unpopularity with the Bavarian reactionaries; and on his way to open the Bavarian assembly on Feb. 21, 1919, he was shot dead in the street by Count Arco-Vally. Among Eisner's various written works are *Psychopathia Spiritualis* (1892); *Eine Junkerrevolte* (1899); *Wilhelm Liebknecht* (1900); *Feste der Festlosen* (1903); and *Die Neue Zeit* (1919). His works were published in collected form in 1919.

EISTEDDFOD (īs-tĕ*th*′vŏd), (plural Eisteddfodau), the national bardic congress of Wales, which seeks to encourage bardism and music and the general literature of the Welsh, to maintain the Welsh language and customs of the country, and to foster and cultivate a patriotic spirit amongst the people. This institution, so peculiar to Wales, is of very ancient origin, the *Gorsedd* or assembly, an essential part of the modern Eisteddfod, being as old at least as the time of Prydain the son of Aedd the Great, who lived many centuries before the Christian era. The term *Eisteddfod*, however, which means "a session" or "sitting," was probably not applied to bardic congresses before the 12th century.

The Eisteddfod in its present character appears to have originated in the time of Owain ap Maxen Wledig, who at the close of the 4th century was elected to the chief sovereignty of the Britons on the departure of the Romans. It was at this time, or soon afterwards, that the laws and usages of the Gorsedd were codified and remodelled, and its motto of "Y gwir yn erbyn y byd" (The truth against the world) given to it. "Chairs" (with which the Eisteddfod as a national institution is now inseparably connected) were also established, or rather, perhaps, resuscitated, about the same time. The chair was a kind of convention where disciples were trained, and bardic matters discussed preparatory to the great Gorsedd, each chair having a distinctive motto.

The first Eisteddfod of which any account seems to have descended to us was one held on the banks of the Conway in the 6th century, under the auspices of Maelgwn Gwynedd, prince of North Wales. Maelgwn, on this occasion, in order to prove the superiority of vocal song over instrumental music, is recorded to have offered a reward to such bards and minstrels as should swim over the Conway.

Griffith ap Cynan, prince of North Wales, who had been born in Ireland, brought with him from that country many Irish musicians, who greatly improved the music of Wales. During his long reign of 56 years he offered great encouragement to bards, harpers and minstrels, and framed a code of laws for their better regulation. He held an Eisteddfod about the beginning of the 12th century at Caerwys in Flintshire, "to which there repaired all the musicians of Wales, and some also from England and Scotland." For many years afterwards the Eisteddfod appears to have been held triennially, and to have enforced the rigid observance of the enactments of Griffith ap Cynan. The places at which it was generally held were Aberffraw, formerly the royal seat of the princes of North Wales; Dynevor, the royal castle of the princes of South Wales; and Mathrafal, the royal palace of the princes of Powys; and in later times Caerwys in Flintshire received that honourable distinction, it having been the princely residence of Llewelyn the Last.

On the annexation of Wales to England, Edward I. deemed it politic to sanction the bardic Eisteddfod by his famous statute of Rhuddlan, and the meetings continued to be held, in many cases by royal mandate, till towards the end of the 17th century, after which for a considerable period—some 130 years—they fell into abeyance. At the close of the Napoleonic wars, however, there was a general revival of Welsh national feeling bringing about their resumption and they have been held annually, almost without intermission, ever since.

To constitute a provincial Eisteddfod it is necessary that it should be proclaimed by a graduated bard of a Gorsedd a year and a day before it takes place. A local one may be held without such a proclamation. A provincial Eisteddfod generally lasts three, sometimes four, days. A president and a conductor are appointed for each day. The proceedings commence with a Gorsedd meeting opened with sound of trumpet and other ceremonies, at which candidates come forward and receive bardic degrees after satisfying the presiding bard as to their fitness. At the subsequent meetings the president gives a brief address; the bards follow with poetical addresses, adjudications are made, and prizes and medals with suitable devices are given to the successful competitors for poetical, musical and prose compositions, for the best choral and solo singing, and singing with the harp or "Pennillion singing" as it is called, for the best playing on the harp or stringed or wind instruments, as well as occasionally for the best specimens of handicraft and art. In the evening of each day a concert is given, generally attended by very large numbers. The great day of the Eisteddfod is the "chair" day—usually the third or last day—the grand event of the Eisteddfod being the adjudication on the chair subject, and the chairing and investiture of the fortunate winner. This is the highest object of a Welsh bard's ambition. The ceremony is an imposing one, and is performed with sound of trumpet. (*See* also the articles BARD; CELT: *Celtic Literature;* and WALES.) (R. W.; X.)

EITNER, ROBERT (1832–1905), German composer and music historian, was born at Breslau on Oct. 22, 1832. He published a number of musical compositions, notably *Cantata pour la Pentecôte*, *Judith*, an opera, *Stabat Mater* and *Ouvorture du Cid.* In 1863 he established a music school in Berlin. It is as an historian of music, however, that he is best known, and among his important publications were *Verzeichnis Neuer Ausgaben alter Musikwerke* (1871); *Bibliographie der Musiksammelwerke des 16. und 17. Jahrhunderts* (1877); and *Biographisch-bibliographisches Quellenlexikon der Musiker und Musikgelehrten bis zur Mitte des 19. Jahrhundert* (10 vol., 1900–04). He died in Templin on Feb. 2, 1905.

EITZ, CARL A. (1848–1924), German teacher of music, was born at Wehrstedt on June 25, 1848. He is the inventor of a system of teaching elementary singing by syllabic notation, which he has named the *Tonwortmethode*. Opinion is divided as to the value of this method, but it has been put into practice by Eitz's adherents in Bavaria and in Prussia (1922) and is finding many new supporters. The principles of the system are set forth in *Bausteine zum Schulgesangunterricht im Sinne der Tonwortmethode* (Leipzig, 1911) and in *Teaching of Singing as Foundation of Musical Education* (Leipzig, 1914). He died at Eisleben on Apr. 18, 1924.

See G. Borchers, *C. Eitz* (Würzburg, 1908); O. Messmer, *C. Eitz, Tonwortmethode* (Würzburg, 1911); F. Bennedik, *Historical, Psychological and Musical Investigations in relation to the Eitz-Tonwort Method* (Langensalza, 1914).

EJECT, a term introduced by Clifford (in *Seeing and Thinking*) and adopted by Romanes and others, for the conception that another self is in the first instance apprehended in terms of one's own self, which is ejected, as it were, into another body (Latin *eiectum*, something thrown out). The conception has also been employed in connection with animism and anthropomorphism.

EJECTMENT, in English law, an action for the recovery of the possession of land, together with damages for the wrongful withholding thereof. In the old classifications of actions, as real or personal, this was known as a mixed action, because its object was twofold, viz., to recover both the realty and personal damages. It should be noted that the term "ejectment" applies in law to distinct classes of proceedings—ejectments as between rival claimants to land, and ejectments as between those who hold, or have held, the relation of landlord and tenant. Real and mixed actions were abolished in 1833. The action of ejectment has now been assimilated (under the name of action for the recovery of land) to ordinary actions by the rules of the supreme court, but is subject to one special rule, viz. that except by leave of the court or a judge the only claims which may be joined with one for recovery of land are claims in respect of arrears of rent or double value for holding over, or mesne profits (*i.e.*, the value of the land during the period of the illegal possession), or damages for breach of a contract under which the premises are held or for any wrong or injury to the premises claimed (R.S.C., O. xviii. r. 2).

Where an action to recover land is brought against the tenant by a person claiming adversely to the landlord, the tenant is bound, under penalty of forfeiting the value of three years' improved or rack rent of the premises, to give notice to the landlord in order that he may appear and defend his title (Law of Property Act, 1925, s. 145). A landlord can recover possession in the county court (i.) by an action for the recovery of possession, where neither the value of the premises nor the rent exceeds £100 a year, and the tenant is holding over (County Courts Acts of 1888, s. 138, and 1903, s. 3); (ii.) by "an action of ejectment," where (*a*) the value or rent of the premises does not exceed £100, (*b*) half a year's rent is in arrear, and (*c*) no sufficient distress (*see* RENT) is to be found on the premises. Where a tenant at a rent not exceeding £20 a year of premises at will, or for a term not exceeding seven years, refuses or neglects, on the determination or expiration of his interest, to deliver up possession, such possession may be recovered by proceedings before justices under the Small Tenements Recovery Act, 1838. (*See* also the Housing Act, 1925, s. 13, and article HOUSING.) Under the Distress for Rent Act, 1737, and the Deserted Tenements Act, 1817, a landlord could have himself put by the order of two justices into premises deserted by the tenant where half a year's rent was owing and no sufficient distress could be found. The Courts (Emergency Powers) Acts, 1914–16, imposed temporary restriction on the recovery of premises during the World War. Under the Increase of Rent and Mortgage Interest (Restriction) Acts, 1920–25, landlords of dwelling houses to which those acts applied were prevented during their continuance from effectually raising the rents of such dwelling houses above specified limits, and except in certain cases from recovering possession thereof on the termination of the tenancy. (*See* LANDLORD AND TENANT; RENT.)

An insured person in receipt of sickness benefit may be protected against proceedings in ejectment on the certificate of the medical practitioner attending him that the taking of such proceedings would endanger his life. Every such certificate continues in force for a week but may be renewed for similar periods up to, but not beyond, the expiration of three months; but proper security for payment of rent must be found, if demanded, within a month. (National Health Insurance Act, 1924, s. 102.)

In *Ireland,* the practice with regard to the recovery of land resembled that of England. Possession might be recovered summarily by a special endorsement of the writ, as in England; and there were analogous provisions with regard to the recovery of small tenements (*see* Land Act, 1860, ss. 84 and 89). The law with regard to the ejectment or eviction of tenants was consolidated by the Land Act, 1860. (*See* ss. 52–66, 68–71, and further under IRELAND; LANDLORD AND TENANT.)

In *Scotland,* the recovery of land is effected by an action of "removing" or summary ejection. In the case of a tenant, "warning" is necessary unless he is bound by his lease to remove without warning. In the case of possessors without title, or a title merely precarious, no warning is needed. A summary process of removing from small holdings is provided for by the Sheriff Courts (Scotland) Act, 1907, s. 38, and as to actions of removing within the ordinary jurisdiction of the sheriff's court *see* ss. 34, 37.

In *French law* the landlord's claim for rent is fairly secured by the hypothec, and by summary powers which exist for the seizure of the effects of defaulting tenants. Eviction or annulment of a lease can only be obtained through the judicial tribunals. The Civil Code deals with the position of a tenant in case of the sale of the property leased. If the lease is by authentic act (*acte authentique*) or has an ascertained date, the purchaser cannot evict the tenant unless a right to do so was reserved on the lease (art. 1743), and then only on payment of an indemnity (arts. 1744–47). If the lease is not by authentic act, or has not an ascertained date, the purchaser is not liable for indemnity (art. 1750). The tenant of rural lands is bound to give the landlord notice of acts of usurpation (art. 1768). There are analogous provisions in the Civil Codes of Belgium (arts. 1743 *et seq.*) and Holland (arts. 1613, 1614), and see the German Civil Code (arts. 535 *et seq.*). In many of the colonies there are statutory provisions for the recovery of land or premises on the lines of English law. (Cf. Ontario, Rev. Stats. 1897, *c.* 170, ss. 19 *et seq.;* Manitoba, Rev. Stats. 1902, *c.* 1903).

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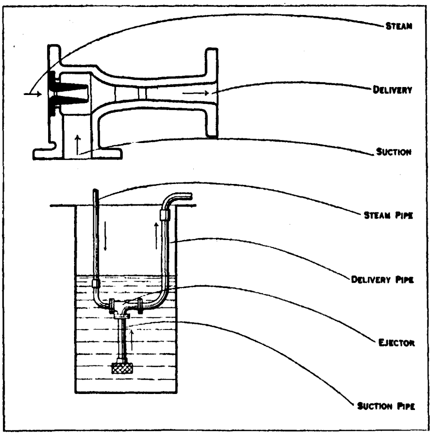
In the *United States* the action of ejectment retains its essential common law character, namely that the action is a possessory one for the recovery of corporeal hereditaments. The procedure for maintaining the action has largely been modified by statute, the fictitious proceedings of the common law being generally abolished. The purpose of the action is to determine the legal right to possession, a determination of which may or may not involve the question of legal title. The plaintiff may also in the action of ejectment recover damages for the wrongful use and occupation of the property. Ejectment lies only for property interests of which possession can be given, that is, corporeal hereditaments. It will not, therefore, lie for an easement or a right of way. A lessee may maintain ejectment to recover possession of a term of years. The general principle governing maintenance of the action is that the plaintiff may recover only upon the strength of his title and not upon the weakness of his adversary's. Ordinarily the plaintiff's right of entry must be based upon a legal claim but many States have extended the scope of the action to permit recovery upon an equitable title as against the holder of a bare legal title where the equitable title is coupled with a right to possession. (J. M. LA.)

EJECTOR. An apparatus which moves air, liquids, and loose materials such as sand, cinders, gravel, liquid clay and chemicals, by the eductive force of steam or compressed air. Inlets are arranged for the steam and the suction, and the former rushing along at high speed draws the air or other element with it. A simple form of ejector and its mode of piping to force water out of a pit or tank are shown in the figure. The draining of wells, foundations, quarries, and the emptying of ships' bilges and ballast tanks lie within the scope of an ejector.

The vacuum brake is operated with the help of an ejector on the engine, steam being admitted around the cones and passing through the ejector barrel at great velocity; this action withdraws the air from the train-pipe and cylinders. This type really combines two ejectors in the body, a small one that works continually to maintain the vacuum, and a large one for rapid production of the vacuum. Another type, for securing economy in

steam consumption against greatly varied working conditions of trains of different classes, has two small ejectors, one or both being used to keep the vacuum up, the large ejector still being employed for rapid working.

Other sorts of ejectors are those in which compressed air is applied to the surface of a liquid, as in the Shone apparatus (*see* AIRLIFT), and the air-ejector employed in connection with



DIAGRAMS SHOWING (ABOVE) AN EJECTOR FOR LIFTING OR FORCING LIQUIDS BY USE OF STEAM, AND (BELOW) AN EJECTOR ARRANGED FOR FORCING WATER OUT OF A PIT

The ejector works by the suction of the steam rushing along at high velocity. In the vacuum-brake system the train pipe is cleared of air by an ejector on the engine

a condenser (*q.v.*) One type of condenser used in conjunction with steam engines is the ejector condenser. Sometimes water is fed in large volumes by the eductive action of a high-pressure jet of water. Mechanical ejectors include those in revolvers and guns which abstract the cartridge-case, and devices which push punched or stamped articles out of the dies in power-presses, when they cannot fall away by gravity. Air-ejection is adopted in some cases, a blast of compressed air blowing the work into a chute, and also cleaning the die of dirt and scale. (*See* also INJECTOR.)

EKATERINBURG: *see* SVERDLOVSK.

EKATERINODAR: *see* KRASNODAR.

EKATERINOSLAV: *see* DNEPRO-PETROVSK.

EKHOF, KONRAD (1720–1778), German actor, was born in Hamburg on Aug. 12, 1720. In 1739 he became a member of Johann Friedrich Schönemann's (1704–1782) company in Lüneburg, and made his first apearance there on Jan. 15, 1740 as Xiphares in Racine's *Mithridate.* From 1751 the Schönemann company performed mainly in Hamburg and at Schwerin, where Duke Christian Louis II. of Mecklenburg-Schwerin made them comedians to the court. During this period Ekhof founded a theatrical academy. In 1757 Ekhof left Schönemann to join Franz Schuch's company at Danzig; but he soon returned to Hamburg, where, with two other actors, he succeeded Schönemann in the direction of the company. He resigned in favour of H. G. Koch, with whom he acted until 1764, when he joined K. E. Ackermann's company. In 1767 was founded the National theatre at Hamburg, made famous by Lessing's *Hamburgische Dramaturgie,* and Ekhof was the leading member of the company. Ekhof became, in 1775, co-director of the new court theatre at Gotha, the first permanently established theatre in Germany. Goethe called Ekhof the only German tragic actor; and in 1777 he acted with Goethe and Duke Charles Augustus at a private performance at Weimar. He died on June 16, 1778. He was regarded by his contemporaries as an unsurpassed exponent of naturalness on the stage; and he has been not unfairly compared with Garrick. His fame, however, was rapidly eclipsed by that of Friedrich U. L. Schröder.

See H. Uhde, biography of Ekhof in vol. iv. of *Der neue Plutarch* (1876); J. Kürschner, *K. Ekhofs Leben und Wirken* (1872); H. Devrient, *J. F. Schönemann und seine Schauspielergesellschaft* (1895); Landau, *Mimen* (1912).

EKKPÉ or **EGBO,** a secret society flourishing in southern Nigeria and the Calabar district, West Africa. Ekkpé (leopard in Ibibio) is a dual spirit, male and female, and only males can join, boys being initiated about the age of puberty. Members are bound to secrecy and heavy entrance fees are payable. The Egbo-men are ranked in seven or nine grades, for promotion to each of which fresh initiation ceremonies, fees and oaths are necessary. The society combines a cult, a freemasonry with political and law-enforcing aims. The society was used to recover debts from an outsider and to maintain the authority of the free-born over slaves. The cult turns on ancestor worship and includes fertility rites. There are esoteric secrets known only to the highest grade of initiate. The Egbo-house, an oblong building, usually stands in the middle of the villages. The walls are of clay elaborately painted inside and ornamented with clay figures in relief. Inside are wooden images, sometimes of an obscene nature, to which reverence is paid. At certain festivals in the year the Egbo-men wear black wooden masks with horns which it is death for any woman to look on.

See Mary H. Kingsley, *West African Studies* (1901); P. A. Talbot, *The Peoples of Southern Nigeria* (1926).

EKRON, an ancient city of Palestine (mod. 'Âkir); pop. 1,200; 5 m. from Ramleh, on the Jaffa-Jerusalem railway. Although included by the Israelites in the territory of Judah and mentioned in Joshua xix. as a city of Dan, it was occupied by the Philistines in the days of Samuel, and was the nearest of the Pentapolis to Israelite territory. The sanctuary of Baal-Zebub was here, and the restoration of the ark to Israel was by the road up the Vale of Sorek to Beth-Shemesh, 12 m. away. According to Assyrian records, its king was forced by his subjects to side with Hezekiah, but regained his independence with the advance of Sinaherib. The town was ceded to the Maccabees (147 B.C.); and after the destruction of Jerusalem (A.D. 70) many Jews established themselves here. The neighbourhood is fertile, and in 1884 Baron Rothschild settled there a Jewish colony. (E. Ro.)

ELABUGA, a town in the Tatar A.S.S.R., on the Kama river, 201 m. by steamboat down the Volga from Kazan and then up the Kama, in lat. 55° 50′ N., long. 52° 6′ E. It has flour-mills, and carries on a brisk trade in exporting corn and is supplied with electricity. Pop. (1926) 11,162.

The famous *Ananiynskiy Mogilnik* (burial-place) is on the right bank of the Kama, 3 m. above the town. It was discovered in 1858, was excavated by Alabin, Lerch and Nevostruyev, and has since supplied extremely valuable collections belonging to the Stone, Bronze and Iron Ages. It consisted of a mound, about 500 ft. in circumference, adorned with decorated stones (which have disappeared), and contained an inner wall, 65 ft. in circumference, made of uncemented stone flags. Nearly fifty skeletons were discovered, mostly lying upon charred logs, surrounded with cinerary urns filled with partially burned bones. Bronze decorations and glazed clay pearls were strewn round the skeletons. The knives, daggers and arrowpoints are of slate, bronze and iron, the last two being very rough imitations of stone implements. One of the flags bore the image of a man, without moustaches or beard, dressed in a costume and helmet recalling those of the Circassians.

ELAM, the name given in the Bible to the province of Persia called Susiane by the classical geographers, from Susa or Shushan its capital. Strabo (xv. 3. 12, etc.) makes Susiane a part of Persia proper, but a comparison of his account with those of Ptolemy (vi. 3, 1, etc.) and other writers would limit it to the mountainous district to the east of Babylonia, lying between the Oroatis and the Tigris. Along with this mountainous district went a fertile low tract of country on the western side, which included the marshes

at the mouths of the Euphrates and Tigris. This low tract, producing large quantities of grain, was intensely hot in summer; the high regions, however, were cool and well watered.

The whole country was occupied by a variety of tribes, speaking agglutinative dialects for the most part, though the western districts were occupied by Semites. Immediately bordering on the Persians were the Amardians or Mardians, as well as the people of Khapirti (Khatamti, according to Scheil), the name given to Susiane in the Neo-Susian texts. Khapirti appears as Apir in the inscriptions of Mal-Amir, which fix the locality of the district. Passing over the Messabatae, who inhabited a valley which may perhaps be the modern Māh-Sabadan, we come to the fourth principal tribe of Susiane, the Cissii (Aesch. *Pers.* 16), or Cossaei, the Kassi of the cuneiform inscriptions (*see* Kassites). So important were they, that the whole of Susiane was sometimes called Cissia after them, as by Herodotus (iii. 91, v. 49, etc.). In fact Susiane was only a late name for the country, dating from the time when Susa had been made a capital of the Persian empire. In the Sumerian texts of Babylonia it was called Numma, "the Highlands," of which Elamtu or Elamu, "Elam," was the Semitic translation. Apart from Susa, the most important part of the country was Anzan (Anshan, contracted Assan), where the native population lived unaffected by Semitic intrusion.

The principal mountains of Elam were on the north, belonging to the Parachoathras chain. There were numerous rivers flowing into either the Tigris or the Persian Gulf. The most important were the Ulai or Eulaeus (*Kūran*) with its tributary the Pasitigris, the Choaspes (*Kerkhah*), the Coprates (river of *Diz*, called the Ititē in the inscriptions), the Hedyphon or Hedypnus (*Jerrāhi*), and the Croatis (*Hindyan*). Shushan or Susa, the capital now marked by the mounds of *Shush*, stood near the junction of the Choaspes and Eulaeus (*see* Susa). J. de Morgan's excavations at Susa have thrown a flood of light on the early history of Elam and its relations to Babylon. The earliest settlement there goes back to neolithic times, but it was already a fortified city when Elam was conquered by Sargon of Akkad (3800 B.C.) and Susa became the seat of a Babylonian viceroy. From this time onward for many centuries it continued under Semitic suzerainty. Before the rise of the 1st Dynasty of Babylon, however, Elam had recovered its independence, and in 2280 B.C. the Elamite king Kutur-Nakhkhunte made a raid in Babylonia and carried away from Erech the image of the goddess Nanā. The monuments of many of his successors have been discovered and their inscriptions deciphered. One of them was the Chedor-laomer (Kutur-Lagamar) of Genesis xiv. About 1330 B.C., Khurba-tila was captured by Kuri-galzu III., the Kassite king of Babylonia, but Sutruk-Nakhkhunte (1220 B.C.) carried fire and sword through Babylonia, slew its king, Zamama-sum-iddin, and carried away a stela of Naram-Sin and the famous code of laws of Khammurabi from Sippara. He also conquered the land of Asnunnak. He was succeeded by his son, who was followed on the throne by his brother, one of the great builders of Elam. In 720 B.C. Khumbanigas met the Assyrians under Sargon at Dur-ili in Yamutbal, and though Sargon claims a victory the result was that Babylonia recovered its independence under Merodach-baladan and the Assyrian forces were driven north. From this time forward it was against Assyria instead of Babylonia that Elam found itself compelled to exert its strength, and Elamite policy was directed towards fomenting revolt in Babylonia and assisting the Babylonians in their struggle with Assyria. In 704 B.C. the combined forces of Elam and Babylonia were overthrown at Kis, and in the following year the Kassites were reduced to subjection. The Elamite king was dethroned and imprisoned in 700 B.C. by his brother Khallusu, who six years later marched into Babylonia, captured the son of Sennacherib, and raised a nominee of his own, Nergal-yusezib, to the throne. In 689 B.C. Khumba-Khaldas II. endeavoured to gain Assyrian favour by putting to death the son of Merodach-baladan, but was himself murdered by his brothers, Urtaki and Teumman (681 B.C.), the first of whom seized the crown. On his death Teumman succeeded and immediately provoked a quarrel with Assur-banipal by demanding the surrender of his nephews who had taken refuge at the Assyrian court. The Assyrians pursued the Elamite army to Susa, where the Elamites were defeated, Teumman captured and slain, and Umman-igas, the son of Urtaki, made king, his younger brother Tammaritu being given the district of Khidalu. Umman-igas afterwards assisted in the revolt of Babylonia, but his nephew, a second Tammaritu, raised a rebellion against him and seized the crown. Tammaritu marched to Babylonia; while there, his officer Indabigas made himself master of Susa but was himself overthrown and slain by a new pretender, Khumba-Khaldas III., who was opposed by three other rivals, two of whom maintained themselves in the mountains until the Assyrian conquest of the country. The return of Khumba-Khaldas led to a fresh Assyrian invasion, and the Elamite army was almost exterminated on the banks of the Ititē. The whole country was reduced to a desert, Susa was plundered and razed to the ground, the royal sepulchres were desecrated, and the images of the gods and of 32 kings "in silver, gold, bronze and alabaster," were carried away. All this must have happened about 640 B.C. After the fall of the Assyrian empire Elam was occupied by the Persian Teispes, the forefather of Cyrus, who, like his immediate successors, is called in the inscriptions "king of Anzan." Susa once more became a capital, and on the establishment of the Persian empire remained one of the three seats of government, its language, the Neo-Susian, ranking with the Persian of Persepolis and the Semitic of Babylon as an official tongue. In the reign of Darius the Susianians attempted to revolt, but they gradually became completely Aryanized, and their agglutinative dialects were supplanted by the Aryan Persian from the south-east.

Elam, "the land of the cedar-forest," with its enchanted trees, figured largely in Babylonian mythology, and one of the adventures of the hero Gilgamesh was the destruction of the tyrant Khumbaba who dwelt in the midst of it. A list of the Elamite deities is given by Assur-bani-pal; at the head of them was In-Susinak, "the lord of the Susians," whose image and oracle were hidden from the eyes of the profane.

See *Cambridge Ancient History*, vol. iii. (with useful bibliography); A. Billerbeck, *Susa* (1893); J. de Morgan, *Mémoires de la Délégation en Perse* (1899–1906).

ELAND, the largest of the South African antelopes (*Taurotragus oryx*), the bull reaching a height of as much as 6ft. at the shoulder, and a length of over 9ft.; a species akin to the kudu, but with horns present in both sexes, and their spiral much closer. There is a large dewlap, while old bulls have a thick forelock. In the southern form the body is wholly pale fawn, but north of the Orange river the body is marked by narrow vertical white lines. In Senegambia the genus is represented by *T. derbianus*, a larger animal, with a dark neck; while in the Bahr-el-Ghazal district there is a gigantic local race of this species.

ELANDSLAAGTE, ACTION OF (Oct. 21, 1899): *see* South African War.

ELASMOBRANCH: *see* Selachians.

ELASTICITY. The word *elastic*, derived originally from the Greek verb ἐλαύνειν to drive, has acquired its present meaning largely from the writings of Robert Boyle. In 1660, in a description of his experiments relating to the spring of the air he says, "There is a spring or elastical power in the air in which we live." This spring he attributed to an effort made by each particle of air to drive its neighbours away. For the sake of illustration, a particle of air was at that time pictured with little springs attached to it, these springs being compressed by those of neighbouring particles.

The chief characteristic of a spring is its power of recovering a former durable shape and size when the load causing a temporary deformation is removed. The spring possesses this power whether it is stretched or compressed. A similar power of recovery, when deforming forces are removed, is possessed to some extent by any solid body. This power is described in a general way by saying that the body is elastic. If recovery is prevented by some other body or bodies, the effort which the body makes to recover its original durable form may be represented by an elastic force or system of elastic forces. This application of the word elastic to the forces exerted by deformed solid bodies was made by Boyle. In an essay on effects of motion, written in 1685, he says, "By

the elastical force of the bent bow the string is brought into a violent state of tension."

LAWS OF ELASTICITY

Boyle's Law.—The first law of elasticity was published in 1662 by Boyle, and in 1676 by Edmé Mariotte. It is now called the law of the isothermal expansion or contraction of a "perfect" gas, and is generally written in the form

$$pv = f(\theta),$$

where v is the volume of unit mass of the gas and p the pressure intensity (*see* HYDROMECHANICS). The quantity on the right-hand side depends only on the temperature θ, which was kept constant in Boyle's experiments. When θ is the *absolute* temperature, as measured by an air-thermometer, $f(\theta)$ becomes simply $R\theta$, where R is a constant depending on the nature of the gas. The quantity v is the reciprocal of the density (ρ), and is frequently called the *specific volume*, while p is called simply the *pressure*. The law indicates that, under isothermal conditions, the pressure is proportional to the density. For a real gas this law has only a limited validity, it fails at high pressures and low temperatures, *i.e.*, under conditions close to those at which liquefaction occurs.

If dp and dv denote small changes in p and v at constant temperature, Boyle's law gives the equation

$$p = -v\frac{dp}{dv} \quad (=k).$$

The quantity on the right is called the *volume-elasticity*; under isothermal conditions it is equal to the pressure, but under adiabatic conditions, *i.e.*, when there is neither gain nor loss of heat it is equal to γp where γ, the ratio of the specific heats at constant pressure and constant volume, is always greater than 1 and is about 1·4 for air.

In Boyle's law the pressure is supposed to be constant throughout the unit mass of gas, but, since the choice of this unit is arbitrary, the law may be applied to a small portion of the gas, whose size may be diminished indefinitely. The limiting value of the ratio dv/v is called the *dilatation* (Δ), and $-\Delta$ is called the *compression*. The volume-elasticity k is thus the ratio of the increase of pressure to the resulting compression. With a suitable definition of pressure this law is also applicable to solids, and to prevent misunderstanding the pressure so defined is often called *hydrostatic pressure*.

Hooke's Law.—The first law of elasticity for solid bodies was discovered by Robert Hooke in 1660, and published in 1676 in the form of an anagram meant to represent the words *Ut tensio sic vis*. *Tensio* is understood to mean what is now called *extension*. This, in the case of a wire stretched to a new length L, is the ratio of the gain in length, $L-l$, to the original length l. Interpreting *vis* as the tension in the wire, the law states that the tension is proportional to the extension. If the tension is regarded as a force, the factor of proportionality is found, not to be a physical constant for the substance of which the wire is made, but to depend upon the area of the cross-section of the wire as well as upon the properties of the substance. For this reason it is more convenient to regard tension as a *stress*, *i.e.*, the ratio of a force to the area across which it is transmitted. A more general and precise definition of stress, due to Augustin Louis Cauchy, will be given later, but the present one will suffice to indicate the physical dimensions of a stress and the most convenient units of stress. Extension will be regarded as a particular type of *strain*, a physical quantity which is always the ratio of two lengths and therefore a mere number, so no unit of strain is needed.

Hooke's law may be expressed in the form of an equation

$$S = Es,$$

where S is the stress, s the strain and E a modulus of elasticity, now called *Young's modulus*, in honour of Thomas Young, who gave it a physical meaning. This law does not hold for very great values of S, and even with small values of S it does not give a complete description of the elastic behaviour of the substance, as there is a lateral contraction when a rod or wire is stretched. For a long time, however, problems in the theory of elasticity were treated with the aid of this law alone, the first use of the law being made by Mariotte, who discovered it independently. He pointed out that, when a beam is bent, some of the longitudinal fibres are stretched and others contracted.

Bending of Rods.—This idea was developed by Jacques (Jakob, James) Bernoulli and Leonhard Euler into a theory of thin elastic rods, which involved the idea of a *couple* whose moment resists the *bending moment* and is proportional at each place to the curvature of the rod when bent. If the deflection y at a distance x from one end of the rod is small, the equation for the bending moment M is approximately

$$M = EI\frac{d^2y}{dx^2},$$

where EI is a constant called the *flexural rigidity* of the beam, E is Young's modulus for the material and I is a constant depending on the shape of the cross-section of the rod. In the case of a rod, of length l, free to turn about its ends and bent by forces acting along the line joining these ends, the bending moment (fig. 1) is $-yP$, and this is balanced by the resisting moment if

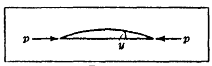


FIG. 1

$$EI\frac{d^2y}{dx^2} + Py = 0.$$

Since y is zero when $x = 0$ and when $x = 1$, an appropriate solution is $\quad y = A\sin\alpha x$, where $EI\alpha^2 = P$ and $A\sin\alpha l = 0$.

The last equation gives either $A = 0$ or $\alpha l = n\pi$, where n is an integer. A more complete theory, in which an exact expression for the curvature is used, indicates that the straight form, given by $A = 0$, is stable if $Pl^2 < \pi^2EI$ and unstable if $Pl^2 \geqq \pi^2EI$. In the latter case a bent form, such as that shown in fig. 1 is stable. This result can be extended, with suitable modifications, to columns and frameworks supported and loaded in various ways. The fact that the criterion for the failure of a rod, through instability of the straight form, depends upon the modulus E adds to the importance of this modulus as a physical quantity. The theory has been confirmed by the very careful experiments of Andrew Robertson. In practice a rod generally buckles under a load less than Euler's critical load, because the load is badly centred or because the rod has a slight initial curvature.

In the theory of the flexure of a thick beam, given by C. A. Coulomb, a line through the centroid of the cross-section, called the *neutral line*, is found to possess the property that the extension of a longitudinal fibre through a point Q of the section is represented by Cy, where y is the distance of Q from the neutral line and C is the curvature of the line of centroids at the position of this section. This relation is derived on the assumption that the cross-sections remain plane after bending.

The couple required to maintain flexure is then parallel to the plane of bending if $\iint xydxdy = 0$, where x is measured parallel to the neutral line. The couple is then given by the formula

$$M = \iint (ECy)ydxdy = ECI,$$

where I is the moment of inertia of the cross-section of the beam about the neutral axis. The stress in the fibre under consideration is a tension or compression, according as y is positive or negative; it is given by the quantity ECy which may be expressed in the more convenient form My/I. There may be an additional longitudinal stress in the fibre due to longitudinal end loads. If the total stress in a fibre is greater than the material can sustain there will be rupture. When the problem of flexure is treated by more exact methods, it is found that the bending moment is not always proportional to the curvature of the line of centroids. This was first noted by Karl Pearson, for a special distribution of lateral loads. In the case treated by Barré de Saint Venant, in which the proportionality was confirmed, the bending was supposed to be produced by forces applied to the terminal sections. The propor-

tionality fails even in this case if the beam is a very thin tube and is consequently capable of large displacements. A theory developed for these conditions by L. G. Brazier gives a relation between bending moment and curvature of the type shown in fig. 2. If the bending moment is increased above the maximum value, corresponding to the point A, the beam must collapse. This is a new form of instability, and is an indication of the new results which may be expected from the general theory of elastic stability which has been developed by R. V. Southwell and applied to rods, tubes and plates.

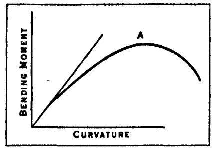


FIG. 2

Torsion and Shearing Stress.—The advantage of using the idea of stress instead of that of force is seen again from a consideration of the torsion of a shaft of length l. If θ is the angular displacement of one end relative to the other, and T the total twisting couple transmitted along the shaft, there is, for small values, of θ, a relation of type

$$lT = K\theta,$$

where K is a constant which may be called the *torsional rigidity* of the shaft. This constant K is not, however, a physical constant for the material; it depends in a rather complicated way on the shape and size of the cross-section. Cauchy's theory showed that, in the case of a cylindrical shaft of uniform cross-section, K could be written in the form μJ, where J is the moment of inertia of the cross-sectional area about the axis of the cylinder and μ is a physical constant called the *rigidity* of the material. Saint Venant later gave a general theory of torsion, in which K has the same form as before except that J is now a geometrical constant, the determination of which for a given section depends on the solution of a problem of potential theory. The stress which, in this theory, is supposed to be transmitted across any element of area of a cross-section, is a *shearing stress, i.e.,* a stress derived from a force tangential to the area. This stress is expressed in terms of geometrical quantities by means of an extension of Hooke's Law appropriate for shearing stresses. This and other extensions of Hooke's Law will be given later when the ideas of stress and strain are made more definite. A mechanical method of determining K by means of a soap film stretched across a hole whose shape is the same as that of the cross-section of the shaft has been developed by A. A. Griffith and Geoffrey I. Taylor from a suggestion made by Ludwig Prandtl.

The Spiral Spring.—In 1848 James Thomson pointed out that the action of an ordinary spiral spring of circular cross-section depends mainly on torsion. The spring consists of a thin wire coiled into a helix of small pitch and radius c. When one end is fixed at a point O and the other attached to a weight W, it may be assumed that the axis of the coil is vertical and along the line OW. The twisting moment is then Wc, and the twist for a length l of coil is given approximately by the equation

$$lWc = K\theta.$$

The vertical displacement due to a twist $\theta\delta s/l$ in an element of length δs is $c\theta\delta s/l$. The total vertical displacement is therefore

$$c\theta = lWc^2/K.$$

There is no appreciable horizontal displacement of the weight, because the horizontal components due to the different elements will on the whole neutralize one another. Unless the pitch is small it is necessary in a more exact theory to take into consideration the bending moment and the flexural rigidity. The spring then tends to uncoil when stretched.

Units of Stress.—The c.g.s. unit of one dyne per square centimetre is rather small, and so a unit of one kilogram per square centimetre is used by many scientists. This unit will be denoted here by the symbol κ. Other convenient symbols which will also be used are τ for a stress of one ton per square inch, π for a stress of one pound per square inch and α for a unit pressure of one atmosphere. The transformation from one unit to another may be made with the aid of the relations

$$1000\alpha = 6{\cdot}5611\tau = 14700\pi = 1033\kappa = 1{\cdot}013 \times 10^9 \text{ C.G.S. units.}$$

The unit used in the International Critical Tables is one kilo-megabyre, a megabyre being equal to $14{\cdot}5\pi$. Young's modulus for steel is a little greater than $13{,}200\tau$, consequently a tensional stress of $13{\cdot}2\tau$ will produce an extension of only about 0·001.

LIMITS OF ELASTICITY

Behaviour of a Substance Under Great Stress.—When a rod or wire has been stretched by a load, it recovers its original length and elasticity after the removal of the load, provided the stress produced by the load does not exceed a certain threshold value. This value is called the *elastic limit;* it generally gives very closely the limit of the range for which the strain is proportional to the stress, but may be slightly less than the proportional limit. With other kinds of stress the reverse may be the case. In Albert A. Michelson's experiments with twisted prisms the elastic strain produced by a stress p was found to be given by an expression of type Cpe^{hp}, where C and h are constants, while in P. W. Bridgman's experiments with substances subjected to hydrostatic pressures up to $12{,}000\kappa$ no elastic limit was detected, though there was always a limit of proportionality. As the pressure increases the compressibility decreases, the decrease for solids being generally less than for liquids.

With stresses beyond the elastic limit the behaviour is different for different substances, but generally the material becomes plastic when the load is applied, and the magnitude of the extension corresponding to a given load is indefinite and varies with the time. With a sufficiently large load the extension may increase with time in such a manner as to lead to rupture; with a smaller load the rate of increase, after quickly reaching a maximum value, may gradually decrease to zero, just as if the motion were resisted by a kind of viscous drag. In this case a state of plastic equilibrium is approached. On the removal of the load the rod may not return to its original length, but may assume a slightly greater length. Sometimes the old or a new length is approached gradually, as if a viscous drag were again operative. This gradual creeping to a different length is called *elastic afterworking;* it was discovered by Wilhelm Weber in 1835.

If, after receiving a permanent set or deformation, a rod is reloaded, the strain may not be exactly proportional to the stress, but in some cases it is, and the proportional limit may be either greater or less than before. Sometimes the proportional limit is surprisingly low, but if the rod be allowed to rest for some days after the overstrain it recovers the property of linear elasticity. The stress at which the strain begins to increase very rapidly as the load is increased is called the *yield point.* For mild steel it may be about 18τ. The cross-section of the bar now diminishes in area, and just before rupture a narrow neck forms. The extension may then be about 30·6% and the reduction in area 67·4%.

In order to avoid calculation of the stress at each stage, engineers generally use a load-extension diagram in preference to a stress-strain diagram, and the stress at rupture, or *ultimate strength,* is a nominal stress calculated on the basis of the original cross-section. The actual stress is much greater than this; and it increases right up to the moment of rupture, while the load may actually decrease after the yield point has been passed. The ultimate strength of ordinary mild steel is about 30τ, that of piano wire about 120τ, while the ultimate strength of wood is generally less than 8τ.

The Principle of Least Work.—The stresses in the members of an over-rigid, that is a redundant, framework of elastic rods may generally be obtained by means of the principle of least work introduced by L. F. Menabrea and C. A. Castigliano. The method is to represent the stresses in a certain number of rods by algebraic symbols, the number being just sufficient to determine uniquely the stresses in the remaining rods when the framework is acted upon by external forces which, if compounded together, would form a system in equilibrium. The total strain energy of the framework is then calculated by summation, using the theorem that the strain energy of a rod of length l and uniform cross-sectional area A is $lF^2/2EA$, where F is the force acting along the rod and E is Young's modulus. This is in fact just l

times' the area under the curve in the force-extension diagram, and is the volume of the rod multiplied by the area under the curve in the stress-strain diagram. The values to be given to the algebraic symbols are now those which will make the total strain energy a minimum. The conditions for a minimum take the form of linear algebraic equations with a single set of solutions.

The stresses thus found do not necessarily form a physically possible system, for it may happen that the calculated stress in one or more of the rods exceeds the proportional limit. One method of treating the problem in such a case is to make the simplifying assumption that, when the stress in a rod reaches a certain yield point, it cannot exceed this value. Assuming that certain rods behave as plastic and the rest as elastic members, the stresses in the plastic rods are given by the known yield points, while the stresses in the elastic rods may be determined by the methods of statics or by an application of the principle of least work.

The stresses determined by the ordinary methods of statics or by the principle of least work may fail to represent a physical possible system for another reason. If the stress in a member is compressive and is greater than a certain critical value, the member will buckle. This critical value depends on the modulus E, and may be less than the yield point of the material. For some purposes it is useful to compare an elastic solid with a structure of elastic rods, and one of the important problems of the theory of elasticity is the determination of the critical loads for struts, structures and elastic plates of various shapes. These loads may be expected in general to depend, not only upon E, but also upon the other elastic constants just as in the case of a structure they depend upon the geometrical form. In some cases the problem can be treated by the elementary methods, in which the displacements of particles are treated as small, but for a full elucidation of some points a more exact theory is needed.

The Growth of the Structure Theory.—In the 17th and 18th centuries some problems relating to the bending and vibration of beams and columns were partially solved, although there was then no general theory of elasticity. The treatment of other problems was, however, erroneous and the need of a comprehensive theory became apparent. Curiously enough the general equations of the mathematical theory of elasticity originated, not from the more or less empirical attempts to solve special problems but from a combination of definite mathematical hypotheses with certain speculations regarding the structure of matter.

Following up Boyle's idea of particles of air endowed with the properties of a spring, Sir Isaac Newton endeavoured to explain the simple proportionality between air pressure and density by introducing the idea of a repulsive force between two molecules depending only on their mutual distance. Newton actually used an inverse distance law, but was careful to state that the force must be regarded as operative only when the distance does not exceed a certain length. An atom or molecule was thus regarded as having a more or less definite sphere of action, and attractive forces of various intensities were regarded as the cause of chemical action. The idea of molecular attractive forces with a limited range of action was used also by P. S. Laplace in his theory of surface tension.

The use in physics of forces depending only on the distance and acting only over a definite range had thus already received some sanction when C. L. M. H. Navier used the idea in 1821 to obtain a set of general equations for the equilibrium and vibration of an elastic solid. Navier's molecules, like those of R. G. Boscovich, were practically centres of force, and his equations for an isotropic substance involved only a single elastic constant analogous to Young's modulus. The theory was carried a step further by Cauchy, who imagined the molecules to form a homogeneous assemblage or lattice. He thus obtained a generalization of Hooke's law involving 15 elastic constants, and regarded it as applicable to any crystalline or aeolotropic substance.

The need for a greater number of elastic constants for both crystalline and isotropic bodies was realized by S. D. Poisson who, prior to Navier's work, had used the Newtonian ideas in some work on the equilibrium of an elastic surface. Poisson proposed to go back to the Newtonian conception of a molecule with a definite shape and size, and to consider the effect of changes in the orientation as well as the position of the molecules of an elastic body. The calculations were completed by Woldemar Voigt in 1887. Shortly afterwards Lord Kelvin (William Thomson), in an attempt to raise the number of elastic constants for a crystalline substance to 21, represented a molecule by a pair of centres of force. This work has been extended by Max Born and his co-workers. By using a number of centres of force as the structural element, it is possible to calculate the elastic constants with fair accuracy and to estimate also the thermal characteristics of a crystalline substance. The hypotheses upon which the structure theory is based are only rough approximations to the truth, and so the general equations of elasticity have also been derived from general mechanical and thermodynamical principles, a solid body being treated as continuous.

THEORY OF STRAIN

In the general theory of strain, let P, Q be two neighbouring points of an elastic body, and P', Q', the new positions of these points when the body is deformed. Using a system of rectangular axes to specify the positions of these points, and denoting their co-ordinates by (x, y, z), $(x+dx, y+dy, z+dz)$, (x', y', z'), $(x'+dx', y'+dy', z'+dz')$ respectively, the differences

$$u=x'-x, \qquad v=y'-y, \qquad w=z'-z,$$
$$u+du=x'+dx'-x-dx,$$
$$v+dv=y'+dy'-y-dy,$$
$$w+dw=z'+dz'-z-dz$$

are regarded as the *component displacements* of the points respectively.

If now ds represents the small distance PQ, and ds' the small distance $P'Q'$, the ratio of $ds'-ds$ to ds is defined to be the *strain* of the element ds. In the mathematical theory, a limiting process is supposed to be carried out in which the length PQ is made indefinitely small, and the strain is defined in very much the same way as a differential coefficient. The strain is then associated with the point P, but depends upon the direction of the element PQ. Indeed, if the space occupied by the body is assumed to be Euclidean before and after deformation, the relations

$$ds'^2=dx'^2+dy'^2+dz'^2, \quad ds^2=dx^2+dy^2+dz^2,$$

give rise to a relation of type

$$ds'^2=ds^2+2(adx^2+bdy^2+cdz^2+2fdydz+2gdzdx+2hdxdy),$$

in which the coefficients a, b, c, $2f$, $2g$, $2h$ depend on the partial derivatives of the displacements u, v, w. These coefficients are called the six components of strain, and may be rewritten as s_1, s_2, s_3, s_4, s_5, s_6, or as e_{xx}, e_{yy}, e_{zz}, e_{yz}, e_{zx}, e_{xy}, according to circumstances, one notation being sometimes more convenient than another.

The six components of strain are connected by certain relations which imply that the expression for ds'^2 is suitable for the representation of the square of the element of length in Euclidean space (x, y, z, are regarded now as generalized co-ordinates). When the squares and products of the partial derivatives are so small in comparison with the derivatives themselves that they may be neglected, the expressions for the components of strain may be written in the form:—

$$a=\frac{\partial u}{\partial x}, \qquad 2f=\frac{\partial w}{\partial y}+\frac{\partial v}{\partial z};$$
$$b=\frac{\partial v}{\partial y}, \qquad 2g=\frac{\partial u}{\partial z}+\frac{\partial w}{\partial x};$$
$$c=\frac{\partial w}{\partial z}, \qquad 2h=\frac{\partial v}{\partial x}+\frac{\partial u}{\partial y};$$

and the relations are easily found. These are called the *conditions of compatibility*.

The strain represented by a single component of type a, the other components being zero, is a *simple extension* parallel to the axis of x. The strain represented by the single component $2f$,

the other components being zero, is called a *shearing strain.* When f is constant this shearing strain may be regarded as made up of two simple shears for which the corresponding displacements are, respectively,

$$u=0, \qquad v=0, \qquad w=fy$$
$$u=0, \qquad v=fz, \qquad w=0.$$

The displacement in a simple shear may be regarded as composed of two parts; viz., a rotational displacement,

$$u=0, \qquad v=-kz, \qquad w=ky, \qquad (2k=f),$$

for which there is no corresponding strain, and the displacement

$$u=0, \qquad v=kz, \qquad w=ky,$$

for which the three components of rotation defined by the equations

$$2\xi=\frac{\partial w}{\partial y}-\frac{\partial v}{\partial z}, \qquad 2\eta=\frac{\partial u}{\partial z}-\frac{\partial w}{\partial x}, \qquad 2\zeta=\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}$$

are all zero. This resolution of a displacement into a rotation and an irrotational part has an analogue in the case when the strain is not constant, for we may write

$$du=(adx+hdy+gdz)+(\eta dz-\zeta dy)$$
$$dv=(hdx+bdy+fdz)+(\zeta dx-\xi dy)$$
$$dw=(gdx+fdy+cdz)+(\xi dy-\eta dx).$$

Invariants.—When the axes of co-ordinates are changed, the six components of strain are changed also, but certain combinations of them remain unaltered in form. These invariants may be obtained by remarking that the ratio $ds':ds$ for any direction through P is inversely proportional to the central radius vector, in that direction, of the quadric surface whose equation in rectangular co-ordinates is

$$x^2+y^2+z^2+2(ax^2+by^2+cz^2+2fyz+2gzx+2hxy)=1;$$

the lengths of the principal axes of this quadric are consequently invariants. The principal axes of the quadric are called the principal axes of strain for the point P, and the extensions of a linear element for these directions are called the principal extensions $\epsilon_1, \epsilon_2, \epsilon_3$. The values of $1+\epsilon_1$, $1+\epsilon_2$, $1+\epsilon_3$ are the positive square roots of the three values of k for which

$$\begin{vmatrix} 1+2a-k & 2h & 2g \\ 2h & 1+2b-k & 2f \\ 2g & 2f & 1+2c-k \end{vmatrix}=0.$$

The coefficients of the different powers of $\frac{1-k}{2}$ in this equation are naturally invariants. These invariants are respectively

$$I_1=a+b+c$$
$$I_2=bc-f^2+ca-g^2+ab-h^2$$
$$I_3=abc+2fgh-af^2-bg^2-ch^2.$$

An invariant expressible in terms of these is obtained by putting $k=0$ in the determinant. This invariant may be written, in an alternative form, as the square of a Jacobian

$$J^2=\left(\frac{\partial(x',y',z')}{\partial(x,y,z)}\right)^2=(1+\Delta)^2,$$

where Δ is a quantity called the *cubical dilatation.* When squares and products of the derivatives of u, v and w are neglected, the formula for the dilatation becomes simply

$$\Delta=\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}.$$

The quantity J represents the ratio of the volume of a small portion of the body after and before deformation. When the approximate expressions for the strains are adopted, it is clear that there is no change of volume in the shearing strain for which f is the only component different from zero.

The Strain Energy Function.—In 1837 George Green obtained a generalization of Hooke's law, suitable for the most general type of crystalline substance, by starting from the assumption that when the components of strain in a deformed body are defined by considering displacements from an initial state in which the body is free from strain, and consequently also free from stress, and when the components are also small, there is a strain energy function W which can be supposed to represent the density of strain energy at each point (x, y, z) of the body. In 1855 Lord Kelvin gave a thermodynamical argument which made Green's hypothesis seem plausible in two cases, first when the deformation takes place at a constant temperature and secondly when it takes place without loss of heat. Green assumed further that there is in general a relation of type

$$2W=\sum_{m=1}^{6}\sum_{n=1}^{6}c_{mn}s_m s_n,$$

where the coefficients c_{mn} are elastic constants characteristic of the material. For convenience it will be assumed that $c_{nm}=c_{mn}$; this may be done without loss of generality because the sum of these two quantities occurs as the coefficient of $s_m s_n$ in the complete expression for W.

Lord Kelvin's thermodynamical argument indicates that it is necessary to distinguish between two sets of elastic constants, the *isothermal* and the *adiabatic*; it also shows that the quantities

$$S_n=\frac{\partial W}{\partial s_n}=\sum_{m=1}^{6}c_{mn}s_m$$

specify the state of stress in the body. The relation

$$2W=s_1S_1+s_2S_2+s_3S_3+s_4S_4+s_5S_5+s_6S_6$$

is, in fact, a natural extension of the formula $2W=sS$ already obtained for the case in which there is only one component of stress which is constant throughout the body and of the nature of a simple tension.

The quantities $S_1, S_2, S_3, S_4, S_5, S_6$ may be regarded provisionally as the *six components of stress.* They are usually denoted by another set of symbols such as $X_x, Y_y, Z_z, Y_z, Z_x, X_y$, and this notation is completed by introducing quantities Z_y, X_z, Y_x defined by the relations $Z_y=Y_z$, $X_z=Z_x$, $Y_x=X_y$. The general expression for W is suitable for a crystalline body or a substance like wood, whose physical properties are related to certain definite directions in the material. For an isotropic substance, *i.e.*, a substance in which all directions are alike as far as structure is concerned, the expression for W should have the same form in all systems of rectangular co-ordinates, and so should depend only on the invariants I_1, I_2, I_3. The natural assumption is thus

$$2W=(\lambda+2\mu)I^2_1-4\mu I_2,$$

where λ and μ are elastic constants. The corresponding relations between stress and strain are now

$$X_x=\lambda\Delta+2\mu a, \qquad Y_z=2\mu f,$$
$$Y_y=\lambda\Delta+2\mu b, \qquad Z_x=2\mu g,$$
$$Z_z=\lambda\Delta+2\mu c, \qquad X_y=2\mu h;$$

where, as before, $\Delta=a+b+c$.

The relations between stress and strain may be solved for the components of strain giving, in particular,

$$Ea=X_x-\sigma(Y_y+Z_z)$$
$$Eb=Y_y-\sigma(Z_z+X_x)$$
$$Ec=Z_z-\sigma(X_x+Y_y),$$

where $$E=\frac{\mu(3\lambda+2\mu)}{\lambda+\mu}, \qquad \sigma=\frac{\lambda}{2(\lambda+\mu)}.$$

In these equations E is *Young's modulus*, σ is *Poisson's ratio*, μ is the *modulus of rigidity*, and the quantity $k=\lambda+\frac{2}{3}\mu$ is the *modulus of compression.* Under ordinary conditions the adiabatic constants for a solid substance are practically the same as the corresponding isothermal constants.

Elastic Constants
(E is expressed in units of $10^6\pi$)

Substance	E	σ
Wrought iron	27–29	·28
Mild steel	29–31	
Cast iron	14–23	·28
Low carbon steel	28	
High carbon steel	27	
Aluminium (cast)	12·5	·34
Aluminium (wire)	18	
Duralumin	9·7–10·7	
Brass	12	·33
Copper	15	·35
Glass	8–10·6	·23
Rubber	250–350π	·5
Spruce (15% moisture)	1·3	
Ash	1·46	
Oak	1·4	
Walnut	1·3–1·5	
Birch	1·8–1·95	
Mahogany	1·3–1·4	
Hickory	1·9	
Celluloid (nitrocellulose)	0·355	·41

It must be remembered that considerable differences are found in the elastic constants of different samples of nominally the same substance. The assumption that a metal is homogeneous and isotropic is not very accurate, for modern metallurgical studies have shown that metals which have been subjected to certain treatments may be composed of long narrow crystals which impart to a specimen of kind of fibrous structure. Much work has indeed been done recently on the strength and elastic properties of single crystals, and these are found to differ considerably from those of a solid composed of an aggregate of small crystals and an amorphous substance which binds them together. The fibrous structure of wood is well known and several elastic constants are really needed to describe its properties, and these depend largely upon the amount of moisture in the wood. The value of E generally used corresponds to tension along the grain.

EQUATIONS OF EQUILIBRIUM

From the Principle of Least Work.—The conditions for the equilibrium of an elastic solid deformed by given forces may be obtained from an earlier form of the principle of least work. Assuming, for simplicity, that the body is deformed only by surface tractions and that the displacements of points on the surface are prescribed, the internal displacements are supposed to be of such a nature that the total strain energy of the body is a minimum when the energy associated with the actual deformation is compared with the energy of a fictitious deformation consistent with the same surface displacements.

Giving arbitrary small increments to the component displacements u,v,w of a point (x,y,z), and assuming that the strains are so small that their expressions (1) may be used in the expression for the total energy, the Eulerian equations of the Calculus of Variations give in this case

$$L\equiv \frac{\partial X_x}{\partial x}+\frac{\partial X_y}{\partial y}+\frac{\partial X_z}{\partial z}=0,$$

$$M\equiv \frac{\partial Y_x}{\partial x}+\frac{\partial Y_y}{\partial y}+\frac{\partial Y_z}{\partial z}=0,$$

$$N\equiv \frac{\partial Z_x}{\partial x}+\frac{\partial Z_y}{\partial y}+\frac{\partial Z_z}{\partial z}=0.$$

These will be regarded as the differential equations for the equilibrium of an element, of the body, which occupies the position (x,y,z).

The first equation gives

$$\iiint L\,dx\,dy\,dz=0,$$

where the integration extends over an arbitrary portion of the body. Transforming this volume integral into a surface integral by the usual method, the resulting equation may be written in the form

$$\iint (lX_x+mX_y+nX_z)dS=0$$

where (l,m,n) are the direction cosines of the normal to the surface-element dS. The quantity under the integral sign is now interpreted to be the x-component of the surface traction acting across the surface element dS, while the quantity within brackets is regarded as the x-component of the stress across this element. Denoting this quantity by X_ν the preceding equation may be written in the form

$$\iint X_\nu dS=0,$$

and there are similar equations involving the y and z-components $Y_\nu Z_\nu$. These may be regarded as three of the conditions of equilibrium of the surface tractions on the elements of the closed surface S. The other conditions for the equilibrium of these surface tractions are obtained by taking moments about the axes of co-ordinates; they are

$$\iint (yZ_\nu-zY_\nu)dS=0,\qquad \iint (zX_\nu-xZ_\nu)dS=0,$$
$$\iint (xY_\nu-yX_\nu)dS=0.$$

Transforming the surface integrals into volume integrals, it is found that the three equations are satisfied in virtue of the differential equations of equilibrium and the three equations

$$Y_z=Z_y,\qquad Z_x=X_z,\qquad X_y=Y_x$$

which were introduced to complete the notation.

With the present definition of stress, the stress components across an area perpendicular to the axis of x are X_x, Y_x, Z_x, while those across an area perpendicular to the axis of y are X_y, Y_y, Z_y. The equation $X_y=Y_x$ is interpreted as a relation between complementary shearing stresses. The usual convention in interpreting X_ν is that it is a stress exerted by the part of the body towards which the normal is drawn. It is clear from the definition that the component stress in the direction (l', m', n') across a plane at right angles to (l, m, n) is

$$l'(lX_x+mX_y+nX_z)+m'(lY_x+mY_y+nY_z)+n'(lZ_x+mZ_y+nZ_z).$$

The state of stress at a point (x,y,z) is thus completely specified by the six components of stress.

Body Forces.—When an elastic solid is acted upon by a body force like gravity, which acts right through the body, the equations of equilibrium take a more general form, and are of type

$$L+\rho X=0,$$

where X is the x-component of the body force per unit mass. When the body is in motion the force of inertia may be treated as an additional body force, and the equations of motion are of type

$$L+\rho X=\rho\frac{\partial^2 u}{\partial t^2}.$$

These equations are particularly useful for a study of the vibrations of solid bodies and the propagation of waves through them.

It was shown by Poisson that there are two distinct velocities with which waves can be propagated without change of type through a homogeneous isotropic elastic solid. The so-called irrotational waves (or waves of compression) travel with velocity $\sqrt{(\lambda+2\mu)}\sqrt{\rho}$, while the equivoluminal waves (or waves of shear) travel with velocity $\sqrt{\mu}\sqrt{\rho}$. Lord Rayleigh (John William Strutt, 3rd baron) discovered that a type of surface wave, compounded in a rather complex way from waves of the two types, can travel with a velocity slightly less than that of the equivoluminal waves. The vibrations of elastic solids are of great interest in the theory of sound and in the design of engineering structures.

PROBLEMS IN THEORY

Simple Distributions of Stress.—Examples will now be given to indicate very briefly some of the steps which must be taken in the solution of problems in the theory of elasticity. If T is a constant, the equations are satisfied by the stress components

$$X_x=T,\qquad Y_y=Z_z=Y_z=Z_x=X_y=0,$$

and the corresponding strains are given by the equations

$$Ea=T,\qquad Eb=Ec=-\ T.$$

In order that this distribution of stress may be possible it is necessary, however, that there should be a distribution of displacements (u, v, w) corresponding to the distribution of strain. In the present case it is easily seen that the expressions,

$$u=ax, \qquad v=by, \qquad w=cz,$$

satisfy requirements, but generally it is necessary to make use of the conditions of compatibility which lead to a set of differential equations for the stresses. In this example the lateral contraction $-b$ is σ times the longitudinal extension a, and so a physical meaning is found for Poisson's ratio. The state of stress may be supposed to exist in a cylindrical rod whose axis and generators are parallel to the x-axis. The curved surface of the rod is then free from surface tractions, but the end surface must be regarded as acted upon by uniformly distributed normal tractions.

If p is a constant, the stress-components

$$X_x=Y_y=Z_z=-p,$$
$$Y_z=Z_x=X_y=0,$$

also satisfy the equations and give

$$a=b=c=-p/(3\lambda+2\mu), \qquad \Delta=-p/k.$$

If l,m,n are the direction cosines of the normal to a surface element of the boundary of the solid, the components of stress across this element are $-lp,-mp,-np$; the stress is thus a *uniform normal pressure*. It is easily seen that displacements corresponding to the strains can be found, and so the stress distribution can exist in a body subjected to a constant hydrostatic pressure p. The case in which p varies with position and there are body forces is easily treated. This example indicates clearly why k is called the modulus of compression.

If S is a constant, the stress components

$$X_x=Y_y=Z_z=Y_z=Z_x=0, \qquad X_y=S,$$

satisfy the conditions and give

$$a=b=c=f=g=0, \qquad 2h=S/\mu.$$

The displacements, $u=2hy$, $v=0$, $w=0$, corresponding to a simple shear are possible in connection with this distribution of strain, and the reason for calling μ the *modulus of shear* or *rigidity* of the material is apparent. It is sometimes convenient to resolve a given distribution of stress into a uniform normal pressure, for which $3p=-(X_x+Y_y+Z_z)$, and a residual distribution of shearing stresses which would by themselves produce no volume change. This gives a general definition of pressure.

The Thin Plate.—The deformation of a thin plate bounded by plane surfaces $z=\pm h$ may in some cases be discussed with the aid of a theory of generalized plane stress, due to Louis Napoleon George Filon. It is assumed in this theory that Z_z is everywhere zero, and that the faces $z=\pm h$ are free from stress. Average values of u, X_x, etc., are defined by means of equations such as

$$2h\bar{u}=\int_{-h}^{h} u\,dz,$$

the bar over a symbol denoting that an average has been taken. Since X_z and Y_z vanish at $z=\pm h$, it is found that

$$\frac{\partial \overline{X}_x}{\partial x}+\frac{\partial \overline{X}_y}{\partial y}=0, \qquad \frac{\partial \overline{X}_y}{\partial x}+\frac{\partial \overline{Y}_y}{\partial y}=0;$$

and these equations may be satisfied, in the same way as in the earlier theory of Sir George Airy, by writing

$$\overline{X}_x=\frac{\partial^2\chi}{\partial y^2}, \qquad \overline{Y}_y=\frac{\partial^2\chi}{\partial x^2}, \qquad \overline{X}_y=-\frac{\partial^2\chi}{\partial x\partial y}.$$

The differential equation for χ may be found by first observing that

$$0=Z_z=\lambda\Delta+2\mu\frac{\partial w}{\partial z}=(\lambda+2\mu)\Delta-2\mu\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right).$$

This gives, on averaging,

$$(\lambda+2\mu)\overline{\Delta}=2\mu\left(\frac{\partial \bar{u}}{\partial x}+\frac{\partial \bar{v}}{\partial y}\right);$$

whilst the relations between stress and strain give

$$\overline{X}_x=\lambda\overline{\Delta}+2\mu\frac{\partial \bar{u}}{\partial x}, \qquad \overline{Y}_y=\lambda\overline{\Delta}+2\mu\frac{\partial \bar{v}}{\partial y}, \qquad \overline{X}_y=\mu\left(\frac{\partial \bar{v}}{\partial x}+\frac{\partial \bar{u}}{\partial y}\right)$$

The elimination of u and v now gives Airy's differential equation,

$$\frac{\partial^4\chi}{\partial x^4}+2\frac{\partial^4\chi}{\partial x^2\partial y^2}+\frac{\partial^4\chi}{\partial y^4}=0.$$

The quantities X_x, Y_y, X_y may be regarded as generalized components of stress, and $\frac{\partial \bar{u}}{\partial x}$, $\frac{\partial \bar{v}}{\partial y}$, $\frac{\partial \bar{v}}{\partial x}+\frac{\partial \bar{u}}{\partial y}$ as generalized components of strain. At each point of the plate there will be principal axes of generalized strain, and these may also be regarded as principal axes of generalized stress. If these are taken as axes of co-ordinates $\overline{X}_y=0$, and $\overline{X}_x$, $\overline{Y}_y$ become the *principal stresses* which will be denoted by the symbols P and Q.

Photoelastic Methods.—Many deductions from the theory have been confirmed by the photoelastic methods of research based upon the discovery, made by Sir David Brewster in 1816, that, when a piece of glass is loaded and viewed in polarized light under suitable conditions, it shows brilliant colour effects due to the fact that the glass has changed its optical properties and has become doubly refracting. Brewster suggested that the stress distribution in masonry bridges might be investigated by constructing glass models, and after many years the suggestion was followed up by Augustin Mesnager in Paris. By means of the apparatus devised by E. G. Coker it is possible to measure, to an accuracy of about 2%, the stress distribution, under any system of stress loads, in any body which can be represented by a plate model of transparent material stressed in its own plane.

Tests are frequently made with models cut from transparent celluloid, but a new transparent material, "phenolite," which appears to be superior to celluloid, has recently been developed in Tokyo by Z. Tuzi. The model is illuminated by plane polarized light, and an image of it projected on the screen through an analyser whose plane of polarization is perpendicular to that of the polarizer. All points at which the principal stresses are either parallel to or at right-angles to the plane of polarization are then readily determined, and, by rotating both polarizer and analyser simultaneously, the directions of the principal stresses can be found at every point of the specimen. The difference $P-Q$ can be found by the colour shown at the point in question when the model is illuminated by circularly polarized light. If either P or Q is zero, as in simple tension or compression, the intensity of stress may be derived from a colour scale, such as that given in the following table, or may be derived by comparison with a simple tension member of the same material subjected to a known stress. Usually the maximum stresses occur at the inner and outer edges of the material, and when these surfaces are not directly loaded the stress across a line at right angles to the boundary can be read off at once.

Colour Scale

Order	Colour	Stress
I.	Black	0
	Grey	3·5
	White	5·5
	Straw	8
	Orange	10
	Brick Red	10·5
	Purple	11
II.	Blue	13
	Yellow	18
	Red	21
	Purple	22

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ELASTICITY OF DEMAND. In economics, a term used to describe the condition of the market for a given commodity in respect of the reaction of demand to supply. Marshall (*Principles of Economics*) puts it that "the elasticity of demand in a market is great or small according as the amount demanded increases much or little for a given fall in price, and diminishes much or little for a given rise in price."

A commodity may at one and the same time, in the same market, be in "elastic demand" by the poor and "inelastic demand" by the rich. Thus, if bananas fell in price to ten a penny, the demand of the well-to-do would not alter, because they would need no more than when bananas were a penny or twopence each, but the demand of the poor would be "elastic," and a greatly increased quantity would be sold. For a discussion of supply and demand, *see* Economics.

ELATERITE, also termed elastic bitumen and mineral caoutchouc, an asphaltic pyrobitumen originally discovered in the Odin lead mines at Castleton, Derbyshire. It occurs in a few other localities, but always in small quantities and is merely of scientific interest. It varies somewhat in consistency, but is typically soft and elastic, often closely resembling india-rubber, and is a derivative of petroleum. A substance of similar physical character is found in the Coorong district of South Australia and is known as coorongite, but some doubt still exists as to whether this is a derivative of petroleum or a vegetable product.

ELATERIUM, a drug consisting of a sediment deposited by the juice of the fruit of *Ecballium Elaterium* (family Cucurbitaceae), the squirting cucumber, a native of the Mediterranean region. The plant grows like the vegetable marrow. The fruit resembles a small cucumber, and when ripe is turgid and separates easily from the stalk. On removal of the stalk the contents of the fruit are squirted through the aperture by the sudden contraction of the wall of the fruit. To prepare the drug the fruit is sliced lengthwise and slightly pressed; the greenish and slightly turbid juice thus obtained is strained and the deposit of elaterium formed after a few hours is collected on linen, rapidly drained, and dried on porous tiles at a gentle heat. Elaterium is met with in commerce in light, thin, friable, flat or slightly incurved opaque cakes, of a greyish-green colour, bitter taste, and tea-like smell.

The drug is soluble in alcohol, but insoluble in water and ether. The official dose is 1/10—½ grain, and the British pharmacopoeia directs that the drug is to contain from 20 to 25% of the active principle elaterinum or elaterin. Elaterin is extracted from elaterium by chloroform and then precipitated by ether as colourless scales. It has the formula $C_{20}H_{28}O_5$. The dose is 1/40—1/10 grain. Elaterium is the most active hydragogue purgative known, causing also much depression and violent griping. When injected subcutaneously it is inert, as its action is dependent upon its admixture with the bile. It must not be used except in urgent cases.

ELBA (Gr. Αἰθαλία; Lat. *Ilva*), island off the west coast of Italy, province of Leghorn, from which it is 45 m. south, and 7 m. southwest of Piombino, the nearest point of the mainland. Pop. (1921) 26,164. It is about 19 m. long, 6½ m. broad, and 140 sq.m. in area; its highest point is 3,340 ft. (Monte Capanne). It forms, like Giglio and Monte Cristo, part of a sunken mountain range extending towards Corsica and Sardinia.

The oldest rocks are schist and serpentine overlaid in the eastern part by Silurian and Devonian beds. The Permian may be represented, but the Trias is absent, and in general the older Palaeozoic rocks are overlaid directly by the Rhaetic and Lias. The Liassic beds are often metamorphosed and the limestones contain garnet and wollastonite. The Eocene shows nummulitic limestone, sandstone and schist; Miocene and Pliocene are absent. Serpentines, peridotites and diabases are interstratified with the Eocene deposits; granite, intruded through the Eocene beds, is associated with a pegmatite containing tourmaline and cassiterite. The celebrated iron ore is of Tertiary age and occurs indifferently in all the older rocks. These ores were worked by the ancients. Some of the ore is now dealt with on the island itself, and some at Piombino. The total iron production was 439,000 tons in 1925 (88% of the total for Italy). Granite was quarried by the Romans, but is not now much worked.

Parts of the island are fertile, and cultivation of vines, and tunny and sardine fishery employ part of the population. The capital is Portoferraio—pop. (1921) 6,018—in the centre of the north coast, enclosed by a mountain amphitheatre, the slopes of which are covered with villas and gardens. This is the best harbour, the ancient *Portus Argous*. The town was built and fortified by Cosimo I. in 1548, who called it Cosmopolis. Above the harbour, is the palace of Napoleon I., and 4 m. to the south-west is his villa; on the north slope of Monte Capanne is another of his houses. At Le Grotte, between Portoferraio and Rio dell' Elba, and at Capo Castello are Roman ruins.

Elba was famous for its mines in early times, and the smelting furnaces gave it its Greek name of Αἰθαλία ("soot island"), In 453 B.C. Elba was devastated by a Syracusan squadron. From the 11th to the 14th century it belonged to Pisa, and in 1399 came under the dukes of Piombino. In 1548 it was ceded by them to Cosimo I. of Florence. In 1596 Porto Longone was taken by Philip III. of Spain, and retained until 1709, when it was ceded to Naples. In 1802 the island was given to France. On Napoleon's deposition, the island was ceded to him with full sovereign rights, and he resided there from May 5, 1814, to Feb. 26, 1815. After his fall it was restored to Tuscany, and passed with it to Italy in 1860.

ELBASSAN, a town of Albania. Pop. (1924) about 16,000, of whom 85% are Muslims and the remainder Orthodox and Roman Catholics. Elbassan lies on a fertile plain amid wooded country and is surrounded by gardens; the climate is healthy and there is an excellent water supply. The Catholic Albanians live in the centre of the town within the ruined castle, outside are the Muslims, and beyond them the Vlachs who belong to the Orthodox Church. The town is fairly prosperous, with good public buildings and a large bazaar where rather shoddy foreign tinware, crockery and linen and cloth goods are sold. Olives and maize are cultivated. The valleys of the Semeni and Devoli afford communication with Berat, and there is a road to Durazzo, and also a light railway built by the Austrians. Elbassan was captured by the Serbs during the Balkan Wars (1912–13) but afterwards restored to Albania.

ELBE. The *Elbe* (*Albis* of the Romans, *Labe* of the Czechs), is a river of Central Europe, rising in Bohemia on the southern side of the Riesengebirge at an altitude of about 4,600 ft. The Elbseifen, after plunging down the 140 ft. of the Elbefall unites with the steep torrential Weisswasser at Mädelstegbaude. Thereafter the united stream of the Elbe pursues a southerly course, turning sharply to the west at Pardubitz and at Kolin bends gradually towards the north west. A little above Brandeis it picks up the Iser and at Melnik the volume of the stream is more than doubled by the Vltava (Moldau) which runs northwards through the heart of Bohemia; at Leitmeritz the Elbe receives the Eger. Thus augmented the Elbe carves a path through the basaltic mass of the Mittelgebirge through a deep narrow rocky gorge, then the river winds through the fantastically sculptured mountains of "Saxon Switzerland" (Bastei).

Shortly after crossing the Czechoslovakian frontier the stream assumes a north westerly direction, which it preserves on the whole all the way to the North Sea. After leaving Saxon Switzerland at Pirna, the Elbe rolls through Dresden, afterwards entering on its long journey across the north German plain, touching amongst other places, Wittenberg, Magdeburg and Hamburg, and gathering the waters of Mulde and Saale from the left and those of Schwarze Elster, Havel and Elde from the right. Above Hamburg the stream divides into Norder and Süder Elbe, linked together by several cross channels. At Blankenese, seven miles below Hamburg, all these branches have been re-united, and the Elbe, with a width of 4–9 miles between bank and bank, travels on between the green marshes of Holstein and Hanover until it becomes merged in the North Sea off Cuxhaven. The width is about

100 ft. at Kolin, 300 ft. at the mouth of the Vltava, 960 ft. at Dresden and over 1,000 ft. at Magdeburg. From Dresden to the sea the river has a total fall of only 280 ft. over a distance of about 430 miles. The tide advances as far as Geesthacht (100 miles from the sea). The river is navigable as far as Melnik (525 miles, of which 67 in Czechoslovakia). Its total length is 725 miles (190 in Czechoslovakia). The area of the drainage basin is estimated at 56,000 square miles.

Navigability.—Since 1842, but more especially since 1871, the riparian states have carried out works to increase the navigability of the Elbe. From the point of view of navigation on the Elbe-Vltava system, three different sections are to be distinguished. (1) The canalised section, (2) the regulated section and (3) the maritime section. The canalised section includes the Vltava from Prague to Melnik and the Elbe from Melnik to Lovosice. Shortly the canalisation will go as far as Usti, after finishing the Strekov dam. In this section, 115 km. long, the navigable channel has a minimum depth of 2m10. The normal largest type of barge now in use has a carrying capacity of 900 tons. The draft at full load does not exceed 1m80. This section of the river therefore meets all traffic requirements. The canalisation is effected by locks and movable dams, the latter so designed that in times of flood or frost they can be dropped flat on the bottom of the river. The regulated section between Usti and Hamburg, 649 km. long, has been regulated at middle water. The depth of the navigable channel varies according to the water level, which is dependent on general hydraulic conditions. The loading capacity of 900 ton barges can be fully utilized during about 220 days and for ¾ during about 80 days. (In 1925, owing to shortage of water, this period was considerably less.) The German programme for improvement works establishes a depth of 1m.25 below and 1m.10 above the Saale mouth at the lowest water level. Czechoslovakia also contemplates the improvement of its section below Usti. The maritime section between Hamburg, Härburg and the sea, long about 150 km., has an average depth of 9m.50. (Near Oste-bank 8 m. below average low water level.) Unremitting efforts are being made to meet the constantly increasing draught of vessels. All vessels can go up to Hamburg at high water.

Canals of the Elbe River System.—During the last quarter of the 19th century some 100 miles of canal were dug for the purpose of connecting the Elbe through the Havel and the Spree with the Oder system; the Spree has also been canalized for 28 miles. Since 1900 Lübeck has been in direct communication with the Elbe to Lawenburg by the Elbe-Trave Canal, length 42 miles, width 12 ft. at the bottom and 105 to 126 ft. at the top: minimum depth 8½ ft., equipped with 7 locks each 80 m. long, and with a gate width of 12 m. (See *Der Bau des Elbe-Trave Canals und seine Vorgeschichte* [Lübeck 1900]; Dr. Emil Hammermann *Der Elbe-Trave-Kanal* [Jena, Fischer, 1914].) The Mittelland Canal (*see* INLAND WATER TRANSPORT), last part (Hanover-Magdeburg) of which is now under construction, will establish water communication between the Elbe and Rhine systems.

Traffic.—The traffic on the Elbe cannot rival the Rhine, particularly in so far as heavy goods transport is concerned. The principal heavy goods on the Elbe are lignite and potash. The Elbe has not many important tributaries (only Saale and Havel are of some importance). The main sphere of activity for navigation is therefore the river itself. This fact increases the importance of the transhipment places for the hinterland. It is to be expected that the completion of the Mittelland Canal and of the canalisation of the Saale with canals to Leopoldshall-Leipzig, will tend to diminish this importance, particularly with regard to transhipment places on the middle Elbe. The principal commodities in Elbe traffic are potash and other salts, sugar, paper, ore, glass and glassware, raw steel, bauxite, iron pyrites, phosphates, timber, cereals, fertilizers, oils, fats and beer.

Before the World War the Elbe carried considerably more goods than the competing railways, the general direction of which is parallel to the river, and this notwithstanding an important number of exceptional tariffs for consignments by rail to and from sea ports. Out of Hamburg export by sea of goods from the upper Elbe region 5·2 million arrived by rail; 4·6 million tons by water (47 per cent). Out of Hamburg import of goods for the upper Elbe region 2·6 million tons went by rail, 5·8 million tons (69%) by water. Corresponding figures for the present period are: 1925 (1927): *exports,* rail 3·9 million tons (5·9), water 3·2 (3·5) or 45% (37%): *imports,* rail 3·3 million tons (3·9) water 3·1 (4·6) or 48% (54%). These figures show that rail competition has become important, but it should be observed that whilst the proportion of water-traffic in down-stream direction is still decreasing water-traffic in up-stream direction shows an increase, both absolute and relative. Before the war there were several competing railway systems. Thus the Saxon railways favoured transhipment in Saxon ports by special rates, which to a certain degree counter-balanced the influence of exceptional seaport rates. All exceptional tariffs were abolished during the war. Afterwards the peace treaties prohibited Germany for a time from granting special tariffs either for river or seaports.

After the World War the various German railway systems were amalgamated and there no longer existed an interest for the railway to favour transhipment in river ports. Moreover in 1920 the German railways introduced the system of long distance rebate rates and sometime ago re-established exceptional tariffs for seaports, but not for river ports. It should be observed also that the falling off in down-stream traffic is also partly due to change in economic conditions, *e.g.,* a considerable decrease in timber floating and in coal exports from Bohemia. Only in 1926 (British coal strike) did the figure for coal exports from Czechoslovakia approach the pre-war figure. In order to meet railway competition the shipping companies formed a combine, which for the greater part of the time only applied to down-stream traffic. The results have been fairly satisfactory, and although the railways captured part of the heavy goods traffic from the waterway the latter were able to secure the transport of certain classes of valuable goods.

Czechoslovakia has a considerable interest in Elbe navigation. For 1926: Out of a total of 6,385 vessels crossing the German Czechoslovak frontier (both directions together) 1,804 sailed under the Czechoslovakian flag. Of all the vessels entering and leaving the ports of Dresden and Riesa 10% or over were Czechoslovakian and the proportion of the Czechoslovak flag in the movements of vessels entering or leaving the ports of Hamburg, Harburg and Altona from or to up-stream was over 5%. For the same year the total exports of Czechoslovakia via the Elbe amounted to 1,529,000 tons (550,000 tons of sugar); in addition 112,000 tons of timber were floated. Its total imports via the Elbe for the same period amounted to 556,000 tons.

The total quantity of goods transported on the international river system exceeded 10,400,000 tons, which constitutes an increase of 2,280,000 tons over the 1925 figures, or 28%. The intercourse between the Elbe and the principal waterways connected with it was, for the Saale 369,000 tons, for the Havel about 3 million tons, for the Trave Canal 1,226,000 tons. Generally speaking river navigation begins and ends in the ports of Hamburg, Harburg and Altona. (For figures giving the despatches and arrivals of goods *see* below).

Ports.—In Czechoslovakia: *Holesovic.*—Total movement of goods 1926, 158,000 tons, principally traffic in downstream direction. *Melnik.* 255,000 tons, mainly downstream. *Usti.* 860,000 tons, increase of 66% over 1925 (British Coal Strike). The transhipment traffic before the war was over 2 million tons. It fell to ½ million tons after the war, but is now again increasing. *Loubí-Decin,* 282,000 tons (138,000 less than 1925). These ports used to be very important transhipment places, but have lost a good deal of traffic.

In Germany: *Dresden.*—Besides the important König Albert Harbour, there are old and new town quays, and the Prieschner Harbour traffic amounted to 574,000 tons in 1926, showing an increase of almost 100,000 tons over the preceding year. *Riesa* is an important place for transhipment from water to rail, and vice versa. In 1926, traffic in downstream direction amounted to 230,000 tons, in upstream direction to 423,000 tons. ***Dessau-Wallwitz,*** total traffic 318,000 tons. ***Aken,*** total traffic 358,000 tons. *Schöne-*

beck, total traffic 471,000 tons. For the last two ports traffic in downstream direction amounts to 89% of the total traffic. *Magdeburg,* the most important Elbe port after Hamburg, for 1926 total arrivals of goods, 586,000 tons, total despatches, 575,000 tons. The ports complex of *Hamburg, Harburg and Altona* show a total of arrivals from upstream of 5,050,000 in 1926 (3,382,000 in 1925); total of despatches in upstream direction for the same period, 3,724,000 (3,874,000). The port complex of Hamburg is, of course, much more important as a *maritime port.* In 1913, over 15,000 vessels with a net tonnage of 14·2 million reg. tons, visited the Port of Hamburg; imports amounted to 16·6 million tons; exports to 8·9 million tons net. After the war there was a very considerable fall-off of traffic. In 1919, for instance, only 2,800 vessels (1·6 million reg. tons) called at the Port. Imports and exports together only reached a figure of 2·3 million tons. From then the Port statistics show a constant and important increase of traffic. Already in 1923, the total net tonnage of 1913 is surpassed (15·3 million reg. tons). Imports and exports for the same year amounted to 21 million tons. The figures for the years 1926 and 1927 are:

	Number of vessels	Net tonnage	Imports of goods	Exports of goods
		Million reg. t.	Million tons	Million tons
1926 . .	14,788	17·4	10·7	10·6
1927 . .	16,011	19·6	16·8	8·3

These figures show that the goods traffic reached the pre-war figures at the same time. The movement of vessels shows an increase of 1,000 in number and 5·4 million reg. tons. The proportion of vessels under German flag is now 41·5% (1913: 60%). For the shipping industry, the present development is far from favourable in comparison with pre-war times, but the increased traffic of vessels is all to the interest of commerce, since the number of arrivals and departures of vessels has become much greater.

International Régime.—Under Article 331 of the Treaty of Versailles, the Elbe from its confluence with the Vltava (Moldau) was declared international. The administration of its system was entrusted to an International Commission composed of four representatives of the German Riparian States, two of Czechoslovakia and one each of Great Britain, France, Italy and Belgium. This Commission drew up the Navigation Act signed at Dresden, February 22nd, 1922 (*League of Nations Treaty Series,* volume XXVI. No. 649, 1924). The Commission has to provide for freedom of navigation and equality of treatment; to take decisions on complaints arising out of the application of the Act; to see that the navigable waterway is kept in good condition and to supervise improvements. Its jurisdiction may be extended, subject to the unanimous consent of the Commission, by decision of the riparian State or States concerned. A Supplementary Convention signed at Prague, January 27th, 1923, laid down detailed regulations for navigation tribunals and for appeal. The headquarters of the commission are at Dresden. It holds one or two sessions a year.

Tolls.—In the days of the old German Empire no fewer than 35 different tolls were levied between Melnik and Hamburg, to say nothing of the special dues and privileged exactions of various riparian owners and political authorities. By the Elbe Navigation Act of 1822, concluded between the various riparian States, a definite number of tolls at fixed rates was substituted for the often arbitrary tolls which had been exacted previously. Still further relief was afforded in 1844 and 1850, and in 1863 the number of tolls was reduced to one, levied at Wittenberg. Finally, in 1870, 1,000,000 thalers were paid to Mecklenburg and 85,000 thalers to Anhalt, which thereupon abandoned all claims to levy tolls upon the Elbe shipping, and thus navigation on the river became at last entirely free.

A Bill adopted by the Reich in 1911 introduced taxes on navigation on German waterways with the exception, however, of the international rivers on which taxes had been abolished by international agreement. During the World War Germany established a general tax on transport (Verkehrssteuer) which was also levied on goods transported on the Rhine and the Elbe. Owing to protests, however, of foreign Governments concerned this tax was abolished for Rhine and Elbe transport. The new Navigation Act provides that the International Commission may exceptionally and under certain conditions authorise the levying of taxes in order to cover the cost of important works of improvement. The taxes should, however, not be higher than the service rendered.

Fish.—The river is well stocked with fish, both salt-water and fresh-water species. Of the many varieties the kinds of greatest economic value are sturgeon, shad, salmon, lampreys, eels, pike and whiting.

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ELBERFELD, a manufacturing town of Germany, in the Prussian Rhine province, on both sides of the deep valley of the Wupper, and immediately west of and contiguous to Barmen (*q.v.*). Pop. (1925) 167,025. Local intercommunication is provided by an electric tramway line and a hanging railway—on the Langen mono-rail system—over the bed of the river. In the centre are a number of irregular and narrow streets, but many insanitary dwellings have been replaced by fine blocks. The schools include the Gymnasium (founded in 1592 by the Protestant community as a Latin school), an industrial drawing school and a commercial school. There are also a theatre, an institute of music, a museum, a zoological garden. The majority of the inhabitants are Protestant, with a strong tendency towards Pietism; but the Roman Catholics form about one-fourth of the total population. Elberfeld is the chief centre in Germany of textile manufactures and haberdashery of all descriptions, of dyes, and of fine chemicals. Leather and rubber goods, machinery, wall-paper, and stained glass are also among its staple products. On the south side of the valley is the main line from Aix-la-Chapelle, Cologne and Düsseldorf to central Germany and Berlin, on the north are many railway connections with the Ruhr Valley.

The 12th century castle of the lords of Elberfeld, feudatories of the archbishops of Cologne, passed later to the counts of Berg. A colony of bleachers, attracted by the clear waters of the Wupper, were granted in 1532 the exclusive privilege of bleaching yarn. It was not, however, until 1610 that Elberfeld was raised to the status of a town, and in 1640 was surrounded with walls. In 1760 the manufacture of silk was introduced, and dyeing with Turkey-red in 1780; but it was not till the end of the century that its industries developed into importance under the influence of Napoleon's continental system, which barred out British competition. In 1815 Elberfeld was assigned by the congress of Vienna, with the grand duchy of Berg, to Prussia, and its prosperity rapidly developed under the Prussian Zollverein.

ELBERFELD POOR RELIEF SYSTEM. This system was first identified with the town of Elberfeld in Rhenish Prussia, but has since been introduced into many of the large German towns and called after the place of its origin. The essence of the system is that it seeks to prevent pauperism and not merely to relieve the poverty of the moment. It is not purely charitable; it is also disciplinary and educational. In fact, amongst the duties that are imposed upon the Elberfeld administrators are "investigation into the conditions of the poorer classes of the population and the causes of their poverty; and the adoption of effectual

preventive and remedial measures, or the recommendation of these to the municipal administrative authority."

The Elberfeld system dates back more than 120 years, although it was only placed upon its present footing in 1853. The relief of the poor in Elberfeld up to the end of the 18th century rested in the hands of the Churches, which administered voluntary contributions and donations. This charity was so freely distributed that mendicants became a danger to public morality and order. The labouring class found it comparatively easy to live by doles rather than work. Even high wages were not a sufficient inducement to prevent able-bodied men from living a life of idleness. In 1800 sufficient experience had been gained to enable an orderly system of poor relief to be set up. This consisted in a committee or board of six citizens and the principles adopted for the guidance of this board were:—

(1) Only really destitute people should be relieved.
(2) Such destitute people should be visited frequently.
(3) Relief should not exceed the necessaries of life.
(4) Every recipient of relief should be obliged to do work suited to his capacity in return for the help given.

The Elberfeld system was modified from time to time owing to the great increase in the size of the town and the necessity of centralizing relief in public hands. The main principles however have not changed. The system followed is due in the main to three men—Daniel von der Heydt, David Peters and Gustav Schlieper. In 1852 the burden of poor relief had become almost intolerable following on severe industrial and commercial depression. The plan was devised of dividing work and responsibility so far as possible. Herr von der Heydt organized the poor relief of the town in such a way that for every four recipients of assistance there was an almoner whose duty it was not only to keep the central authority acquainted with the circumstances of the poor under his charge, but also to help by personal influence and advice those in distress. It is this in the main which is the distinguishing feature of the Elberfeld System and experience has shown that the method has succeeded where the British poor law has failed. Berlin, Cologne, Crefeld, Dresden, Stuttgart and many other towns have adopted the same system, with such modifications as local circumstances have rendered necessary. The Elberfeld System recognizes two kinds of poverty, the one due to incapacity and the other to unemployment. The first kind of paupers have an unconditional claim to relief providing that those who are responsible, such as relatives, cannot supply their needs. The second may and must if possible be given work suited to their powers. The "Instruction" is interesting. "The needy but capable person, if he, or another on his behalf, applies for aid, and if he can prove that he has honestly but in vain endeavoured to obtain work and support himself, may be temporarily supported until he can earn a sufficient income, in so far as others are not liable and able to maintain him, or voluntary charity does not supply his needs; but he is bound to do such work, suited to his capacity, as may be allotted to him."

Citizen Almoners Compelled to Serve.—The relief itself is of two kinds, out-door relief (*Offene*) and closed relief (*Geschlossene*) which means maintenance in public institutions for the poor. Outdoor relief is given in money, food, clothing, furniture, medical assistance or tools. The general work of administration is in the hands of a body of nine men appointed by the municipal council and consisting of the mayor for the time being, four members of the council and four private citizens chosen by the Council, each for a period of three years. The town is divided into 39 districts (*Bezirke*) and these districts are again subdivided into 14 circuits (*Kreise*) each district has a superintendent (*Bezirksvorsteher*) and there is an almoner (*Armenpflege*) for each circuit, making 546 almoners in all.

Service in this department of public work is obligatory on every duly qualified citizen who may be nominated to it and in the event of illness the almoner is required to provide an efficient substitute. The money needed for relief is paid to the district superintendents at the periodic sittings of the Poor Administration and they allot it as required. On the other hand, food, clothing and such articles as are needed are procured from the Poor House. No orders are given on the local tradesmen. Each almoner has charge of a certain number of houses and is responsible for the care of the poor in those houses. Since the number in his care is strictly limited, he is able to make the personal acquaintance of each applicant for relief and to investigate the conditions under which they live. As a rule an almoner must not have more than four cases to look after at any one time and he must visit them in their own homes at least once a fortnight.

The Elberfeld system differs from the poor law administration in England in one important respect; indoor relief is not adopted as a test of destitution. It is true that this is no longer in every case the actual practice in England, but the theory remains the same. In any case under the Elberfeld system relief is only given where the applicant's earnings fail to provide the absolute necessaries of life, and in order to determine when this point has been reached a "standard of income" has been laid down which of course varies from time to time and has been changed since the World War. Tested by its results, it must be conceded that the Elberfeld system has been a success, and although the War caused its break-down, in normal times it reduces mendicancy to a minimum, diminishes pauperism, and encourages provident habits and a desire for honourable employment. (P. A.)

ELBERTON, a city of north-eastern Georgia, U.S.A., 10m. from the Savannah river; the county seat of Elbert county. It is served by the Elberton and Eastern, the Seaboard Air Line, and the Southern railways. The population was 6,475 in 1920 (37% negroes). The region produces especially cotton, grain, clovers, alfalfa and peaches. There are many granite quarries in the vicinity, and the city manufactures cotton drills and denims, cotton-seed oil and artificial silk. It was founded about 1790.

ELBEUF, a town of northern France in the department of Seine-Inférieure, 14 m. S.S.W. of Rouen by the Ouest-État railway. Pop. (1926) 17,325. Elbeuf, a town of wide, clean streets, with handsome houses and factories, stands on the left bank of the Seine at the foot of hills over which extends the forest of Elbeuf. Elbeuf was, in the 13th century, the centre of an important fief held by the house of Harcourt, but its previous history goes back at least to the early years of the Norman occupation, when it appears under the name of Hollebof. It passed into the hands of the houses of Rieux and Lorraine, and was raised to the rank of a duchy in the peerage of France by Henry III. in favour of Charles of Lorraine (d. 1605), grandson of Claude, duke of Guise, master of the hounds and master of the horse of France. The last duke of Elbeuf was Charles Eugène of Lorraine, prince de Lambesc, who died in 1825. The churches of St. Étienne and St. Jean, both Renaissance with later additions, preserve 16th century stained glass. A tribunal and chamber of commerce, a board of trade-arbitrators, a school of industry and a school of cloth manufacture are among its institutions. The town with its suburbs, Orival (pop. 1,019), Caudebec-lès-Elbeuf (8,856), St. Aubin (3,971) and St. Pierre (3,029), is one of the principal and most ancient seats of the woollen manufacture in France. As a river-port it has a brisk trade in the produce of the surrounding district as well as in the raw materials of its manufactures, especially in wool from La Plata, Australia and Germany.

ELBING, a seaport town of Germany, in the Province of East Prussia, on the Elbing, 5 m. above the Frische Haff. Pop. (1925) 67,762. Elbing originated as a colony of traders, from Lübeck and Bremen, which established itself under protection of a castle of the Teutonic Knights, built in 1237. In 1246 the town acquired "Lübeck rights," *i.e.*, the full autonomy conceded by the charter of the emperor Frederick II. in 1226 (*see* LÜBECK), and it was early admitted to the Hanseatic League. In 1454 the town repudiated the overlordship of the Teutonic Order, and placed itself under the protection of the king of Poland, becoming the seat of a Polish voivode. From 1560 to 1626 it was the seat of the English Eastland Company, and the sole emporium for English goods on the Baltic. Later its decline was hastened by the wars of the early 18th century. In 1772, when it fell to Prussia through the first partition of Poland, it was utterly decayed. The

town is connected by canals to the Vistula and to lakes Geserich and Drewenz. The old town was formerly surrounded by fortifications, but of these only a few fragments remain. The Marienkirche dates from the 15th century and is as restored in 1887. The classical school was founded in 1536. The town-hall (1894) contains a historical museum.

The great Schichau iron-works in Elbing make locomotives and machinery. In addition to this there are important iron foundries, and manufactories of cigars, lacquer and metal ware, ploughs, sugar, organs, etc. There is a considerable trade also in agricultural produce.

ELBOW, in anatomy, the articulation of the *humerus*, the bone of the upper arm, and the *ulna* and *radius*, the bones of the forearm (*see* JOINTS). The word is thus applied to things which are like this joint in shape, such as a sharp bend of a stream or river, an angle in a tube, etc.

ELBURZ, more correctly **ELBRUZ,** a chain of mountains, separating the Caspian depression from the Persian highlands, and extending without any break for 650 m. from the western shore of the Caspian Sea to north-eastern Khurasan. According to the direction, or strike, of its principal ranges the Elburz may be divided into three sections: the first 120 m. in length with a direction nearly N. to S., the second 240 m. in length with a direction N.W. to S.E., and the third 290 m. in length striking S.W. to N.E. The first section, which is connected with the system of the Caucasus, and begins west of Lenkoran in 39° N. and 49° E., is known as the Talish range and has several peaks 9,000 to 10,000 ft. in height. It runs almost parallel to the western shore of the Caspian, and west of Astara is only 10 or 12 m. distant from the sea. At the point west of Resht, where the direction of the principal range changes to one of N.W. to S.E., the second section of the Elburz begins, and extends from there to beyond Mount Damavand, east of Tehran. South of Resht this section is broken through at almost a right angle by the Safid Rud (White river), and along it runs the motor road between the Caspian and inner Persia, Resht-Kazvin-Tehran. The Elburz then splits into three principal ranges running parallel to one another and connected at many places by secondary ranges and spurs. Many peaks of the ranges in this section have an altitude of 11,000 to 13,000 ft., and the elevation of the passes leading over the ranges varies between 7,000 and 10,000 ft. The highest peaks are situated in the district of Talikan, N.W. of Tehran, and thence eastwards to beyond Mount Damavand. The part of the Elburz immediately north of Teheran is known as the Kuh i Shamran (from the name of the Shamran district on its southern slopes) and culminates in the Sar i Tuchal (12,600 ft.). Beyond it, and between the border of Talikan in the N.W. and Mount Damavand in the N.E., are ranges with elevations of 12,000 to 13,500 ft., while Damavand towers above them all with its altitude of 18,600 ft. The eastern foot of Damavand is washed by the river Harhaz, which there breaks through the Elburz in a S.-N. direction in its course to the Caspian, past the town of Amul. The third section of the Elburz, with its principal ranges striking S.W. to N.E., has a length of about 290 m., and ends some distance beyond Bujnurd in northern Khurasan, where it joins the Ala Dagh range, which has a direction to the S.E., and, continuing with various appellations to northern Afghanistan, unites with the Paropamisus range. This section of three principal ranges has many peaks over 10,000 ft. in height, and the Nizva mountain on the southern border of the unexplored district of Hazar Jarib, north of Samnan, and the Shah Kuh, between Shahrud and Astarabad, have an elevation exceeding 13,000 ft. Beyond Khush Yailaq, with an elevation of 10,000 ft., are the Kuh i Buhar (8,000) and Kuh i Suluk (8,000), which latter joins the Ala Dagh (11,000).

The northern slopes of the Elburz and the lowlands which lie between them and the Caspian, and together form the provinces of Gilan, Mazandaran and Astarabad, are covered with dense forest and traversed by hundreds of perennial rivers and streams. The breadth of the lowlands between the foot of the hills and the sea is from 2 to 25 m., the greatest breadth being in the meridian of Resht in Gilan, and in the districts of Amul, Sari and Barfurush in Mazandaran. The inner slopes and ranges of the Elburz south of the principal watershed, generally the central one of the three principal ranges which are outside of the fertilizing influence of the moisture brought from the sea, have little or no natural vegetation, and those farthest south are, excepting for a few stunted cypresses, completely arid and bare.

The higher ranges of the Elburz are snow-capped for the greater part of the year, and some, which are not exposed to the refracted heat from the arid districts of inner Persia, are rarely without snow. Water is plentiful, and situated in well-watered valleys and gorges are innumerable flourishing villages, with extensive cultivated fields, orchards and pastures, and at higher altitudes small plateaus, under snow until March or April, afford cool camping grounds to the nomads of the plains, and luxuriant grazing to their sheep and cattle during the summer. The Elburz mountains are said to abound in mineral wealth, particularly coal, lead and iron.

See L. S. Fortescue, "The Western Elburz and Persian Azerbaijan," *Geog. Jour.*, vol. lxiii., pp. 301–318 (London, 1924).

EL CANO, JUAN SEBASTIAN DEL (d. 1526), Spanish navigator, was born in Guetaria. He commanded one of the five vessels in the famous expedition of Magellan, and in 1521, on Magellan's death, became chief. He visited the Moluccas and returned to Spain on Sept. 8, 1522, having been the first to circumnavigate the globe. He died on the expedition to Loaisa which had set sail on July 25, 1525.

See F. Navarette, *Coleccion de documentos ineditos*, t. i. (1842); O. Koelliker, *Die Erste Erdumseglung etc.* (Munich, 1908); A. M. Alvarez, *Juan Sebastian del Cano* (1923).

EL CENTRO, a city of southern California, U.S.A., 10m. from the Mexican border; the county seat of Imperial county. It is on Federal highway 80, at the southern terminus of number 99, and is served by the Southern Pacific railway. The population in 1920 was 5,464, and was estimated locally at over 11,000 in 1928. The city lies 51ft. below sea-level, in the midst of the Imperial valley, which has been transformed by irrigation from a barren desert into extraordinarily fertile farmland. Alfalfa, cantaloupes, lettuce, grape-fruit, asparagus and dates are among the distinctive products. Stock-raising and dairying also are important industries, and there are creameries in the city. The growing season extends through the entire year, and some crop is harvested every month. There is a petrified forest near Dixieland, 20m. W., and Painted Canyon is 23m. W. by north. El Centro was settled in 1906, and was incorporated as a city in 1907.

ELCHE, town in eastern Spain, province of Alicante, on the river Vinalapo and the Murcia–Alicante railway. Pop. (1920) 33,167. Elche contains no building of high architectural merit, except, perhaps, the collegiate church of Santa Maria, with its lofty blue-tiled dome and fine portico. Its narrow streets and flat-roofed, whitewashed houses, however, and, above all, the innumerable date-palms, give the city, standing on a low hill in the midst of a sandy plain, a strikingly oriental aspect. Date cultivation in the country is almost limited to this locality, where it is the chief occupation, and though the dates are inferior to those of the Barbary States, large quantities are exported. The blanched fronds are also sold for Palm Sunday processions, and when blessed by the priest are regarded throughout Spain as certain defences against lightning. Other products are pomegranates, figs, olives, almonds and cereals, and Elche manufactures oil, soap flour, esparto fabrics and many leather and rope-soled shoes for export. The harbour is Santa Pola (pop. 4,022), 6 m. E.S.E., where the Vinalapo enters the Mediterranean.

Elche, probably the Iberian *Helike* and the Roman *Ilici* or *Illici*, was held from the 8th to the 13th century by the Moors, who gave it the irrigation system on which its wealth depends. In 1332 it was finally captured by the Spaniards.

ELCHINGEN, a village of Germany, in Bavaria, not far from the Danube, 5m. N.E. from Ulm. Here, on Oct. 14, 1805, the Austrians under Riesch were defeated by the French under Ney, who by taking the bridge decided the day and gained for himself the title of duke of Elchingen. (*See* NAPOLEONIC CAMPAIGNS.)

ELDAD BEN MAHLI, also surnamed HAD-DANI, or the Danite, Jewish traveller, was the supposed author of a Jewish

travel narrative of the 9th century A.D. The story, which is highly fictitious, describes how Eldad set out to visit the Jews in Africa and Asia, and fell into the hands of cannibals. Saved by his leanness, he was captured by another tribe, with whom he spent four years before being ransomed by a Jewish merchant. He then describes his visits to the dwelling-places of the lost tribes. Issachar he found in the mountains of Media, Zabulon and Reuben near the Paran mountains, Ephraim and half Manasseh near Mecca, and Simeon and the other half of Manasseh in Chorazin. Dan, Napthali, Asher and Gad had founded an independent kingdom in the gold land of Havilla beyond Abyssinia, whither also Levi had come from near Babylon.

The real Eldad, to whom this work is ascribed, was a celebrated Jewish traveller and philologist, fl. *c.* 830–890. Born in Arabia, Palestine, or Media, he travelled in Mesopotamia, northern Africa, and Spain, spent several years in Tunis, and died at Córdova.

Epstein and D. A. Müller suggest a relationship between the letter of Prester John and the narrative of Eldad, but the affinity is not close. Eldad is quoted as an authority on linguistic points by the leading Jewish philologists of the time.

BIBLIOGRAPHY.—The work ascribed to Eldad is in Hebrew, divided into six chapters, probably abbreviated from the original text. The first edition appeared at Mantua about 1480; the second at Constantinople in 1516; this was reprinted at Venice in 1544 and 1605, and at Jessnitz in 1722. A Latin version by Gilb. Génébrard was published at Paris in 1563, under the title of *Eldad Danius . . . de Judaeis clausis eorumque in Aethiopia . . . imperio,* and was afterwards incorporated in the translator's *Chronologia Hebraeorum* of 1584; a German version appeared at Prague in 1695, and another at Jessnitz in 1723. In 1838 E. Carmoly edited and translated a fuller recension which he had found in a ms. from the library of Eliezer Ben Hasan, forwarded to him by David Zabach of Morocco (see *Relation d'Eldad le Danite,* Paris, 1838). Both forms are printed by Dr. Jellinek in his *Bet-ha-Midrasch,* vols. ii. p. 102, etc., and iii. p. 6, etc. (Leipzig, 1853–55). *See* also Bartolocci, *Bibliotheca magna Rabbinica,* i. 101–130; Fürst, *Bibliotheca Judaica,* i. 30, etc.; Hirsch Graetz, *Geschichte der Juden* (3rd ed., Leipzig, 1895), v. 239–244; Rossi, *Dizionario degli Ebrei;* Steinschneider, *Cat. librorum Hebraeorum in bibliotheca Bodleiana,* cols. 923–925; Kitto's *Biblical Cyclopaedia* (3rd ed., *sub nomine*); Abr. Epstein, *Eldad ha-Dani* (Presburg, 1891); D. H. Müller, "Die Recensionen und Versionen des Eldad-Had-dani," in *Denkschriften d. Wiener Akad.* (Phil.-Hist. Cl.), vol. xli. (1892), pp. 1–80; C. C. Rossini, "Leggende geografiche guidaiche del IX. secolo (il Sefer Eldad)," *Reale soc. geografica italiana,* Serie 6, vol. ii., pp. 160–190 (Roma, 1925).

ELDER, the name given at different times to a ruler or officer in certain political and ecclesiastical systems of government.

1. The office of elder is in its origin political and is a relic of the old patriarchal system. The unit of primitive society is always the family; the only tie that binds men together is that of kinship. With the development of civilization there came a time when age ceased to be an indispensable condition of leadership. The old title was, however, generally retained, *e.g.,* the γέροντες so often mentioned in Homer, the γερουσία of the Dorian states, the *senatus* and the *patres conscripti* of Rome, the sheikh or elder of Arabia, the alderman of an English borough, the *seigneur* (Lat. *senior*) of feudal France.

2. It was through the influence of Judaism that the originally political office of elder passed over into the Christian Church and became ecclesiastical. The Israelites inherited the office from their Semitic ancestors (just as did the Moabites and the Midianites, of whose elders we read in Numbers xxii. 7), and traces of it are found throughout their history. During the sojourn in the wilderness the elders were the intermediaries between Moses and the people, and it was out of the ranks of these elders that Moses chose a council of seventy "to bear with him the burden of the people" (Numbers xi. 16). The elders were the governors of the people and the administrators of justice. The powers of the elders were gradually curtailed by the development of the monarchy, by the appointment of special judges and the use of the priestly orders.

3. The name "elder" was probably the first title bestowed upon the officers of the Christian Church—since the word deacon does not occur in connexion with the appointment of the Seven in Acts vi. Its universal adoption is due not only to its currency amongst the Jews, but also to the fact that it was frequently used as the title of magistrates in the cities and villages of Asia Minor. For the history of the office of elder in the early Church and the relation between elders and bishops *see* PRESBYTER.

4. In modern times the use of the term is almost entirely confined to the Presbyterian church, the officers of which are always called elders. According to the Presbyterian theory of church government, there are two classes of elders—"teaching elders," or those specially set apart to the pastoral office, and "ruling elders," who are laymen, chosen generally by the congregation and set apart by ordination to be associated with the pastor in the oversight and government of the church.

See W. R. Smith, *History of the Semites;* H. Maine, *Ancient Law;* E. Schürer, *The Jewish People in the Time of Christ;* J. Wellhausen, *History of Israel and Judah;* G. A. Deissmann, *Bible Studies,* p. 154; and *see* PRESBYTERIANISM.

ELDER, the popular designation of the deciduous shrubs and trees constituting the genus *Sambucus* of the family Caprifoliaceae. The common elder, *S. nigra,* is found in Europe, north Africa, western Asia, the Caucasus and southern Siberia; in sheltered spots it attains a height of over 20 ft. The bark is smooth; the shoots are stout and angular, and the leaves glabrous, pinnate, with oval or elliptical leaflets. The flowers, which form dense flat-topped clusters (corymbose cymes), with five main branches, have a cream-coloured, gamopetalous, five-lobed corolla, five stamens and three sessile stigmas; the berries are purplish-black, globular and three- or four-seeded, and ripen about September. The elder thrives best in moist, well-drained situations, but can be grown in a great diversity of soils. It is found useful for making screen-fences in bleak, exposed situations, and also as a shelter for other shrubs in the outskirts of plantations. By clipping two or three times a year, it may be made close and compact in growth. The young trees furnish a brittle wood, containing much pith; the wood of old trees is white, hard and close-grained, polishes well, and is employed for shoemakers' pegs, combs, skewers, mathematical instruments and turned articles. Young elder twigs deprived of pith have from early times been in request for making whistles, popguns and other toys.

BY COURTESY OF THE ROYAL HORTICULTURAL SOCIETY

BRANCHES OF THE COMMON ELDER (SAMBUCUS NIGER) SHOWING (A) INFLORESCENCE AND (B) BERRIES, FROM WHICH WINE IS MADE

Several varieties of *S. nigra* are known in cultivation: *aurea,* golden elder, has golden-yellow leaves; *laciniata,* parsley-leaved elder, has the leaflets cut into fine segments; *rotundifolia* has rounded leaflets; forms also occur with variegated white and yellow leaves, and *virescens* is a variety having white bark and green-coloured berries.

The elder was known to the ancients for its medicinal properties, and in England the inner bark was formerly administered as a cathartic. The flowers contain a volatile oil, and serve for the distillation of elder-flower water, used in confectionery, perfumes and lotions. The leaves are employed to impart a green colour to fat and oil, and the berries for making wine, a common adulterant of port. The leaves and bark emit a sickly odour, believed to be repugnant to insects. According to German folklore, the hat must be doffed in the presence of the elder-tree; and in certain of the English midland counties a belief was once prevalent that the cross of Christ was made from its wood. It was, however, a common mediaeval tradition that the elder was the tree on which Judas hanged himself. In Denmark the tree was supposed by the superstitious to be under the protection of the "Elder-mother": its flowers may not be gathered without her leave; its wood must not be employed for any household furniture; and a child sleeping in an elder-wood cradle would certainly be

strangled by the Elder-mother.

The scarlet-berried elder, *S. racemosa,* is the handsomest species of the genus. It is a native of various parts of Europe, Asia and North America, growing in Britain to a height of over 15 ft., but often producing no fruit. The dwarf elder or danewort (supposed to have been introduced into Britain by the Danes), *S. Ebulus,* a common European species, reaches a height of about 6 ft. Its cyme is hairy, has three principal branches, and is smaller than that of *S. nigra;* the flowers are white tipped with pink.

Besides the red-berried elder, found in rocky soil from Newfoundland to Alaska and southward to Georgia and California, several other species are native to North America. The best known of these is the American or sweet elder (*S. canadensis*), common in moist soil from Nova Scotia to Manitoba and south to Florida, Texas and the West Indies, with deep-purple or black edible fruit. The blue elder (*S. glauca* or *S. caerulea*), found from British Columbia to Montana south to Lower California and New Mexico, usually a thicket bush 6 ft. to 10 ft. but sometimes a tree 25 ft. high, bears blue fruit covered with a white bloom.

ELDON, JOHN SCOTT, 1st Earl of (1751–1838), Lord High Chancellor of England, was born at Newcastle on June 4, 1751. His father was a coal-broker in Newcastle who had made a fortune. He was educated at Newcastle Grammar school, and was to have been apprenticed to his father's business, but his brother William (afterwards Lord Stowell) interfered to send him to University college, Oxford, where he won the English Essay prize, and graduated in 1770 and took a fellowship. He destroyed his chances of a college living by eloping with Bessy, daughter of Aubone Surtees, of Newcastle. His father was subsequently reconciled to them, as was Mr. Surtees. He entered the Middle Temple in Jan. 1773, and was called to the bar in 1776, practising in London and on the Northern Circuit. He was helped on by his brother, now Camden Professor of Ancient History, and by Andrew Bowes, who retained him as junior in his election petition for Newcastle. In 1780 he made his name in *Ackroyd* v. *Smithson,* still a leading case, which he insisted on taking up on appeal in opposition to his clients' opinion, and won before Lord Thurlow. The next year he enhanced his reputation in the Clitheroe election petition. In 1782 he took silk, and soon had a huge practice on the Northern Circuit, at the Parliamentary Bar, and in Chancery.

In 1782 he went into Parliament for Lord Weymouth's close borough of Weobley, as a supporter of Pitt. His first speeches were made against Fox's India bill, and were very thoroughly ridiculed by Sheridan. In 1788 he was made Solicitor-General and knighted, and the next year he is said to have drafted the Regency bill. In 1793 he became Attorney-General, and conducted the prosecutions against the supporters of the French Revolution, especially that against Horne Tooke. In 1799 he became Chief Justice of the Common Pleas, with the title of Baron Eldon, and in 1799 he was Lord Chancellor in Addington's ministry, which he owed to his anti-Catholic zeal. In 1804 we find him conducting the negotiations that led to Pitt succeeding Addington, and he remained Lord Chancellor under Pitt. Pitt's death was followed by Grenville's ministry, and then under Liverpool, Eldon returned to the Woolsack, where he continued the predominant member of the Cabinet for 20 years. He was made an earl in 1821. In 1827 Canning, a supporter of Catholic Emancipation, became Prime Minister, and he resigned; he fully hoped to be asked to take office again under Wellington, but was disappointed. His wife, to whom he was entirely devoted, died in 1831, and Eldon died in London on Jan. 13, 1838.

As a legislator he was profoundly conservative. For 40 years he fought innovation by repression, seeing in every reform proposed the downfall of the country, and preserving himself and his party in power by tact, conservatism and anti-Catholicism. As a judge, his greatness is indisputable, though his judgments, as voluminous as they are profound, are notably clumsy in form. During the many years he presided over the Chancery he naturally had a considerable effect on the development of Equity. Most of this is purely technical, but it should be observed that it was under his influence that the injunction became so important a weapon in the Chancellor's armoury, and the rules for its use became settled. But he had one fatal fault, his slowness, which outweighed all his virtues. The notorious slowness of the Chancery reached its climax under him, and it is said that he would keep papers by him for years, though he rarely altered his first estimate of a case. It is the procedure under him that is satirized in the famous verse that ends, "And the Chancellor said —'I doubt'."

Bibliography.—Horace Twiss, *Life of Lord Chancellor Eldon* (1844); W. E. Surtees, *Sketch of the Lives of Lords Stowell and Eldon* (1846); Lord Campbell, *Lives of the Chancellors;* W. C. Townsend, *Lives of Twelve Eminent Judges* (1846); *Greville Memoirs.*

EL DORADO (Span. "the gilded one") a name applied first to the king or chief priest of a South American tribe, who was said to cover himself with gold dust, at a yearly religious festival held near Santa Fé de Bogotá; next, to a legendary city called Manoa or Omoa; and lastly to a mythical country in which gold and precious stones were found in fabulous abundance. The legend had many variants, especially as regards the situation attributed to Manoa. It induced many Spanish explorers to lead expeditions in search of treasure, but all failed. Among the most famous were the expedition undertaken by Diego de Ordaz, whose lieutenant Martínez claimed to have been rescued from shipwreck, conveyed inland, and entertained at Omoa by "El Dorado" himself (1531); the journeys of Orellana (1540–41), who passed down the Rio Napo to the valley of the Amazon; that of Philip von Hutten (1541–45) who led an exploring party from Coro on the coast of Caracas; and of Gonzalo Ximenes de Quesada (1569), who started from Santa Fé de Bogotá.

Sir Walter Raleigh, who resumed the search in 1595, described Manoa as a city on Lake Parimá in Guiana. This lake was marked on English and other maps until its existence was disproved by A. von Humboldt (1769–1859). Meanwhile, the name of El Dorado came to be used metaphorically of any place where wealth could be rapidly acquired. It was given to a county in California, and to towns and cities in various states. In literature frequent allusion is made to the legend, perhaps the best-known references being those in Milton's *Paradise Lost* (vi. 411) and Voltaire's *Candide,* (ch. 18, 19).

See A. F. A. Bandelier, *The Gilded Man, El Dorado* (1893).

EL DORADO, a city of southern Arkansas, U.S.A., 15m. from the Louisiana boundary; the county seat of Union county. It is on Federal highway 167, and is served by the El Dorado and Wesson, the Missouri Pacific and the Rock Island railways. The population was 3,887 in 1920 (26% negroes) and was estimated locally at 30,000 in 1928. It is the metropolis of the pioneer oil-field of the State, which in 1928 was producing about 85,000bbl. daily. In 1921 the discovery well was brought in. El Dorado was settled in 1843 and incorporated in 1870.

ELDORADO, a city of Saline county, Ill., U.S.A., in the south-eastern part of the State, on Federal highway 45, and served by the Big Four, the Illinois Central and the Louisville and Nashville railways. The population was 5,004 in 1920 (95% native white). It is the trade centre and shipping point for a coal-mining and farming region, and has some manufacturing industries.

ELDORADO, a city in the oil-fields of south-eastern Kansas, U.S.A., 31m. N.E. of Wichita; the county seat of Butler county. It is on Federal highways 54 and 77, and is served by the Missouri Pacific and the Santa Fe Railways. The population was 3,129 in 1910; 10,995 in 1920 (95% native white); and 9,500 in 1925 (State census). It is the shipping and supply centre for a farming, stock-raising and oil-producing region.

ELDUAYEN, JOSÉ DE, 1st Marquis del Pazo de la Merced (1823–1898), Spanish politician, was born in Madrid on June 22, 1823. He was educated in the capital, took the degree of civil engineer, and directed important works in Asturias and Galicia, entered the Cortes in 1856 as deputy for Vigo, and sat in all the parliaments until 1867 as member of the Union Liberal with Marshal O'Donnell. He attacked the Miraflores cabinet in 1864, and became under-secretary of the home office when Canovas was minister in 1865. He was made a councillor of State in 1866, and in 1868 assisted the other members of the Union Liberal in preparing the revolution. He accepted office as member of the

last Sagasta cabinet under King Amadeus. On the proclamation of the republic Elduayen co-operated in the Alphonsist conspiracy, and endeavoured to induce the military and politicians to work together. He went abroad to meet and accompany the prince after the *pronunciamiento* of Marshal Campos, landed with him at Valencia, was made governor of Madrid, a marquis, grand cross of Charles III., and minister for the colonies in 1878. He accepted the portfolio of foreign affairs in the Canovas cabinet from 1883 to 1885, and was made a life senator. He died at Madrid on June 24, 1898.

ELEANOR OF AQUITAINE (*c.* 1122–1204), wife of the English king Henry II., was the daughter and heiress of Duke William X. of Aquitaine, whom she succeeded in April 1137. She married Prince Louis, the heir to the French crown, and a month later her husband became king of France under the title of Louis VII. Eleanor bore Louis two daughters but no sons. Their marriage was annulled by mutual consent in 1151. She then married Henry of Anjou. Louis, who had hoped that Aquitaine would descend to his daughters, was mortified and alarmed by the Angevin marriage; all the more so when Henry of Anjou succeeded to the English crown in 1154. From this event dates the beginning of the secular strife between England and France which runs like a red thread through mediaeval history.

Eleanor bore to her second husband five sons and three daughters; John, the youngest of their children, was born in 1167. But her relations with Henry passed gradually through indifference to hatred. Henry was an unfaithful husband, and Eleanor supported her sons in their great rebellion of 1173. Throughout the latter years of the reign she was kept in a sort of honourable confinement. It was during her captivity that Henry formed his connection with Rosamond Clifford, the Fair Rosamond of romance. Eleanor, therefore, can hardly have been responsible for the death of this rival, and the romance of the poisoned bowl appears to be an invention of the next century.

Under the rule of Richard and John the queen became a political personage of the highest importance. To both her sons the popularity which she enjoyed in Aquitaine was most valuable. She helped to frustrate the conspiracy with France which John concocted during Richard's captivity. She afterwards reconciled the king and the prince, thus saving for John the succession which he had forfeited by his misconduct. In 1199 she crushed an Angevin rising in favour of John's nephew, Arthur of Brittany. In 1201 she negotiated a marriage between her grand-daughter, Blanche of Castile, and Louis of France, the grandson of her first husband. It was through her staunch defence of Mirabeau in Poitou that John got possession of his nephew's person. She died on April 1, 1204, and was buried at Fontevrault. Although a woman of strong passions and great abilities she is, historically, less important as an individual than as the heiress of Aquitaine, a part of which was, through her second marriage, united to England for some 400 years.

See the chronicles cited for the reigns of Henry II., Richard I. and John. Also Sir J. H. Ramsay, *Angevin Empire* (1903); K. Norgate, *England under the Angevin Kings* (1887); and A. Strickland, *Lives of the Queens of England*, vol. i. (1841).

ELEANOR OF CASTILE (d. 1290), daughter of Ferdinand III. of Castile by his second wife Joanna, half-sister of Alfonso X., married Edward I. in Oct. 1254, at the monastery of Las Huelgas. Through this marriage Edward succeeded to the provinces of Ponthieu and Montreuil in his wife's right, and Alfonso also gave up in his favour his claims on Gascony. After a year with her husband in Gascony, Eleanor came to England, on Oct. 17, 1255, and Edward joined her in November of the same year. In 1264, after the battle of Lewes, the earl of Leicester influenced the king to send her out of England, and she took refuge in France, returning to England on Oct. 29, 1265, after the battle of Evesham. She went with Edward in 1270 on his crusade, and on Aug. 19, 1274 they were both crowned. She caused some scandal by using the services of Jewish usurers to obtain estates from some Christians, and Archbishop Peckham was obliged to intervene on behalf of tenants on whom she laid too heavy a burden. She was in other respects a pious woman. She fell ill towards the end of 1290, and died on Nov. 28, probably at Harby, Nottinghamshire.

ELEATIC SCHOOL, a Greek school of philosophy which came into existence towards the end of the 6th century B.C., and ended with Melissus of Samos (*fl. c.* 450 B.C.). It took its name from Elea, a Greek city of lower Italy, the home of its chief exponents, Parmenides and Zeno. Its foundation is often attributed to Xenophanes of Colophon, but, although there is much in his speculations which formed part of the later Eleatic doctrine, it is probably more correct to regard Parmenides as the founder of the school. At all events, it was Parmenides who gave it its fullest development. The main doctrines of the Eleatics were evolved in opposition, on the one hand, to the physical theories of the early physical philosophers who explained all existence in terms of primary matter (*see* IONIAN SCHOOL), and, on the other hand, to the theory of Heraclitus that all existence may be summed up as perpetual change. As against these theories the Eleatics maintained that the true explanation of things lies in the conception of a universal unity of being. The senses with their changing and inconsistent reports cannot cognize this unity; it is by thought alone that we can pass beyond the false appearances of sense and arrive at the knowledge of being, at the fundamental truth that "the All is One." There can be no creation, for being cannot come from not-being; a thing cannot arise from that which is different from it. The errors of common opinion arise to a great extent from the ambiguous use of the verb "to be," which may imply existence or be merely the copula connecting subject and predicate.

In these main contentions the Eleatic school achieved a real advance, and paved the way to the modern conception of metaphysics. Xenophanes in the middle of the 6th century had made the first great attack on the crude mythology of early Greece, including in his onslaught the whole anthropomorphic system enshrined in the poems of Homer and Hesiod. In the hands of Parmenides this spirit of free thought developed on metaphysical lines. Subsequently, whether from the fact that such bold speculations were obnoxious to the general sense of propriety in Elea, or from the inferiority of its leaders, the school degenerated into verbal disputes as to the possibility of motion, and similar academic trifling. The best work of the school was absorbed in the Platonic metaphysic.

See E. Caird, *Evolution of Theology in the Greek Philosophers*, 1904. *See* also the articles on XENOPHANES; PARMENIDES; ZENO (of Elea); MELISSUS, with the works there quoted; also the histories of philosophy by Zeller, Gomperz, Windelband, etc.

ELECAMPANE (*Inula Helenium*), a perennial plant, family *Compositae*, common in many parts of Britain, and ranges throughout central and southern Europe, and in Asia as far eastwards as the Himalayas. It is also widely naturalized in North America, occurring along roadsides and in fields from Nova Scotia westward to Ontario and Minnesota and southward to North Carolina and Georgia. Elecampane is a rather stout and rigid herb, the stem of which attains a height of 3 to 5 ft.; the leaves are large and toothed, the lower ones stalked, the rest embracing the stem; the flowers are yellow, 2 in. broad, and have many rays, each three-notched at the extremity. The root is thick, branching and mucilaginous, and has a warm, bitter taste and a camphoraceous odour. Besides *inulin* $(C_6H_{10}O_5)6n$, isomeric with starch, the root contains *helenin*, C_6H_8O. By the ancients the root was employed both as a medicine and as a condiment, and in England it was formerly in great repute as a tonic and stimulant of the secretory organs. As a drug, however, the root is now seldom resorted to except in veterinary practice, though it undoubtedly possesses antiseptic properties.

ELECTION, in English law, the obligation imposed upon a person whose property is purported to be disposed of by an instrument which confers property on him, to choose whether he will retain his own property and compensate the person to whom it is purported to be given, or transfer his own property and take the property given him by the instrument. To put a donee of property to his election three conditions must be fulfilled: (i.) The donor's gift to him must be of property the donor had free

power to dispose of. Thus a gift to a beneficiary under a special power of part of the funds subject thereto does not put the beneficiary to his election if the donee of the power attempts by the same instrument to give the beneficiary's own property to someone else. (ii.) The property given must be given in such a way that the beneficiary can make compensation out of it if he chooses to retain his own. Thus a gift to a married woman of property subject to a condition against alienation does not put her to an election. (iii.) The gift must not be made conditional on the donee transferring his property. Here the case is not one of election but of alternative gifts, and if the donee elects against the instrument he thereby abandons all claim to the gift.

In cases of election it must be made clear that the donor intended to dispose of the donee's property, but it is of no importance whether he knew or not at the time he executed the instrument that it was the donee's property.

Elections almost invariably arise under wills, but they may arise under deeds, as, for example, when a minor executes a marriage settlement under which she assigns her property on certain trusts and receives benefits in her husband's property. She cannot, on attaining full age, repudiate her assignment and retain the benefits conferred on her by the settlement. (*See* also ELECTORAL SYSTEMS; PARLIAMENT; REPRESENTATION; VOTE.)

ELECTORAL COMMISSION, in United States history, a commission created to settle the disputed presidential election of 1876. In this election Samuel J. Tilden, the Democratic candidate, received 184 uncontested electoral votes, and Rutherford B. Hayes, the Republican candidate, 163. The states of Florida, Louisiana, Oregon and South Carolina, with a total of 22 votes, each sent in two sets of electoral ballots, and from each of these states except Oregon one set gave the whole vote to Tilden and the other gave the whole vote to Hayes. From Oregon one set of ballots gave the three electoral votes of the state to Hayes; the other gave two votes to Hayes and one to Tilden.

The manner of selecting the electors is left to State law; the electoral ballots are sent to the president of the Senate, who "shall, in the presence of the Senate and House of Representatives, open all certificates, and the votes shall then be counted." Concerning this provision many questions of vital importance arose in 1876: Might Congress or an officer of the Senate go behind a State's certificate and review the acts of its certifying officials? Might it go further and examine into the choice of electors? And if it had such powers, might it delegate them to a commission? The fact, however, that the Senate in 1876 was controlled by the Republicans and the House by the Democrats, lessened the chances of any harmonious settlement of these questions by Congress. In consequence, the country seemed on the verge of civil war. Hence it was that by an act of Jan. 29, 1877, Congress created the Electoral Commission to pass upon the contested returns, giving it "the same powers, if any" possessed by itself in the premises, the decisions to stand unless rejected by the two houses separately.

The commission was composed of five Democratic and five Republican Congressman, two justices of the Supreme Court of either party, and a fifth justice chosen by these four. As its members of the commission the Senate chose G. F. Edmunds of Vermont, O. P. Morton of Indiana and F. T. Frelinghuysen of New Jersey (Republicans); and A. G. Thurman of Ohio and T. F. Bayard of Delaware (Democrats). The House chose Henry B. Payne of Ohio, Eppa Hunton of Virginia and Josiah G. Abbott of Massachusetts (Democrats); and George F. Hoar of Massachusetts and James A. Garfield of Ohio (Republicans). The Republican judges were William Strong and Samuel F. Miller; the Democratic, Nathan Clifford and Stephen J. Field. These four chose as the fifteenth member Justice Joseph P. Bradley, a Republican but the only member not selected avowedly as a partisan. It had been expected that the fifth member from the Supreme Court would be David Davis, an independent, but he was elected to the Senate by the Illinois legislature and declined to serve on the commission.

The popular vote seemed to indicate that Hayes had carried South Carolina and Oregon, and Tilden Florida and Louisiana. It was evident, however, that Hayes could secure the 185 votes necessary to elect only by gaining every disputed ballot. As the choice of Republican electors in Louisiana had been accomplished by the rejection of several thousand Democratic votes by a Republican returning board, the Democrats insisted that the commission should go behind the returns and correct injustice; the Republicans declared that the State's action was final, and that to go behind the returns would be invading its sovereignty. When this matter came before the commission it virtually accepted the Republican contention. By the votes of the eight Republicans to the seven Democrats, the electoral votes of Florida and Louisiana were given to Hayes. The commission unanimously awarded the South Carolina and Oregon votes to Hayes.

The strictly partisan votes of the commission and the adoption by prominent Democrats and Republicans, both within and without the commission, of an attitude toward States-rights principles quite inconsistent with party tenets and tendencies, have given rise to much severe criticism. The Democrats and the country, however, quietly accepted the decision. The judgments underlying it were two: (1) That Congress rightly claimed the power to settle such contests within the limits set; (2) that, as Justice Miller said regarding these limits, the people had never at any time intended to give to Congress the power, by naming the electors, to "decide who are to be the president and vice-president of the United States."

There is no doubt that Tilden was morally entitled to the presidency, and the correction of the Louisiana frauds would certainly have given satisfaction then and increasing satisfaction later, in the retrospect, to the country. The commission might probably have corrected the frauds without exceeding its Congressional precedents. Nevertheless, the principles of its decisions must be recognized by all save ultra-nationalists as truer to the spirit of the Constitution and promising more for the good of the country than would have been the principles necessary to a contrary decision.

BIBLIOGRAPHY.—J. F. Rhodes, *History of the United States*, vol. 7, covering 1872–1877 (1906); P. L. Haworth, *The Hayes-Tilden disputed Presidential Election of 1876* (Cleveland, 1906); J. W. Burgess, *Political Science Quarterly*, vol. 3 (1888), pp. 633–53, "The Law of the Electoral Count"; and for the sources, Senate Miscellaneous Document No. 5 (vol. 1), and House Miscel. Doc. No. 13 (vol. 2), 44 Congress, 2 Session—*Count of the Electoral Vote. Proceedings of Congress and Electoral Commission*,—the latter identical with *Congressional Record*, vol. 5, pt. 4, 44 Cong., 2 Session; also about twenty volumes of evidence on the State elections involved. The volume called *The Presidential Counts* (1877) was compiled by Mr. Tilden and his secretary. *See* also P. L. Haworth, *The Hayes-Tilden Election* (Indianapolis, new ed., 1927); and H. R. Bruce, *American Parties and Politics* (1927).

ELECTORAL SYSTEMS. To elect is to choose, and in the sense of the present discussion, an electoral system is a means of choice of members of a governmental organization—a term used in preference to the word state, to emphasize the concrete nature of the purpose served by an electoral system. Political theorists and practical politicians can be ranged into two great schools of thought; those who look upon systems of election absolutely as equitable expressions of the sovereignty of the people; and those who, accepting the sovereignty of the people and the representative principle, yet regard the system of election pragmatically, as an instrument of government in which absolute equity must not seldom retreat before the pressing need for government. On every occasion of the modification of the franchise in regard to age and sex, or in the controversies about proportional representation, or in the matter of compulsory voting, this difference of attitude is apparent.

The electoral system is, then, part of the machinery of government, and the part it plays varies from country to country in accordance with the political system. The number of elective offices may be very large, as in the United States at the present time, or very small, as in Germany before the advent of representative institutions. Or it may, as in most democratic countries, be confined to the legislative assemblies of central and local government. We confine our attention to the central representa-

tive assembly, in particular to the lower house, though what we have to say applies almost in every detail to municipal elections. The significance of these electoral systems is determined by the extent to which the sovereignty of the people is admitted by the Constitution, but the mere declaration of such sovereignty either in the written Constitution or in the conventional opinion of the day must not be taken as a measure of the rôle of election. One must look to all the other institutions which compose the State: the power of a House of Lords, in Great Britain; presidential powers, as in America, France and Germany, royal power in countries with a constitutional monarchical system. It would be idle, too, after the electoral experience of the last half-century wherever representative institutions have been created, to judge the electoral systems upon their literary form. Every election is a time of intense, though underground pressure of interests, social and economic, in more or less organized form, disturbing constitutional symmetry and abrogating its equity. Threats, intimidation, terrorization and victimization of the most diverse kinds become operative, and in their obvious and indiscreet forms are forbidden by law everywhere. But the economic power of an employer in an industrial country, or a landed proprietor in an agricultural country under modern productive methods is subtle, pervasive and legally unregulated.

Thus, of electoral systems in general we may say that their real meaning depends upon their ultimate governmental effectiveness, their relationship to other political institutions and the social system within which they operate. In considering the subject, then, we ought not to confine our examination to the written text of the franchise acts alone, but must consider an electoral system broadly, as all those means whereby a person becomes a member of an elected assembly, and narrowly, as those means which are sanctioned by the laws. Of ancient practice some account will be found in the article on voting. (*See* VOTE and VOTING.) In modern practice the topics which must be discussed are:—(*a*) candidature; (*b*) returning officer; (*c*) the franchise: qualifications and disqualifications; (*d*) election day; (*e*) ballot; (*f*) expenses and the canvassing of voters; (*g*) representative or delegate; (*h*) non-voting and compulsory voting.

Candidature.—The democratic development of the 19th century and of our own day has generally brought about (1) ease and freedom of candidature, and (2) an approximation of the age limit of candidature to that for the exercise of the vote.

As regards freedom of candidature, the tendency has been to avoid the interference of the State in the electors' choice of candidates, and to restrict the action of the State to providing that ineligibility shall be determined after the election by a tribunal likely to be impartial. Such tribunals are parliamentary as in the United States Federal authority, in Norway, the Netherlands and Belgium or extra-parliamentary as in Great Britain, the Australian Commonwealth and Germany. But statesmen have been unwilling to allow a perfect freedom of candidature, and have sought to secure an element of electoral responsibility by requiring a candidate to be sponsored by a number of electors who sign a nomination form. The number thus required differs very much. For example:—

TABLE I.

Number of electors required to support candidates for lower house

Great Britain	8	Germany	50
Canada	10	Czechoslovakia	100
Portugal	10	Belgium	100
Denmark	25	Italy (1918–22)	300
Holland	25		

The age of candidature and its present approximation to age for the right to vote is observable from table II. (lower house only).

But not all countries now accept the freedom of candidature. Indeed, one of the most remarkable phenomena of modern government is the extent to which the tenets of 19th century democracy have been challenged in this respect. The counter action comes from two quarters: the United States, and Italy and Russia; the source in the first-named country is the excesses of democracy brought about partly by the type of people who are politically active, and partly by the social environment; in the

TABLE II.

Country	Voting age	Age of candidature
Russia	18	18
Turkey	18	30
Argentina	18	25
Mexico	18 (if married, 21 if unmarried)	25
Switzerland	20	21
Germany	20	25
Italy	21	25
Canada	21	21
Czechoslovakia	21	30
Austria	20	30
Poland	21	21
Belgium	21	25
France	21	25
Britain	21	21
U.S.A.	21 (all States)	25
Norway	23	30
Finland	24	24
Spain	25	25
Japan	25	30
Denmark	25	25
Holland	25	25

latter it is the plain denial of the political validity of democratic electoral systems.

RIGHTS OF THE INDIVIDUAL

In the United States, as in Great Britain, the British dominions and Europe, the electoral systems were established on the basis of the "natural" rights of the individual. The individual thus envisaged was regarded as an independent, self-sufficient, freely-acting entity, without social or economic relationships, except those which originated in his self-interest, and which were created by his private activity, unaided and unimpeded by the State. Thence naturally followed freedom of candidature and the universal franchise. But men do not act as independent atoms, and three-quarters of the way through the 19th century nothing was more striking than the enormous power and indispensable services exercised by political parties in organizing the enfranchised atoms; nor could one mistake the growing significance to men of the sense of State and its activities and institutions, or the grouping of men in vocations. The 19th century State relied exclusively upon political parties for the choice of candidates and even, in many countries, for other electoral services, like the distribution of ballot papers. But while the State was thus periodically created, dissolved and recreated by party activity, it is amazing that this process went on in a fit of statutory absent-mindedness. The State certainly did not seek to regulate the activity of parties in their choice of candidates, and with the exception of the countries we are about to discuss does not do so now.

The States of the United States of America were the first to suffer from this blithe unconsciousness. The large number of offices filled by election, the enormous territorial range of the country, and the popular preoccupation with economic activity, necessitated strong party organizations. Into the hands of their "bosses" fell the nomination of candidates. They looked upon the nominations as commodities saleable to individuals and companies and excluded voters from the nominating conventions by various devices; conventions were held without due notice and in out-of-the-way places; they were "packed" with hooligans, electoral lists were "padded" and ballot boxes "stuffed." A reaction set in in the '80s, and the States (California commenced as early as 1866) began to regulate the method of nomination. Legislation, at first permissive, became compulsory, and more and more offices were included. In 1912, the primary conventions for the presidency were added. All States, save three or four, have now established principles and methods for regulating the nomination of candidates through the party machinery. This involves rules (1) to decide which are the parties entitled to nominate, and this is settled variously by the number of votes returned at

the preceding election or, more frequently, by a fixed proportion of the votes cast, and these range from 2% to 25% of the entire vote; (2) to define those who are entitled to appear at the nominating primaries, that is to define party membership, and this is done by a special enrolment in the party, by secret or open process, some time before the elections; by declaration by ballot when actually at the primary; by decision of the party officials (this in the southern States, where the problem of negro franchise gives trouble); and the Wisconsin method, whereby the voter at the primary votes for the candidate he desires on a ballot paper of his special party colour, which he *secretly* detaches from a perforated pad of ballot papers, each of which represents a different party; (3) the time, place, method of voting and counting are legally regulated.

One question still remains to be solved; how can a citizen get his name placed on the nomination paper at the primary elections? This leads back to the ultimate problem. The methods laid down by the States vary. One method is that of petition which must be signed by a fixed number or an agreed percentage of the voters. This is a very expensive method. In another the party committee nominates long before the election and dissentient elements may by petition present others. One other problem arises: what vote at the primary election constitutes an effective choice of a candidate? Some States require an absolute majority, secured in some places by the second ballot and in others by the alternative vote system; others require at least 35% of the votes to be obtained for a nomination, and if the primary does not secure this, a party convention is called. In Oregon statutory arrangements, at State expense, have been made to give the candidates for candidacy an opportunity of writing their views in a pamphlet printed and circulated by the State.

This system has not notably improved the American electoral systems. The politically conscious electors are still in control of the machine, but the cruder forms of corruption have disappeared. Wirepulling has by no means ceased; it is simply driven back one stage further to the pre-primary arrangements. For the ordinary citizen electioneering has been complicated and the possibility of a clear view of electoral responsibility diminished. Expenses have been increased. Popular interest in the nominations has slightly increased; but nothing can effect a radical change of electoral manners save a change of popular outlook and education.

Another peculiarity of the choice of candidates in the United States is that candidates are by law and custom required to be inhabitants of the State in which they stand. Some States go further and demand that the candidate shall be a resident of the district which he seeks to represent. Many intelligent American observers are agreed that this restriction of choice is seriously detrimental to the quality of American legislatures.

No greater contrast could be presented to the recent developments in the United States than those in Italy and Russia. Italy since 1922 and Russia since 1918 rest upon a political basis which totally denies the individual's right to freedom. Fascism starts out with the whole nation as the unit of State life, and within that unity recognizes the personality of corporations, economic and social, but only as integral elements of the State. The individual has electoral significance in his proper corporation, and the corporation in the State, and it is positively denied that all individuals and all corporations are electorally equal and free. Since 1922 Italian legislation has abolished the democratic electoral system. First (in Nov. 1923) all Fascist candidates were chosen by a central committee for nominations, the list being revised by Mussolini and then, in May 1928, the corporative State having been created by the Fascist regime, a new system was set up. Various corporations were to nominate 900 candidates, the Fascist Grand Council to choose from these some 400 candidates, and these 400 candidates to be put before the electors for approval *en bloc*. (*See* also FASCISM: *Italy*.)

Though the policy of the Union of Socialist Soviet Republics (U.S.S.R.) is much different from the Fascist system, the electoral system is similarly converted to the use of a special organization working within a system which asserts the priority of the State over groups and individuals. The right of nomination as candidates for the Soviet is given to parties, professional organizations, military units, workshops and other vocational units. All this seems to favour a freedom of nomination so long as such nomination issues from a recognized "productive" group. But the Communist Party is all-powerful, and is made so by various *de jure* privileges and its *de facto* capacity to extirpate opposition. Candidature is thus not free in practice.

Candidature may always be taken as a safe guide to the real nature of the political system under discussion. Though we have characterized the systems of Europe as, in general, free, we mean free of legal interference, save for the rules with respect to age, nationality and so on. Systems can therefore be graded from the minimum to the maximum of State interference as in the United States, Italy and Russia; but the intentions of those who have interfered are poles asunder. In the countries where there is little or no legislative interference with nomination, there are still local party caucuses who set their own terms for nomination—wealth, beauty, social status, electoral cleverness, even intellect. These caucuses have a great amount of power, though the law has not given it to them; they are representatives of the Idea, and control and organize the money and the workers for the Idea. Where party organization is strong, as in the Anglo-Saxon countries, the party is the deciding factor in the choice of candidates, though this does not mean the central authority of the party. In the Latin countries and in the Balkans, party organization is still too weak to regard such a monopoly as a safe one, and small evanescent groups nominate. In Germany, since the elections to the constituent assembly in 1919, the peculiar nature of its system of proportional representation has made the party machine dominant in the choice of candidates, for the party headquarters wishes to count upon safe seats for certain men and is able to offer safe seats to others out of its national fund of votes accumulated from the votes of unsuccessful candidates at the elections. It can be taken as a fair generalization that, wherever the system of "P.R." operates with what is known as a "list system," the party machine and central control within the party machine has the nominating power strongly in its hands.

ELECTORS' QUALIFICATIONS

The Franchise.—The development of the franchise in the last 100 years has steadily tended towards the abrogation of all electoral inequalities. The principal barrier to a vote was the property qualification, and this has in practically all countries been reduced to a minimum. Stability of citizenship is rather sought in residence qualifications such as the six months' residence or occupation as in Great Britain, six months' residence as in France, a "fixed place of abode" as in Denmark. In the United States residence qualifications range from three months to two years, and in Japan in 1925 male suffrage was enacted for all over 25, resident in their constituency for six months and "with their own means of subsistence." The age for the vote varies a good deal (*see* Table II.). So far no limitation has been put on the oldest age at which one may vote. The variation in age is differently explicable in each country. Russia, where the lowest age pertains, typifies the argument that those who are already industrially productive can be trusted to vote, that the earlier the age at which one begins to vote, within reason, the sooner is one politically educated, and the political system needs the infusion of the spirit of youth. A high age, on the other hand, is counselled by rather conservative minds, who desire youthful rashness to be tempered by mature wisdom.

Women's suffrage (*q.v.*) has conquered most countries, but curiously enough not France, and other Latin countries like Spain, Italy, Portugal, Brazil and Argentine; nor do women vote in Belgium, Greece, Netherlands, Yugoslavia, South Africa or Japan. The attempts made during the 19th century to find an objective determinant of the right to vote in an educational test have been almost universally abandoned. They still exist in the educational tests of the States of the United States of America, but they come to very little, since only ability to read is required. But in the Southern States these tests are used to deprive the negroes of the vote. Brazil and Chile exclude illiterates from the vote, and this

in the former country excludes more than one-half of all male adults. Hungary demands by the law of 1925 that male voters must have had at least three years in elementary schools, and women six. Plural voting is still permitted only in Great Britain, where special educational qualifications confer extra votes, and where university graduates, duly registered, have a vote in respect of their university degree for the member of a university (Oxford, Cambridge, London and the northern universities) but such a vote cannot be used if it would make a third when added to the maximum of two votes acquired by residence or occupation of premises. Under the revision of the constitution in 1921, Belgium had a complicated system of plural voting, introduced in 1893.

The countries we have so far included in our review of franchise qualifications only differ from each other a little in degree, but Russia differs from all others in having adopted the principle of productivity as the basis of the right to vote. In this system the vote is looked upon not as an individual right irrespective of any objective standard of worth, but as a gift of the community to be granted only to those who are productive. The Constitution of 1925 (Article 68a) says "All persons living by productive labour and of a general utility, and also persons employed in domestic economy making it possible for the former to do productive work" shall enjoy the franchise. The definition of productivity is obviously of the essence of this qualification, and that definition has varied since the inception of the Soviet Republic, and varies between locality and locality. In the first flush of the revolution the "bourgeois," that is, the "unproductive" classification, was drawn very widely, but recently, people who receive interest on State or municipal loans have been admitted to the franchise and peasants employing wage-labour are not excluded. Russia differs from other countries in not disqualifying for the vote on account of want of nationality. Productivity and political loyalty are the prime qualifications.

Aliens, convicts and lunatics are well-nigh universally disqualified, and in some countries bankrupts also. In Great Britain peers are not allowed to vote, and until 1918 people in receipt of poor relief within a certain period before the election were disqualified.

The Election.—The time of the year when elections are held, the day of the week, how early the booths are opened and how late shut are important points. In agricultural countries elections (where there are fixed terms of parliament) are fixed after the spring sowing or in autumn after the harvest. The day of the week is especially important in an industrial country, where work must proceed with strictly disciplined regularity. Most European countries have adopted a Sunday or a holiday as election day, but in Great Britain a characteristic muddle-headedness has so far prevented its adoption. The dominions still retain the English practice. In the United States there are laws allowing voters to be absent from work for the time necessary to give their vote. In Great Britain arrangements are made for the polling until 10 P.M.; in Germany and France, where polling does not fall on an ordinary work-day, it ends at 6 P.M.

Other countries were earlier than Great Britain in adopting the system of one-day elections. A longer period has certain advantages, but the single day has the decided advantage of reducing the economic effects of electioneering excitement. The one-day election is practically universal.

SECRECY OF THE BALLOT

The Process of Polling.—Around the process of polling great parliamentary fights were waged in the 19th century, and the issue was to secure (1) The freedom of the voter from outside influence and, (2) the honesty of the counting of the votes. The first was secured by (*a*) the proper organization of the presidency of the whole electoral procedure; (*b*) by the institution of the secret ballot, and (*c*) more recently by associating the representatives of the contending parties with the supervising officer of the proceedings.

The proper organization of the presidency involved the appointment of a public official, sometimes of the central authority like the *Prefét* (*see* PREFECT) in France, or a local government authority like the town clerk in Great Britain, or in the United States. The intention of the representative assemblies was rarely corrupt; but corruption did creep in, and is still not altogether excluded in countries like France, Hungary, Rumania, Poland and Greece where the Government of the day does not hesitate to impress the returning officers that the elections must be "made." And in the State and city politics of the United States the parties and the "bosses" are not yet entirely of the opinion that returning officers should be just. There are many points at which the power of the returning officer may be corruptly used: the permission of personation (*q.v.*), the "stuffing" of ballot boxes, the verification of title and the acceptance of doubtful votes. On the whole, the tendency is towards greater integrity in these matters, but party watchers and the representatives of civic associations cannot afford to relax their vigilance.

South Australia was the first State to introduce secrecy of the ballot (1856), since when it is usual to find the secret ballot referred to as the Australian ballot. Thence the system spread to Europe and America to meet the growing public and parliamentary demand for protection of voters. The means for securing secrecy vary very much. Perhaps the most careful arrangements are to be found in Germany, that is, in the elections for the Federal authority, and it may be taken that the various States closely follow its practice. The voting urns are required to be four-cornered, of certain dimensions and closed, the only aperture being a small slit at the top. These urns are examined before the poll begins and must not be opened until the count begins. The voter indicates his choice by placing his list of candidates (Germany has a strict list system of proportional representation) into an officially stamped envelope. The latter is given to him by an official, and no other envelope is legally valid. This envelope is made of opaque paper of a statutorily determined size. The voter places his ballot into the envelope in a special stall called an isolation cell (*Isoliercelle*), which is so arranged as to make observation by anybody, officials or other voters, impossible. An election was once challenged in the *Reichstag* because even the feet of a voter were observable. The envelope containing the ballot is then given by the voter to the returning officer, who takes the name of the voter, verifies his title, and then puts the vote into the urn.

Variations of this procedure now exist all over the world, the substantial part thereof being the secrecy of choice. In Hungary, by the electoral rules of April 1922, all rural constituencies numbering 200 out of a total of 245 are subject to open voting. In Great Britain the secret ballot was finally introduced for all parliamentary and municipal elections by the Ballot Act of 1872. In the United Kingdom, as in the British dominions generally, the ballots are officially provided and issue from a counterfoiled volume, but no envelope is provided, and the voter casts his ballot directly into the urn. Until 1913 the French system was full of defects; the candidates circulated the ballots even outside the polling-sections, and the voter merely folded the paper and gave it to the presiding official to put into the ballot box. After 1913 the "envelope system" was adopted (law of July 1913, modified by law of March 31, 1914). Since Oct. 1919 also, the State prints the ballots, though at the expense of the candidates, and sends them to the voters by post under an official stamp. No voter can be offered ballots on election day except from the returning officer's staff inside the polling-station. Before 1884 the general practice in the United States was either open voting, or where this rudimentary and clumsy process had been superseded, voting by ballot. After the presidential elections of 1884 the Australian ballot system was extensively adopted. Now without exception ballots are printed at the public expense, distributed in the polling stations, officially numbered, secretly marked and folded, and are identifiable by reference to the counterfoil retained by the official.

In the United States a great controversy has long raged around the question, how far the party organization ought to interfere with the voter by putting emblems on the ballot. Until recently the ballot was so arranged that the voter had only to mark the

ballot paper at one certain point, and this indicated his acceptance of all the candidates of any one party. America has attempted to foil such assaults upon the independence of voters by such plans as the Massachusetts plan, adopted there in 1888. All the names of candidates *for all parties* for each office are placed in alphabetical order under the title of the office. The only way to vote is to mark a cross opposite the name of each candidate desired. The law so far compromises with the competence of the voter that it allows the printing of the party name or emblem by the side of each name. In many States the party signs are forbidden, especially for municipal offices.

Political parties are associated with the administration of the ballot in the better-organized democracies to an interesting but not surprising extent. In Great Britain agents of the candidates are allowed to be present at the polling station. They are sworn to secrecy and may not interfere with a voter. They are present at the count of votes and raise objections to spoiled or uncertain ballot papers. The clerks are appointed by the public authority. In the United States the parties have a larger share in the electoral proceedings. Besides the rights given by British law, American laws provide for the clerical work to be done by people chosen by the parties. In Germany the presence of representatives of the candidates is permitted, on the general principle of publicity of proceedings, and in each constituency the presiding officer appoints from three to six electors from the political parties to act as supervisors and clerks during the proceedings and at the counts. In much the same way the Czechoslovakian law provides for the conduct of the elections by a departmental commission (the local authority) with the collaboration of members of all parties. In France the parties have no such connection with electoral procedure.

ELECTIONEERING TACTICS

The Influencing of Voters.—Though, in practice, many voters cast their votes for candidates they know nothing about, it is rarely the fault of the candidates. It is of the essence of their desire to represent others that they should make clear to their constituents their purposes and character. Indeed, the large number of constituents for each representative in the modern State compels the creation of a machine and methods to impress the others. Representation is unthinkable, under modern social conditions, on any other basis. Candidates have rarely conceived their task as one simply of enlightening the electors. The attitude of a John Stuart Mill or a Macaulay is a rarity. The candidate, and certainly his party followers and workers, as well as his agent, want victory, and this desire too often causes them to adopt tactics which they alone would be likely to confound with enlightening the elector. There is a class of acts—large, not easily definable—which causes undue or unfair influence, making impossible any rational vote and destroying that elusive entity, the "real will" of the electors. Laws have therefore been made restraining injurious activity, and they can be broadly divided into two classes, those regulating the expenditure at elections, and those defining and creating penalties for corrupt practices.

In Great Britain, the Corrupt and Illegal Practices Act of 1883 codified and added to the piecemeal legislation of previous centuries, making a code of admirable strictness. Corrupt practices include: (1) *Bribery* by gift, loan or promise of money or money's worth to vote or abstain from voting; by offer or promise of a situation or employment to a voter or any one connected with him, by giving or paying money for the purpose of bribery, by gift or promise to a third person to procure a vote, or payment for loss of time, wages or travelling expenses to secure a vote; and the consequences are the same whether bribery is committed before, during or after an election. (2) *Treating*, which means the provision or payment for any person, of meat, drink, entertainment or provision, at any time, in order to induce him, or any other person to vote or abstain from voting—and such extends to the wives or relatives of voters. (3) *Undue influence, i.e.*, the making use, or the threatening to make use of any force, violence or restraint, or inflicting or threatening to inflict any temporal or spiritual injury on any person in order to influence his vote, or by duress or fraud impeding the free exercise of the franchise by any man. (4) *Personation* (*q.v.*) applying for a ballot paper in the name of another person, whether alive or dead, voting twice at the same election, aiding or abetting personation, forging or counterfeiting a ballot paper. (5) *Unauthorized expenditure.* That expenditure which is not authorized in writing by the election agent. Illegal practices include paid conveyancing, advertising, and hiring, without authority, committee rooms; voting without qualification; false statements made about candidates; disturbance of public meetings between the issue of the election writ and the return of the election; printing, publishing or posting any bill, placard or poster not bearing on its face the name and address of the printer and publisher; illegal proxy voting. Heavy fines and withdrawal of the right to vote or be a candidate are attached to these offences. The expenses of the candidates were limited by the act of 1883 and now, after the passage of the Reform Acts of 1918 and 1928 stand at 5d. per elector in a borough constituency and 6d. per elector in a county constituency.

Nothing, however, has been done to prevent party headquarters giving aid to a candidate as an organization not in his pay and in a general fashion. Poorer candidates and party organizations have much to complain of, nor can any close observer of elections deny that richer candidates can and do have materially more influence. The conveyance of voters to the poll in hired vehicles is prohibited. But it is a well known fact that candidates and their agents have found ways and means of driving many a motor car through this clause of the act. Nor are the parties which have a legitimate right to contest an election always ready to do so, for they are restrained by the fear of unpopularity, whether they succeed or not. Thus widely illegal and corrupt practices go unpunished. The dominions have codes of electoral propriety closely resembling that of the Mother Country and offer no conspicuous variations.

Among European countries Hungary, Rumania, Bulgaria and Greece have been pre-eminent in the corruption of their political systems. In the United States three means of corruption have been used: money, public office and serious forms of undue influence. It has been estimated by Prof. Charles Merriam that the two major parties alone in only a presidential campaign spend together some $20,000,000. Money is also freely spent in smaller contests; sums of over $100,000 have been spent on the election of a single person to the Senate. An official enquirer (Senator Kenyon, chairman of the Senate committee on privileges and elections, U.S.A., 1921) was justified in calling these sums "a present and growing menace to the nation," even when allowance is made for the wide tracts of land to be covered in the United States in an election campaign. Besides money the party leaders had as election currency thousands of Federal, State and local offices in their gifts, but these, since 1883, are being gradually withdrawn from the "spoils" system. From the office-holders on the "spoils" system collections of a percentage of their salaries were made for the party funds; but these assessments are now in the process of extinction. Since 1890 many laws have sought to regulate electoral sincerity, and they have concentrated upon publicity of the source and destination of campaign funds, have sought to secure reports of personal service; some States (*e.g.*, Alabama, Kentucky, Minnesota, New Jersey, Wisconsin and several others), even going so far as to require accounts and reports several days prior to the election. The laws have gone a long way towards defining and enumerating legitimate expenditure and illegitimate means of influence. Some States (Alabama, Minnesota, Massachusetts and Wisconsin), require that all political advertisements shall be signed and marked "Paid advertisement," stating the price paid, the advertiser and the author. In the three latter States and Kansas the purchase of newspaper support is forbidden. These laws have done much good. While party managers have not been wholly restrained from that class of immoral electoral behaviour now prohibited by statute, their task has been made more difficult to a point which has forced many to become honest. One contribution of American practice to electoral procedure is the introduction of the ***Publicity Pamphlet.*** Oregon in 1908 passed a law requiring all candidates to take at fixed rates from one to four pages of a pamphlet published and sent to all

voters by the secretary of State. Persons desiring to oppose candidates may also take space for that purpose, providing due notice is given to the person attacked and subject to the law of libel. Several other States have adopted this system, but it has worked best in its native State. On the whole these publicity pamphlets have no more value than assembled copies of the English election addresses which are printed by the candidates, and one mail of which may be sent to parliamentary electors at the State's expense.

French law on corrupt practices was codified in the decree of Feb. 1852, but little heed was taken of its provisions until the laws of July 29, 1913, and March 31, 1914, redefined the offences and created severe penalties. A light is thrown upon French electoral procedure when we remark that in the latter statute Government pressure is expressly condemned.

It is always necessary to remember that there is much "influence" which is impalpable but very effective—not usually exercised wholesale, but in the form of individual pressure, difficult to detect or to resist. A shopkeeper, for example, may fear to express his opinions by exhibiting the placard he favours; a policeman may be taken off his guard by a popular local politician, and other known party workers may be victimized in a way which, to the outer eye, appears economically fair. In the Southern States of the United States the negro problem has found a partial solution in variously devised qualifications for the vote, but one must add to the total means of racial discrimination the opinion of the white neighbourhood, which may at any time be supported by injustices done in the law courts, rough handling and even lynching.

Recent electoral proceedings in the more populous countries, such as France, Germany and Great Britain have shown two characteristics of much importance. The first is the increased rowdiness at election meetings. This is undoubtedly due to what may be called the maturity of the franchise. The vote has been given to practically all adults, and these have been simultaneously persuaded that the political struggle may give wealth and power to some and take it from others. Intolerance is bound to be the consequence of such a conviction, and it issues in the attempt to stop opponents from stating their case. The second is the use of the microphone for broadcasting speeches. While in the United States this form of political speaking was effectively used by both leading candidates in the 1928 presidential election, it has not reached its full development in other countries.

Majority and Minority Representation.—Three systems of representation are at present operative. There are countries like Great Britain and most of the States of the United States of America, where however many candidates stand for a single available seat the one candidate who tops the list by however little over the next below him is elected. This is called the plurality majority system, and it is not difficult to see that since all the unsuccessful candidates may have between them more than 50% of the votes cast, the majority may be unrepresented. In order to avoid such inequity two principal methods have been invented: the second ballot, as operative in France and other European countries who have no proportional representation system, and the alternative vote. In the former, where no candidate obtains an absolute majority, *i.e.*, anything over 50% of the total votes cast, a second ballot takes place, in which all unsuccessful candidates are at once or progressively excluded, an absolute decision between the two candidates finally remaining being ultimately arrived at. The alternative vote is the method which secures the benefits of the second ballot at a single election, the voter marking the candidates on his ballot paper with a series of preferences 1, 2, 3 and so on—whence the method is sometimes called the preferential vote. This is much used in Australia. Many countries, notably Belgium, Holland and Germany have adopted a system of proportional representation, that is, methods of casting and counting ballots which allow of a representation of political opinion in fairly strict proportional representation. The respective merits and demerits of these systems are dealt with in the article on PROPORTIONAL REPRESENTATION.

Delegate and Representative.—Once the candidate has succeeded in getting elected, is he to act upon instructions and primarily for the constituency, or to use his discretion broadly for the welfare of the whole country? Until recent years the generally accepted view was that the elected person is a *representative* and has no particular mandate. This theory was embodied in France in the Constitution of Sept. 3, 1791 (sec. 3, art. 7): "The representatives chosen in the departments shall not be representatives of a particular department, but of the entire nation, and no one may give them any instructions (*mandat*)." The theory and even the words of the article have been copied by most countries since in their written Constitutions. In England much the same theory was enunciated by Edmund Burke in his speech to the sheriffs of Bristol (1780), but with less abstract dogmatism. The 19th century has witnessed the triumph of the French view over new forms of political organization. The prime movers in political life became political parties, propagandist organizations and organized economic groups like trade unions. They demand an adherence not to their strict instructions, but to their general principles, and it is a general, though not a legal rule, that the member who finds himself in plain disagreement with his supporting group must explain the grounds of his divergence. In Europe, outside Russia, it is generally recognized that the member cannot do his best work without a certain amount of independence. On the whole, Burke's view is accepted: "Look, gentlemen, to the *whole tenor* of your member's conduct. . . . He may have fallen into errors: he must have faults; but our error is greater and our fault is radically ruinous to ourselves if we do not bear, if we do not even applaud, the whole compound and mixed mass of such a character . . . if by a fair, by an indulgent, by a gentlemanly behaviour to our representatives, we do not give confidence to their minds, and a liberal scope to their understandings; if we do not permit our members to act upon a *very* enlarged view of things, we shall at length infallibly degrade our national representation into a confused and shuffling bustle of local agency." It is, indeed, a nice balance which has to be kept. But the claims of the organized electors have received greater validity in Russia than elsewhere. There, quite plainly, the mandate of the whole people is denied, and the system of the *definite and imperative* mandate has been adopted. By the Constitution of 1925 (art. 63, and the previous Constitution of 1918), the members of the soviets are obliged to report regularly to their electors on their action, and art. 75 gives the electors the right to revoke their mandate at any time and elect another member. The congresses have reiterated this right and power and urged its employment. About a dozen States in the United States have the system of the *recall* for controlling the activity of members both of the legislative and of the administration. It is actually used chiefly against local officials and arouses intense electoral interest.

Non-voting and Compulsory Voting.—A disturbing phenomenon in all electoral systems is the small percentage of actual voters. In England the parliamentary vote is normally about 70% of its full strength; in France it is not much over 60%, in Germany it is often over 75%, and in the United States, where the word "non-voting" was invented, presidential elections have had as great a proportion as 80% voting; but in other elections, State and local, there is a great falling off. The best extant study of non-voting is that by Prof. H. Gosnell of Chicago university, who found by actual research the following causes in the degree expressed in Table III., p. 139.

We cannot say how far the percentages fit conditions outside Chicago for that particular election, but the causes of non-voting as analyzed and defined in this study are useful clues. Non-voting has caused considerable anxiety to the supporters of democracy and it is natural that reformers should have hit upon the idea of compulsory voting. Switzerland, Spain, Argentine, Bulgaria, Austria, New Zealand, Czechoslovakia, Holland and Belgium have penalties for non-voters—all of them with the exception of Holland and Czechoslovakia dating from before the war. The Australian Commonwealth adopted a system in 1924. Belgium, which has enforced its law most stringently, began to compel voters as early as 1893 with the penalty of a fine of from one to three francs or a reprimand for the first omission to vote;

TABLE III.

Reasons for Not Voting at the Chicago Mayoralty Election of April, 1923

Reasons for not voting	No.	Per cent distribution
All reasons	5,310	100·0
Physical difficulties:		
Illness	647	12·1
Absence	589	11·1
Detained by helpless member of family	115	2·2
Legal and administrative obstacles:		
Insufficient legal residence	274	5·2
Fear of loss of business or wages	289	5·5
Congestion at polls	44	0·8
Poor location of polling booth	45	0·8
Fear of disclosure of age	14	0·3
Disbelief in voting:		
Disbelief in woman's voting	414	7·8
Objections of husband	54	1·0
Disgust with politics	230	4·3
Disgust with own party	105	2·0
Belief that one vote counts for nothing	79	1·5
Belief that ballot box is corrupted	40	0·7
Disbelief in all political action	22	0·4
Inertia:		
General indifference	1,347	25·4
Indifference to particular election	129	2·5
Neglect: intended to vote but failed	448	8·4
Ignorance or timidity regarding elections	378	7·1
Failure of party workers	47	0·9

for a second omission within six years a fine of from three to 25 francs; for a third omission within ten years a similar penalty and the exhibition of the offender's name on a placard outside the town hall for a month. The fourth omission in 15 years brings about a more serious punishment: similar fines and the removal of the elector's name from the register for ten years, during which time he may receive from the State no promotion, distinction or nomination to public office in local or central Government. Though the franchise has been greatly widened since 1893 the abstentions have never been higher than 7·5% (in 1896) and in 1900 were 6%, and in 1912 only 4%. Altogether, from 1899–1912 it needed 24,819 convictions of various degrees (about 10,000 being reprimands) to secure this result. The main question is: is it worth while spending the energy and money required to make voters exercise the vote? Is the vote, as some consider it, a right, or as others, a civic duty? (H. Fi.)

ELECTORS (Ger. *Kurfürsten*), a body of German princes, with whom rested the election of the German king, from the 13th until the beginning of the 19th century. Before the middle of the 13th century German kings had succeeded to their position partly by heredity and partly by election. Primitive Germanic practice had emphasized the element of heredity. *Reges ex nobilitate sumunt:* the man whom a German tribe recognized as its king must be in the line of hereditary descent from Woden; and therefore the genealogical trees of early Teutonic kings (as, for instance, in England those of the Kentish and West Saxon sovereigns) are carefully constructed to prove that divine descent which alone will constitute a proper title. Even from the first, however, there had been some opening for election; for the principle of primogeniture was not observed, and there might be several competing candidates, all of the true Woden stock. One of these competing candidates would have to be recognized; and to this limited extent Teutonic kings may be termed elective from the very first. In the other nations of western Europe this element of election dwindled, and the principle of heredity alone received legal recognition; in mediaeval Germany, on the contrary, the principle of heredity, while still exercising an inevitable natural force, sank formally into the background, and legal recognition was finally given to the elective principle.

This difference between the German monarchy and the other monarchies of western Europe may be explained by various considerations. Not the least important of these is what seems a pure accident. Whereas the Capetian monarchs, during the 300 years that followed on the election of Hugh Capet in 987, always left an heir male, and an heir male of full age, the German kings again and again, during the same period, either left a minor to succeed to the throne or left no issue at all. The principle of heredity began to fail because there were no heirs. Again the strength of tribal feeling in Germany made the monarchy into a prize, which must not be the apanage of any single tribe, but must circulate, as it were, from Franconian to Saxon, from Saxon to Bavarian, from Bavarian to Franconian, from Franconian to Swabian; while the growing power of the baronage, and its habit of erecting anti-kings to emphasize its opposition to the Crown (as, for instance, in the reign of Henry IV.), coalesced with and gave new force to the action of tribal feeling. Lastly, the fact that the German kings were also Roman emperors finally and irretrievably consolidated the growing tendency towards the elective principle. The principle of heredity had never held any great sway under the ancient Roman empire (*see* under EMPEROR); and the mediaeval empire, instituted as it was by the papacy, came definitely under the influence of ecclesiastical prepossessions in favour of election. Heredity might be tolerated in a mere matter of kingship; the precious trust of imperial power could not be allowed to descend according to the accidents of family succession. To Otto of Freising (*Gesta Frid.* ii. 1) it is already a point of right vindicated for itself by the excellency of the Roman empire, as a matter of singular prerogative, that it should not descend *per sanguinis propaginem, sed per principum electionem.*

The accessions of Conrad II., Lothair II., Conrad III., and Frederick I. had all been marked by an element, more or less pronounced, of election. That element is perhaps most considerable in the case of Lothair, who had no rights of heredity to urge. Here we read of ten princes being selected from the princes of the various duchies, to whose choice the rest promise to assent, and of these ten selecting three candidates, one of whom, Lothair, is finally chosen (apparently by the whole assembly) in a somewhat tumultuary fashion. In this case the electoral assembly would seem to be, in the last resort, the whole diet of all the princes. But a *de facto* pre-eminence in the act of election is already, during the 12th century, enjoyed by the three Rhenish archbishops, probably because of the part they afterwards played at the coronation, and also by the dukes of the great duchies—possibly because of the part they also played, as vested for the time with the great offices of the household, at the coronation feast. In fact the votes of the archbishops and dukes, which would first be taken, would of themselves, if unanimous, decide the election. To prevent tumultuary elections, it was well that the election should be left exclusively with these great dignitaries; and this is what, by the middle of the 13th century, had eventually been done.

The chaos of the interregnum from 1198 to 1212 showed the way for the new departure; the chaos of the great interregnum (1250–73) led to its being finally taken. The decay of the great duchies, and the narrowing of the class of princes into a close corporation, some of whose members were the equals of the old dukes in power, introduced difficulties and doubts into the practice of election which had been used in the 12th century. The contested election of the interregnum of 1198–1212 brought these difficulties and doubts into strong relief. The famous bull of Innocent III. (*Venerabilem*), in which he decided for Otto IV. against Philip of Swabia, on the ground that, though he had fewer votes than Philip, he had a majority of the votes of those *ad quos principaliter spectat electio,* made it almost imperative that there should be some definition of these principal electors. The most famous attempt at such a definition is that of the *Sachsenspiegel,* which was followed, or combated, by many other writers in the first half of the 13th century. Eventually the contested election of 1257 brought light and definition. Here we find seven potentates acting—the same seven whom the Golden Bull recognizes in 1356; and we find these seven described in an official letter to the pope as *principes vocem in hujusmodi electione habentes, qui sunt septem numero.* The doctrine thus enunciated was at once received; and by the date of the election of Rudolph of Habsburg (1273) the seven electors may be regarded as a definite body, with an acknowledged right: The pope having already acknowledged it in two bulls (1263).

The Golden Bull.—But the definition and the acknowledgment were still imperfect. (1) The composition of the electoral body was uncertain in two respects. The duke of Bavaria claimed as his proper right the electoral vote which had been assumed by the king of Bohemia; and the practice of *partitio* in electoral families tended to raise further difficulties about the exercise of the vote. The Golden Bull of 1356 settled both these questions. Bohemia (of which Charles IV., the author of the Golden Bull, was himself the king) was assigned the electoral vote in preference to Bavaria; and a provision annexing the electoral vote to a definite territory, declaring that territory indivisible, and regulating its descent by the rule of primogeniture instead of partition, swept away the old difficulties which the custom of partition had raised. After 1356 the seven electors are regularly the three Rhenish archbishops, Mainz, Cologne and Trier, and four lay magnates, the palatine of the Rhine, the duke of Saxony, the margrave of Brandenburg and the king of Bohemia; the three former being vested with the three archchancellorships, and the four latter with the four offices of the royal household (*see* Household). (2) The rights of the seven electors, in their collective capacity as an electoral college, were a matter of dispute with the papacy. The result of the election was in itself simply the creation of a German king—an *electio in regem*. But since 962 the German king was also, after coronation by the pope, Roman emperor. Therefore the election had a double result: the man elected was not only *electus in regem*, but also *promovendus ad imperium*. The difficulty was to define the meaning of the term *promovendus*. Must the elected king be promoted inevitably to the imperial crown, or did such promotion depend on the discretion and subsequent action of the papacy? Boniface VIII. pressed the latter view against Albert I. in 1298, even though his election was unanimous; and John XXII. expressed it in its harshest form, when in 1324 he excommunicated Louis IV. for using the title even of king without previous papal confirmation. This action ultimately led to a protest from the electors, whose right of election would have become practically meaningless if such assumptions had been tolerated. A meeting of the electors (*Kurverein*) at Rense in 1338 declared (and the declaration was reaffirmed by a diet at Frankfurt in the same year) that the act of election conveyed both kingship and empire without any need of papal assent. The doctrine thus positively affirmed at Rense is negatively reaffirmed in the Golden Bull, in which a significant silence is maintained in regard to papal rights. But the doctrine was not always in practice followed and Sigismund, for example, did not venture to dispense with papal approbation.

By the end of the 14th century the position of the electors, both individually and as a corporate body, had become definite and precise. Individually, they were distinguished from all other princes, as we have seen, by the indivisibility of their territories and by the custom of primogeniture which secured that indivisibility; and they were still further distinguished by the fact that their person, like that of the emperor himself, was protected by the law of treason, while their territories were only subject to the jurisdiction of their own courts. Powerful as they were, however, in their individual capacity, the electors showed themselves no less powerful as a corporate body. As such a corporate body, they may be considered from three different points of view, and as acting in three different capacities. They were an electoral body, choosing each successive emperor; they were one of the three colleges of the imperial diet (*see* Diet); and they were also an electoral union (*Kurfürstenverein*), acting as a separate and independent political organ even after the election, and during the reign, of the emperor. It was in this last capacity that they had met at Rense in 1338; and in the same capacity they acted repeatedly during the 15th century. According to the Golden Bull, such meetings were to be annual, and their deliberations were to concern "the safety of the empire and the world." Annual they never were; but occasionally they became of great importance. Again and again, from 1424 to 1530, attempts were made by the electoral union to erect a new central Government, either composed of its members or acting under their influence and control, by the side of the emperor. There was one such attempt in 1424; another in 1453; and a third, the most ambitious of all, in which Bertold of Mainz was prominent, in 1500. But the opposition of the emperors combined with the forces of German disunion to shipwreck every attempt.

In the course of the 16th century a new right came to be exercised by the electors. As an electoral body (*i.e.*, in the first of the three capacities distinguished above), they claimed, at the election of Charles V. in 1519 and at subsequent elections, to impose conditions on the elected monarch, and to prescribe the terms on which he should exercise his office in the course of his reign. This *Wahlcapitulation*, similar to the *Pacta Conventa* which limited the elected kings of Poland, was left by the diet to the discretion of the electors, though after the treaty of Westphalia an attempt was made, with some little success, to turn the capitulation into a matter of legislative enactment by the diet. From this time onwards the only fact of importance in the history of the electors is the change which took place in the composition of their body during the 17th and 18th centuries. From the Golden Bull to the early years of the 17th century the composition of the electoral body had remained unchanged. In 1623, however, in the course of the Thirty Years' War, the vote of the count palatine of the Rhine was transferred to the duke of Bavaria; and at the treaty of Westphalia the vote, with the office of imperial butler which it carried, was left to Bavaria, while an eighth vote, along with the new office of imperial treasurer, was created for the count palatine. In 1708 a ninth vote, along with the office of imperial standard-bearer, was created for Hanover; while finally, in 1778, the vote of Bavaria and the office of imperial butler returned to the counts palatine, as heirs of the duchy, on the extinction of the ducal line, and the new vote created for the Palatinate in 1648, with the office of imperial treasurer, was transferred to Brunswick-Lüneburg (Hanover) in lieu of the vote which this house already held. In 1806, on the dissolution of the Holy Roman Empire, the electors ceased to exist.

Bibliography.—W. Maurenbrecher, *Geschichte der deutschen Königswahlen* (1889); G. Blondel, *Etude sur Frédéric II.* (1892), p. 27 *seq.;* T. Lindner, *Die deutschen Königswahlen und die Entstehung des Kurfürstentums* (1893) and *Der Hergang bei den deutschen Königswahlen* (1899); R. Kirchhöfer, *Zur Entstehung des Kurkollegiums* (1893). *See* also J. Bryce, *Holy Roman Empire* (edition of 1904), c. ix.; and R. Schröder, *Lehrbuch der deutschen Rechtsgeschichte* (1919), pp. 471–481 and 819–820. (E. B.)

ELECTRA, a city of Wichita county, Texas, U.S.A., 10m. from the Red river (the northern boundary of the State), at an elevation of 1,220ft. above sea-level. It is on Federal highway 370 and the Fort Worth and Denver City railway. The area is one square mile. The population was 4,744 in 1920 (98·5% native white), and was estimated locally at 10,000 in 1928. In 1892 a town-site was platted on the ranch of W. T. Waggoner, around Beaver Post Office (established 1890), and in 1902 the name was changed to Electra, in honour of Waggoner's daughter. The population had reached only 640 in 1910, but early in 1911 the discovery well in the Electra oil-field (1m. N.) was completed, and by the end of that year there were about 5,000 inhabitants. In 1925 the production of the field was 6,294,455 barrels, and the city had three refineries, eight casinghead gasolene plants, a tank factory and two machine shops making oil-field tools, besides cotton gins, grain elevators, a creamery and a chick hatchery with a capacity of 20,000 eggs. The assessed valuation of property was $4,238,785. The city was incorporated in 1917. It has a commission form of government.

ELECTRA, the name of three Greek legendary figures, ('Ηλέκτρα, Doric 'Αλέκτρα, "bright one"). (1) Daughter of Oceanus, wife of Thaumas, and by him mother of Iris and the Harpies; sister of Styx. (Hesiod, *Theog.*, 265 ff., cp. 349 ff.). (2) One of the Pleiads (*q.v.*); mother by Zeus of Dardanus, the ancestor of the Trojan royal family. This detail is post-Homeric, the genealogy in the *Iliad* beginning with Dardanus, whose mother is not named, Il., xx., 215. She is regularly said to have lived in Samothrace, where once or twice the Cabiri are identified with her sons, although several authorities connect her, or her children, also with Arcadia and Crete, and a late and artificial account makes her an Italian, wife of Corythus. Iasion, the lover of Demeter (*q.v.*) is also her son by Zeus, and

frequently she and Zeus are the parents of Harmonia (*q.v.*). In some late authors she brings the Palladium to Troy for her son (schol. Eurip., *Phoen.*, 1136), or her star is the dim Pleiad, which lost its splendour when Troy fell (Hygin., *Fab.*, 192; Servius Danielis on Virg., *Georg.*, I., 138). For these and other stories *see* Furtwängler in Roscher's *Lexikon*, I., col. 1234–35. (3) Daughter of Agamemnon (*q.v.*) and Clytaemestra (not named in the Homeric list of his daughters, Il., ix., 145, 287), and apparently first in Stesichorus, or Xanthus, (Aelian, *Var. Hist.*, iv. 26), where she is said to have been identified with the Homeric Laodice. In the tragedians who certainly follow the lost *Oresteia* of Stesichorus, in some particulars at least, she rescues Orestes, then a child, at the time of Agamemnon's murder, and sends him with an old servant to Phocis for safe keeping (so Sophocles; in Aeschylus, he had already been sent away before the return of his father). She herself remains with her mother, enduring all manner of insult and ill-treatment and remaining unmarried (in Euripides, she is nominally married to a commoner, who respects and guards her). At length, Orestes, now a man, returns secretly and with the help of Electra entraps Aegisthus and Clytaemestra (the stratagem he uses is variously given), and kills them both. Electra then marries Pylades. Many variants, some very complicated (*e.g.*, Hygin., *Fab.*, 122) exist.

See Aeschylus, *Choephoroe;* Sophocles and Euripides, *Electra*, with Jebb's introduction to his edition of the former for an account of the handling of the theme in literature, ancient and modern; also the mythological handbooks, and the articles in Roscher's *Lexikon* and Pauly-Wissowa, *Realencyclopädie.*

ELECTRICAL ARTICLES. The general article will be found under ELECTRICITY; related subjects are dealt with under ELECTRIC GENERATOR; MOTORS, ELECTRIC; ELECTRICAL MACHINE; ELECTRICITY, ATMOSPHERIC; ELECTRICITY, CONDUCTION OF; ACCUMULATOR; BATTERY; and ELECTRON. Electric Power is dealt with under ELECTRICAL POWER: *National and Regional Schemes;* ELECTRIC POWER IN AGRICULTURE; ELECTRICITY SUPPLY: *Commercial Aspects;* ELECTRICITY SUPPLY: *Technical Aspects;* and ELECTRIFICATION OF INDUSTRY.

Other articles are ELECTRIC FURNACES; INSTRUMENTS, ELECTRICAL; ELECTROMAGNETISM; ELECTROMETALLURGY; ELECTROPLATING; ELECTROCUTION and ELECTROTHERAPY. Articles relating to lighting are found under ELECTRIC LAMPS AND VALVES, MANUFACTURE OF; LIGHTING; and ILLUMINATING ENGINEERING. Articles on electric transport are found under RAILWAYS, ELECTRIFICATION; LOCOMOTIVES, ELECTRIC; TRAMWAYS; TRACTION, ELECTRIC; and TRANSPORT. Electricity as concerned with communication is dealt with under TELEPHONE; TELEGRAPH; BROADCASTING; WIRELESS; and RAILWAYS: *Signalling.*

ELECTRICAL ENGINEER is one who is able to conduct or direct work involving the theory and practical application of electricity. The work of the electrical engineer may include research design, construction, operation and management, and also teaching and writing on any of these branches. The practical application of electricity, in which the great majority of electrical engineers are employed, may be divided into generation, distribution, control and utilization of electrical energy. Utilization may include use of mechanical power produced by electrical devices as in transportation and industrial-machine operation, illumination, communication, electrochemistry, electrometallurgy, electrical heating, measuring by electrical means, and use of electronic forces as in X-rays, cathode rays, etc.

ELECTRICAL INSTRUMENTS: *see* INSTRUMENTS, ELECTRICAL.

ELECTRICAL (or ELECTROSTATIC) **MACHINE,** a machine operating by manual or other power for transforming mechanical work into electric energy by the separation of electrostatic charges of opposite sign delivered to separate conductors. Electrostatic machines are of two kinds: Frictional, and Influence.

Frictional Machines.—A primitive form of frictional electrical machine was constructed about 1663 by Otto von Guericke (1602–1686). It consisted of a globe of sulphur fixed on an axis and rotated by a winch, and it was electrically excited by the friction of warm hands held against it. Sir Isaac Newton appears to have been the first to use a glass globe instead of sulphur (*Optics*, 8th Query). F. Hawksbee in 1709 also used a revolving glass globe. A metal chain resting on the globe served to collect the charge. Later G. M. Bose (1710–1761), of Wittenberg, added the prime conductor, an insulated tube or cylinder supported on silk strings, and J. H. Winkler (1703–1770), professor of physics at Leipzig, substituted a leather cushion for the hand. Andreas Gordon (1712–1751) of Erfurt, a Scotch Benedictine monk, first used a glass cylinder in place of a sphere. Jesse Ramsden (1735–1800) in 1768 constructed his well-known form of plate electrical machine (fig. 1). A glass plate fixed to a wooden or metal shaft is rotated by a winch. It passes between two rubbers made of leather, and is partly covered with two silk aprons which extend over quadrants of its surface. Just below the places where the aprons terminate, the glass is embraced by two insulated metal forks having the sharp points projecting towards the glass, but not quite touching it. The glass is excited positively by friction with the rubbers, and the charge is drawn off by the action of the points which, when acted upon inductively, discharge negative electricity against it. The insulated conductor to which the points are connected therefore becomes positively electrified. The cushions must be connected to earth to remove the negative electricity which accumulates on them. It was found that the machine acted better if the rubbers were covered with bisulphide of tin or with F. von Kienmayer's amalgam, consisting of one part of zinc, one of tin and two of mercury. The cushions were greased and the amalgam in a state of powder spread over them. Edward Nairne's electrical machine (1787) consisted of a glass cylinder with two insulated conductors, called prime conductors, on glass legs placed near it. One of these carried the leather exacting cushions and the other the collecting metal points, a silk apron extending over the cylinder from the cushion almost to the points. The rubber was smeared with amalgam. The function of the apron is to prevent the escape of electrification from the glass during its passage from the rubber to the collecting points. Nairne's machine could give either positive or negative electricity, the first named being collected from the prime conductor carrying the collecting points and the second from the prime conductor carrying the cushion.

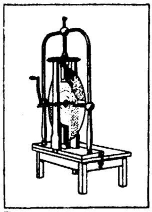


FIG. 1.—RAMSDEN'S ELECTRICAL MACHINE

Influence Machines.—Frictional machines are, however, now quite superseded by the second class of instrument mentioned below, namely, influence machines. These operate by electrostatic induction and convert mechanical work into electrostatic energy by the aid of a small initial charge which is subsequently replenished or reinforced in an accumulative manner. The general principle of all the machines described below will be best understood by considering a simple ideal case. Imagine two Leyden jars with large brass knobs, A and B, to stand on the ground (fig. 2). Let one jar be initially charged with positive electricity on its inner coating and the other with negative, and let both have their outsides connected to earth. Imagine two insulated balls A′ and B′ so held that A′ is near A and B′ is near B. Then the positive charge on A induces two charges on A′, viz.: a negative on the side nearer and a positive on the side more remote. Likewise the negative charge on B induces a positive charge on the side of B′ nearer to it and repels negative electricity to the far side. Next let the balls A′ and B′ be connected together for a moment by a wire N called a neutralizing conductor which is subsequently removed. Then A′ will be left negatively electrified and B′ will be left positively electrified. Suppose that A′ and B′ are then made to change places. To do this we shall have to exert energy to remove A′ against the attraction of A and B′ against

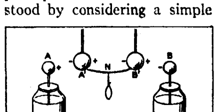


FIG. 2.—LEYDEN JAR APPARATUS WITH BRASS KNOBS

the attraction of B. Finally let A′ be brought in contact with B and B′ with A. The ball A′ will give up its charge of negative electricity to the Leyden jar B, and the ball B′ will give up its positive charge to the Leyden jar A. This transfer will take place because the inner coatings of the Leyden jars have greater capacity with respect to the earth than the balls. Hence the charges of the jars will be increased. The balls A′ and B′ are then practically discharged, and the above cycle of operations may be repeated. Hence, however small may be the initial charges of the Leyden jars, by a principle of accumulation resembling that of compound interest, they can be increased as above shown to any degree or, at least, until the losses due to incomplete insulation do not outweigh the gain of charge of either conductor in the same time. If this series of operations be made to depend upon the continuous rotation of a winch or handle, the arrangement constitutes an electrostatic influence machine. The principle therefore somewhat resembles that of the self-exciting dynamo.

Bennet's Doubler.—The first suggestion for a machine of the above kind seems to have grown out of the invention of Volta's electrophorus. Abraham Bennet, the inventor of the gold leaf electroscope, described a *doubler* or machine for multiplying electric charges (*Phil. Trans.*, 1787).

The principle of this apparatus may be explained thus. Let A and C be two fixed disks, and B a disk which can be brought at will within a very short distance of either A or C. Let us suppose all the plates to be equal, and let the capacities of A and C in presence of B be each equal to p, and the coefficient of induction between A and B, or C and B, be q. Let us also suppose that the plates A and C are so distant from each other that there is no mutual influence, and that p' is the capacity of one of the disks when it stands alone. A small charge Q is communicated to A, and A is then insulated, and B, uninsulated, is brought up to it; the charge on B will be $-(q/p)$Q. B is now uninsulated and brought to face C, which is uninsulated; the charge on C will be $(q/p)^2$Q. C is now insulated and connected with A, which is always insulated. B is then brought to face A and uninsulated, so that the charge on A becomes rQ, where

$$r = \frac{p}{p+p'}\left(1+\frac{q^2}{p^2}\right).$$

A is now disconnected from C, and here the first operation ends. It is obvious that at the end of n such operations the charge on A will be r^nQ, so that the charge goes on increasing in geometrical progression. If the distance between the disks could be made infinitely small each time, then the multiplier r would be 2, and the charge would be doubled each time. Hence the name of the apparatus.

Nicholson's Doubler.—Erasmus Darwin, B. Wilson, G. C. Bohnenberger and J. C. E. Peclet devised various modifications of Bennet's instrument (*see* S. P. Thompson, "The Influence Machine from 1788 to 1888," *Journ. Soc. Tel. Eng.*, 1888, 17, p. 569). Bennet's *doubler* appears to have given a suggestion to William Nicholson (*Phil. Trans.*, 1788, p. 403) of "an instrument which by turning a winch produced the two states of electricity without friction or communication with the earth." This "revolving doubler," according to the description of Professor S. P. Thompson (*loc. cit.*), consists of two fixed plates of brass A and C (fig. 3), each two inches in diameter and separately supported on insulating arms in the same plane, so that a third revolving plate B may pass very near them without touching. A brass ball D two inches in diameter is fixed on the end of the axis that carries the plate B, and is loaded within at one side, so as to act as a counterpoise to the revolving plate B. The axis P N is made of varnished glass, and so are the axes that join the three plates with the brass axis N O. The axis N O passes through the brass piece M, which stands on an insulating pillar of glass, and supports the plates A and C. At one extremity of this axis is the ball D, and the other is connected with a rod of glass, N P, upon which is fixed the handle L, and also the piece G H, which is separately insulated. The pins E, F rise out of the back of the fixed plates A and C, at unequal distances from the axis. The piece K is parallel to G H, and both of them are furnished at their ends with small pieces of flexible wire that they may touch the pins E, F in certain points of their revolution. From the brass piece M there stands out a pin I, to touch against a small flexible wire or spring which projects sideways from the rotating plate B when it comes opposite A. The wires are so adjusted by bending that B, at the moment when it is opposite A, communicates with the ball D, and A communicates with C through G H; and half a revolution later C, when B comes opposite to it, communicates with the ball D through the contact of K with F. In all other positions A, B, C and D are completely disconnected from each other. Nicholson thus described the operation of his machine:—

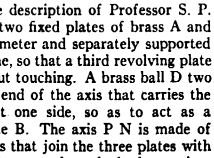


Fig. 3.—Nicholson's Receiving Doubler

"When the plates A and B are opposite each other, the two fixed plates A and C may be considered as one mass, and the revolving plate B, together with the ball D, will constitute another mass. All the experiments yet made concur to prove that these two masses will not possess the same electric state. . . . The redundant electricities in the masses under consideration will be unequally distributed; the plate A will have about ninety-nine parts, and the plate C one; and, for the same reason, the revolving plate B will have ninety-nine parts of the opposite electricity, and the ball D one. The rotation, by destroying the contacts, preserves this unequal distribution, and carries B from A to C at the same time that the tail K connects the ball with the plate C. In this situation, the electricity in B acts upon that in C, and produces the contrary state, by virtue of the communication between C and the ball; which last must therefore acquire an electricity of the same kind with that of the revolving plate. But the rotation again destroys the contact and restores B to its first situation opposite A. Here, if we attend to the effect of the whole revolution, we shall find that the electric states of the respective masses have been greatly increased; for the ninety-nine parts in A and B remain, and the one part of electricity in C has been increased so as nearly to compensate ninety-nine parts of the opposite electricity in the revolving plate B, while the communication produced an opposite mutation in the electricity of the ball. A second rotation will, of course, produce a proportional augmentation of these increased quantities; and a continuance of turning will soon bring the intensities to their maximum, which is limited by an explosion between the plates" (*Phil. Trans.*, 1788, p. 405).

Nicholson described also another apparatus, the "spinning condenser," which worked on the same principle. Bennet and Nicholson were followed by T. Cavallo, John Read, Bohnenberger, C. B. Désormes and J. N. P. Hachette and others in the invention of various forms of rotating doubler.

Belli's Doubler.—A simple and typical form of doubler, devised in 1831 by G. Belli (fig. 4), consisted of two curved metal plates between which revolved a pair of balls carried on an insulating stem. Following the nomenclature usual in connection with dynamos we may speak of the conductors which carry the initial charges as the field plates, and of the moving conductors on which are induced the charges which are subsequently added to those on the field plates, as the carriers. The wire which connects two armature plates for a moment is the neutralizing conductor. The two curved metal plates constitute the field plates and must have original charges imparted to them of opposite sign. The rotating balls are the carriers, and are connected together for a moment by a wire when in a position to be acted upon inductively by the field plates, thus acquiring charges of opposite sign. The moment after they are separated again. The rotation continuing the ball thus negatively charged is made to give up this charge to that

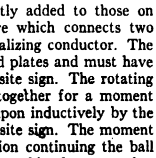


Fig. 4.—Belli's Doubler

negatively electrified field plate, and the ball positively charged its charge to the positively electrified field plate, by touching little contact springs. In this manner the field plates accumulate charges of opposite sign.

Varley's Machine.—Modern types of influence machine may be said to date from 1860 when C. F. Varley patented a type of influence machine which has been the parent of numerous subsequent forms (*Brit. Pat. Spec.* No. 206 of 1860). In it the field plates were sheets of tin-foil attached to a glass plate (fig. 5). In front of them a disk of ebonite or glass, having carriers of metal fixed to its edge, was rotated by a winch. In the course of their rotation two diametrically opposite carriers touched against the ends of a neutralizing conductor so as to form for a moment one conductor, and the moment afterwards these two carriers were insulated, one carrying away a positive charge and the other a negative. Continuing their rotation, the positively charged carrier gave up its positive charge by touching a little knob attached to the positive field plate, and similarly for the negative charge carrier. In this way the charges on the field plates were continually replenished and reinforced. Varley also constructed a multiple form of influence machine having six rotating disks, each having a number of carriers and rotating between field plates. With this apparatus he obtained sparks 6 in. long, the initial source of electrification being a single Daniell cell.

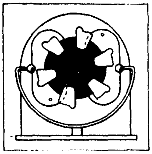


FIG. 5.—VARLEY'S MACHINE

Toepler Machine.—Varley was followed by A. J. I. Toepler, who in 1865 constructed an influence machine consisting of two disks fixed on the same shaft and rotating in the same direction. Each disk carried two strips of tin-foil extending nearly over a semi-circle, and there were two field plates, one behind each disk; one of the plates was positively and the other negatively electrified. The carriers which were touched under the influence of the positive field plate passed on and gave up a portion of their negative charge to increase that of the negative field plate; in the same way the carriers which were touched under the influence of the negative field plate sent a part of their charge to augment that of the positive field plate. In this apparatus one of the charging rods communicated with one of the field plates, but the other with the neutralizing brush opposite to the other field plate. Hence one of the field plates would always remain charged when a spark was taken at the transmitting terminals.

Holtz Machine.—Between 1864 and 1880, W. T. B. Holtz constructed and described a large number of influence machines which were for a long time considered the most advanced development of this type of electrostatic machine. In one form the Holtz machine consisted of a glass disk mounted on a horizontal axis F (fig. 6) which could be made to rotate at a considerable speed by a multiplying gear, part of which is seen at X. Close behind this disk was fixed another vertical disk of glass in which were cut two windows B, B. On the side of the fixed disk next the rotating disk were pasted two sectors of paper A, A, with short blunt points attached to them which projected out into the windows on the side away from the rotating disk. On the other side of the rotating disk were placed two metal combs C, C, which consisted of sharp points set in metal rods and were each connected to one of a pair of discharge balls E, D, the distance between which could be varied. To start the machine the balls were brought in contact, one of the paper armatures electrified, say, with positive electricity, and disk set in motion. Thereupon very shortly a hissing sound was heard and the machine became harder to turn as if the disk were moving through a resisting medium. After that the discharge balls might be separated a little and a continuous series of sparks or brush discharges would take place between them. If two Leyden jars L, L were hung upon the conductors which supported the combs, with their outer coatings put in connection with one another by M, a series of strong spark discharges passed between the discharge balls. The action of the machine is as follows: Suppose one paper armature to be charged positively, it acts by induction on the right hand comb, causing negative electricity to issue from the comb points upon the glass revolving disk; at the same time the positive electricity passes through the closed discharge circuit to the left comb and issues from its teeth upon the part of the glass disk at the opposite end of the diameter. This positive electricity electrifies the left paper armature by induction, positive electricity issuing from the blunt point upon the side farthest from the rotating disk. The charges thus deposited on the glass disk are carried round so that the upper half is electrified negatively on both sides and the lower half positively on both sides, the sign of the electrification being reversed as the disk passes between the combs and the armature by discharges issuing from them respectively. It it were not for leakage in various ways, the electrification would go on everywhere increasing, but in practice a stationary state is soon attained. Holtz's machine is very uncertain in its action in a moist climate, and has generally to be enclosed in a chamber in which the air is kept artificially dry.

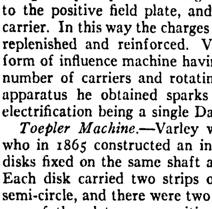


FIG. 6.—HOLTZ'S MACHINE

Voss Machine.—Robert Voss, a Berlin instrument maker, in 1880 devised a form of machine in which he claimed that the principles of Toepler and Holtz were combined. In the Holtz machine the collecting system CEDC (fig. 6) served also as the neutralizing conductor. In the Voss an additional neutralizing conductor was placed at an angle with the former. In addition on a rotating glass or ebonite disk were placed carriers of tin-foil or metal buttons against which the neutralizing brushes touched. This plate revolved in front of a field plate carrying two pieces of tin-foil backed up by larger pieces of varnished paper. The studs on the front plate were charged inductively by being connected for a moment by the neutralizing wire as they passed in front of the paper armatures on the stationary plate, and then gave up their charges partly to renew the field charges and partly to collecting combs connected to discharge balls. In general design and construction, the manner of moving the rotating plate and in the use of the two Leyden jars in connection with the discharge balls, Voss borrowed his ideas from Holtz.

Wimshurst Machine.—All the above described machines, however, were thrown into the shade by the invention of a greatly improved type of influence machine first constructed by James Wimshurst about 1878. Two glass disks are mounted on two shafts in such a manner that, by means of two belts and pulleys worked from a winch shaft, the disks can be rotated rapidly in opposite directions close to each other (fig. 7). These glass disks carry on them a certain number (not less than 16 or 20) tin-foil carriers which may or may not have brass buttons upon them. The glass plates are well varnished, and the carriers are placed on the outer sides of the two glass plates. As therefore the disks revolve, these carriers travel in opposite directions, coming at intervals in opposition to each other. Each upright bearing carrying the shafts of the revolving disks also carries a neutralizing conductor or wire ending in a little brush of gilt thread. The neutralizing conductors for each disk are placed at right angles to each other. In addition there are collecting combs which occupy an intermediate position and have sharp points projecting inwards, and coming near to but not touching the carriers. These combs on opposite sides are connected respectively to the inner coatings of two Leyden jars whose outer coatings are in connection with one another.

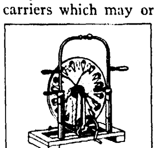


FIG. 7.—WIMSHURST'S MACHINE

The operation of the machine is as follows: Let us suppose that one of the studs on the back plate is positively electrified and one at the opposite end of a diameter is negatively electrified, and that at that moment two corresponding studs on the front

plate passing opposite to these back studs are momentarily connected together by the neutralizing wire belonging to the front plate. The positive stud on the back plate will act inductively on the front stud and charge it negatively, and similarly for the other stud, and as the rotation continues these charged studs will pass round and give up most of their charge through the combs to the Leyden jars. The moment, however, a pair of studs on the front plate are charged, they act as field plates to studs on the back plate which are passing at the moment, provided these last are connected by the back neutralizing wire. After a few revolutions of the disks half the studs on the front plate at any moment are charged negatively and half positively and the same on the back plate, the neutralizing wires forming the boundary between the positively and negatively charged studs. The diagram in fig. 8, taken by permission from S. P. Thompson's paper (*loc. cit.*), represents a view of the distribution of these charges on the front and back plates respectively. It will be seen that each stud is in turn both a field plate and a carrier having a charge induced on it, which then passes on in turn and induces further charges on other studs. Wimshurst constructed very powerful machines of this type, some of them with multiple plates, which operate in almost any climate, and rarely fail to charge themselves and deliver a torrent of sparks between the discharge balls whenever the winch is turned. He also devised an alternating current electrical machine in which the discharge balls were alternately positive and negative. Large Wimshurst multiple plate influence machines are often used instead of induction coils for exciting Röntgen ray tubes in medical work, particularly in countries where other sources are not available; but they cannot compete with sources depending upon electromagnetism when great power is required. They give very steady illumination on fluorescent screens.

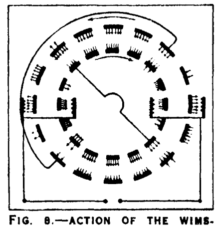


FIG. 8.—ACTION OF THE WIMSHURST MACHINE

In 1900 it was found by F. Tudsbury that if an influence machine is enclosed in a metallic chamber containing compressed air, or, better, carbon dioxide, the insulating properties of compressed gases enable a greatly improved effect to be obtained owing to the diminution of the leakage across the plates and from the supports. Hence sparks can be obtained of more than double the length at ordinary atmospheric pressure. In one case a machine with plates 8 in. in diameter which could give sparks 2·5 in. at ordinary pressure gave sparks of 5, 7, and 8 in. as the pressure was raised to 15, 30 and 45 lb. above the normal atmosphere.

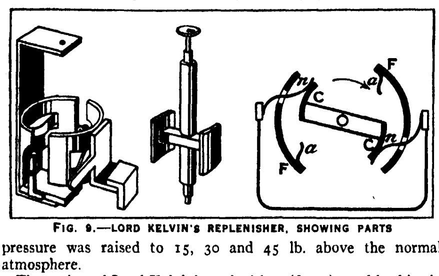


FIG. 9.—LORD KELVIN'S REPLENISHER, SHOWING PARTS

The action of Lord Kelvin's replenisher (fig. 9) used by him in connection with his electrometers for maintaining the charges, closely resembles that of Belli's doubler and will be understood from fig. 9. Lord Kelvin also devised an influence machine, commonly called a "mouse mill," for electrifying the ink in connection with his siphon recorder. It was an electrostatic and electromagnetic machine combined, driven by an electric current and producing in turn electrostatic charges of electricity. In connection with this subject mention must also be made of the water dropping influence machine of the same inventor.[1]

The action and efficiency of influence machines have been investigated by F. Rossetti, A. Righi and F. W. G. Kohlrausch. The electromotive force is practically constant no matter what the velocity of the disks, but according to some observers the internal resistance decreases as the velocity increases. Kohlrausch, using a Holtz machine with a plate 16 in. in diameter, found that the current given by it could in 40 hours only electrolyse acidulated water sufficient to liberate one cubic centimetre of mixed gases. This means that the current was less than one thousandth of an ampere. E. E. N. Mascart, A. Roiti and E. Bouchotte have also examined the efficiency and current-producing power of influence machines.

BIBLIOGRAPHY.—In addition to S. P. Thompson's valuable paper on influence machines (to which this article is much indebted) and other references given, *see* J. Clerk Maxwell, *Treatise on Electricity and Magnetism* (2nd ed., Oxford, 1881), vol. i., p. 294; J. D. Everett, *Electricity* (expansion of part iii. of Deschanel's *Natural Philosophy*) (London, 1901), ch. iv., p. 20; A. Winkelmann, *Handbuch der Physik* (Breslau, 1905), vol. iv., pp. 50–58 (contains a large number of references to original papers); J. Gray, *Electrical Influence Machines, their Development and Modern Forms* (London, 1903). The design of influence machines is very fully discussed in V. Schaffes, *La Machine à Influence* (1908). (J. A. F.; A. W. Po.)

ELECTRICAL POWER: NATIONAL AND REGIONAL SCHEMES. The 20th century has witnessed the world-wide development of national and regional schemes of electrical power generation and transmission. Development has been very unequal in different countries. Thus, in the United States, with its possession of magnificent coalfields, oilfields, natural gas supplies and water-power, the schemes have been based upon varied resources scattered over an enormous territory. In Italy, on the other hand, where coal is, for practical purposes, non-existent, but where there is a fine store of power in lake and mountain stream, the regional plans made have been almost entirely based upon transmission from gigantic hydro-electric generating stations. In Great Britain, where water-power is comparatively small, while the coalfields are fine and extensive, the plans made are necessarily based chiefly upon generation from the coal supply. In Great Britain development of electrical power generation and transmission has been notably behind that of several other countries, although long before the World War S. Z. Ferranti, when president of the Institute of Electrical Engineers, devoted his presidential address to concrete proposals to establish super-power stations, on the British coalfields and at other places to which coal could be economically transported, to create an all-electrical power-supply. Half a generation was, however, to elapse before British legislation set up a central board to develop a British national electric system.

In the following sections is given an account of the regional electrical power schemes of Great Britain, Germany, France, Italy, Switzerland, Holland and other European countries, and of Canada, followed by a description of the extensive developments which have taken place in the United States. (L. C. M.)

EUROPEAN ELECTRICAL SCHEMES

Great Britain.—The British public service of electricity supply has been carried out by local authorities and by power companies, the former accounting for about 64·5% of the total production by public undertakings. A number of tramway, railway, water-power and aluminium undertakings, not to be directly classified with public utilities, produce an additional 18 per cent. In 1927 the number of supply undertakings with distributing rights were 623, possessing 491 generating stations with a total output, in 1927–28, of 8,750,000,000 units. To these should be added railway, tramway and non-statutory undertakings possessing 79 stations with a production of 1,500,000,000 units, so that the real national total in that year was 10,250,000,000 units.

Acting on the report of a special committee, presided over by Lord Weir, dealing with the power situation, the Government de-

[1]*See* Lord Kelvin, *Reprint of Papers on Electrostatics and Magnetism* (1872); "Electrophoric Apparatus and Illustrations of Voltaic Theory," p. 319; "On Electric Machines Founded on Induction and Convection," p. 330; "The Reciprocal Electrophorus," p. 337.

cided to introduce legislation reinforcing the acts of 1919 and 1922 and establishing a central electricity board which would have a constitution similar to that of an industrial company outside of direct Parliamentary control. The functions of the central board, as constituted in the Electricity (Supply) Act of 1926, were to develop a national super-power system, erect main transmission lines to cover the whole country, to finance standardization of frequency so that one standard of transmission and distribution could be adopted—namely, that of 50 cycles—to take over the output of all the stations selected to supply the country under the new scheme, and to sell it to authorized distributors at cost price.

It was estimated that, by 1940–41, the national production of electricity would be 25,000,000,000 units, supplied by 60 stations with a total installed capacity of about 11,000,000 kw. The average working cost of electricity, when such concentration had been effected, would fall from .94d. as recorded in 1925–26 to less than .4d. per unit, while the large industrial consumer would be able to obtain his power requirements at ½d. per unit, and the national average for all supplies would lie in the vicinity of 1d.

The central electricity board worked on a triple programme:—

(a) The creation of giant power stations located in the main industrial areas under the control of public supply undertakings.

(b) The construction of a main transmission system operating at a pressure of 132,000 volts, so that the entire country would be held in a power ring or series of power rings radiating out from the giant power stations. To this system would be attached also smaller secondary lines tapping agricultural and other outlying areas.

(c) Standardization of frequency in the areas where 50 cycles were not used for generation and distribution—namely, on the North-East Coast, in the west of Scotland and in the area covered by Birmingham corporation and the Shropshire, Worcestershire and Staffordshire Electric Company in the Midlands.

All three developments were estimated to reach a first point of completion in 1934–35, when the main transmission system would have been constructed, and the greater part of the conversion to a standard frequency effected in the west of Scotland and the Midlands.

The zones surveyed and under construction in 1927 were South-East England, which included London and the surrounding area, with a population, according to the census of 1921, of 11,400,000; Central England, covering the five shires of Leicester, Northampton, Stafford, Warwick and Worcester, with a population of 5,218,000; Lancashire and North Wales; Yorkshire; Northumberland and Durham; Lincolnshire; South-West England and South Wales; North-West England; Central Scotland and probably Northern Scotland.

By April 1928, three main power zones had been surveyed and definite schemes of development drawn up for them—the three being South-East England, Central England and Central Scotland. These three areas, with a combined population of 21,000,000 and an estimated output for 1941 of 11,760,000,000 units produced in power stations with a total capacity of 4,668,000 kw., represented three of the most important industrial and economic areas in Great Britain, responsible for the maintenance of 48 per cent. of the entire population. The fourth great scheme, devoted to South-East Lancashire, was due to be published in June 1928, and the remaining zones were to be surveyed and designed before the end of 1929, so that the actual work of constructing the main transmission system and of bringing the whole national production of electricity into a scientific scheme would be definitely initiated by 1930.

Under full development—*i.e.*, by 1940–41—it was estimated that main transmission and standardization of frequency would account for an expenditure of between £30 and £35 millions, all to be incurred by the central board, which would raise the capital required for this purpose in the open market with a Treasury guarantee, while the supply undertakings owning the selected stations and furnishing the central board with their entire output would probably expend on generation alone about £120 millions. The elaboration of distribution systems connecting the consumer to the main transmission zones would account for an additional £100 millions, so that the average annual expenditure on electricity supply alone would not be far short of £250 millions.

Germany.—The progress of electricity supply in Germany has been similar to that of Great Britain. Much the same problems had to be overcome and the legislative measures destined to advance reorganization were based on the same principles in Germany as in Britain.

In Britain the national production of electricity has been spread over a number of undertakings, few of them large enough to take advantage of modern technical and administrative experience; in Germany, small undertakings have been even more firmly established. Thus, inclusive of industry, the total number of power stations in 1925 was 7,492 and of this number 6,930 were responsible for an output of 3,313,000,000 units, and 562 for 17,015,000,000 units. Thus 85 per cent. of the national production was concentrated in 562 power stations.

The most spectacular developments were associated with the large corporations, and through their activities a number of super-power zones were determined by 1927 in Germany. Thus, in Central Germany, the *Elektrowerke A.G.* (State-owned) developed a main transmission system from its three super-power stations at Zschornewitz, Lauta and Trattendorf, operating at 110,000 volts. This system covered the whole of the brown-coal area of Central Germany, fed into Berlin and extended into Lower Silesia with connections to Breslau. In Saxony proper it linked up with the system elaborated by the *Sächsische-Werke* (owned by the State of Saxony), which owned two main generating stations at Hirschfelde and Böhlen with a smaller plant at Chemnitz. This undertaking supplied Dresden and fed into Leipzig as well as Lower Silesia. To the south-west, at Herlasgrün, it was connected to the 110,000 volt system constructed by the *Bayernwerk,* which, obtaining its electricity from the water-power plant owned by the *Walchensee-Werk A.G.* at Walchensee and the *Mittlere-Isar A.G.* on the Isar, was supplying electricity north to Nuremberg and Bamburg, and, at Höchst, came into the super-power zone controlled by the *Rheinisch-Westfälisches E.W.* From Nuremberg to Regensburg a main transmission line had been constructed to bring the Kachlet water-power plant into the Bavarian scheme. Through Kachlet the southern German zone was connected with the Austrian system. Further south, through Stuttgart, it came again, at Karlsruhe, into touch with the super-power zone owned by the *Badenwerk,* and in this way was able to tap the giant brown-coal stations of the Ruhr and the water-power stations of the Black Forest and the Alps.

The fourth great zone had been elaborated by the *Rheinisch-Westfälisches E.W.*, operating from its giant station at Knapsack, interconnected with smaller stations at Reisholz, Essen and the Fortuna station of a different company which supplied Cologne. This undertaking constructed main transmission lines at 110,000 volts as far north as the Dutch border, and was connected with Dutch undertakings. To the south it constructed a 220,000 volt line from Knapsack to Coblenz and Mannheim, with a further projection through Stuttgart to the Swiss Alps. Its main line would ultimately operate at 380,000 volts and connect the Swiss water-power resources with the Ruhr and with Holland. A fifth smaller zone was served by the *Badenwerk,* with a system extending from Ludwigshafen to Homberg in the west, Karlsruhe, Villingen and Laufenburg in the south.

Secondary transmission lines operating at 33,000 to 80,000 volts radiated out from these main systems to cover wide areas in the south and in the centre of Germany. The result was that, under full development, five series of great power rings may operate in Germany: one extending from the Ruhr north to Emmerich and north-east to Bremen and Emden; a second from the Ruhr to Nienberg and thence north-east to Hanover, Herschel, Berkum, Frankfurt, Höchst, returning to the Ruhr; a third covering the whole of southern Germany with its northern limits at Frankfurt, its south-western at Laufenburg, its south-eastern at Walchensee, its eastern at Kachlet and the eastern frontier, and its north-eastern at Herlasgrün. The fourth power ring was composed of the two systems operated by the *Elektrowerke A.G.* and the *Sächsische-Werke,* covering Saxony and feeding into Berlin; while the fifth ring covered Lower Silesia. Under full development, one great ring will surround the whole of Germany between the

Ruhr, Berlin, Silesia, Saxony, Bavaria, Württemberg and Baden.

This had been very largely the work of the mixed supply corporation, where the model of the private industrial company had been adopted, with a majority public control in administration and finance, and these undertakings were due to become more and more important in the production of electricity. Thus, in 1926, the *Elektrowerke* accounted for an output of 1,500,000,000 units, the *Rheinisch-Westfälisches E.W.* for 1,350,000,000 units, the *Sächsische-Werke* for 600,000,000 units, the *Bayernwerk* for 400,000,000 units, the *Badenwerk* for 230,000,000 units, while the *Berliner Elektrizitätswerke*, which was linked up with the system of the *Elektrowerke*, produced over 600,000,000 units, and the *Hamburgisches Elektrizitätswerke*, 280,000,000 units. These seven undertakings accounted for a total of almost 5,000,000,000 units, the greater part of which was derived from brown-coal and water-power stations.

France.—The main principles at issue in France, as in Britain and Germany, were:—

1. The construction of efficient super-power stations interconnected to create power pools;
2. The exploitation of water-power sites with a view to effecting the maximum economy in fuel, with interconnection of the steam generating stations with these water-power stations to permit of the exchange of energy;
3. The elaboration of a high-pressure transmission system which would link up the main power zones, permit of railway electrification on the largest possible scale, and transform the whole country ultimately into one great power system.

Five power zones could be distinguished in 1927:—

1. The coal-mining and textile areas of the Nord and Pas-de-Calais
2. Paris
3. The Meurthe et Moselle
4. The Massif Central
5. The Pyrenees.

The reconstruction of the devastated territories made it possible to equip French coal-mines with the most modern machinery and to carry out a complete scheme of electrification. Thus the Nord and Pas-de-Calais became one of the most highly electrified coal-mining areas in the world, already supplied by a number of highly efficient stations located at the pit-heads, using waste fuel and waste heat, and interconnected to effect the fullest possible exchange of energy. The main stations located in this area were Comines, Pont-à-Vendin, Beuvry, Bully, Harnes, Seguedin, Wasquehal, Lomme, Valenciennes and Sin-le-Noble. The total productive capacity of the area was in excess of 1,200,000,000 units, and the main connecting lines operated at 45,000 volts. Through Maubeuge, Hirson and Mézières, this zone was linked up with the Meurthe et Moselle, while an elaborate system operating at the same voltage brought it, through the power station at Beaugarde and the transforming stations at Laon and Soissons, to the outskirts of the Paris zone, so that interconnection with the latter can be effected easily when necessary.

In Paris, the situation had become so simplified through reorganization that four undertakings supplied power for the entire zone. They were, in order of importance:—*Union d'Electricité*, with super-power stations at Gennevilliers (340,000 kw.), Vitry (90,000 kw.) and Vitry-Sud (100,000 kw.) under construction; the *Compagnie Parisienne de Distribution d'Electricité* at Issy-les-Moulineaux (130,000 kw.) and Saint-Ouen (400,000 kw.); the *Société d'Electricité*, with the Saint-Denis station (120,000 kw.); and the *Société d'Electricité de la Seine* at Ivry (under construction, 1928). All these stations, with the exception of Saint-Denis, were interconnected by underground cables operating at 60,000 volts, while from Gennevilliers overhead transmission lines at 60,000 volts branched out to Creil. Paris was encircled by a high-pressure power ring capable of developing 1,000,000 kw., while an additional 200,000 kw. projected in 1927 would bring the total plant capacity of the zone to 1,200,000 kw. by the end of 1929. The total productive capacity of the area, under full development, would be in excess of 4,000,000,000 units.

In 1928 the Paris power scheme could be regarded as almost fully developed, but in the Meurthe et Moselle area important plans were under consideration in 1927 which would render it almost as important as Paris. The consumption of electricity in the area was, in 1924–25, 600,000,000 units, while it might be estimated at 1,400,000,000 units in 1935, equivalent to a generating plant capacity in the latter year of 520,000 kw.

A second significant move could be seen in the authorization granted in 1927 to the *Société des Forces Motrices du Haut Rhin* to build a water-power station at Kembs. This meant that one of the biggest water-power schemes in Europe would be begun within a short time. The exploitation of the Rhine, according to the scheme, should mean the construction of eight generating plants along the river from Kembs to Strasbourg, with a total final capacity of 581,500 kw.

In the *massif central* and in the Pyrenees, water-power provided the main source of energy. From the new super-power station at Chancy-Pougny on the Rhone, a main transmission line operating at 100,000 volts went north-west via Le Creusot to Dijon, while large stations were projected at Bellegarde, Maty, Balley, Bregnier, Le Sault Brienez and Villette Danton, all the stations being ultimately interconnected, and feeding into Lyons, which was already supplied from one water-power plant and three steam-power stations. From Lyons, one main transmission line operating at 100,000 volts went to Villefranche in the north, Albertville and Moutiers in the east, with a second main transmission line finishing at the Viclaire water-power station on the Italian frontier. Further south, new schemes were under consideration, covering Salembert, Tournon, Etoile, Montélimar, Montflan below Avignon. With the completion of these schemes, the Rhone area would become one of the most important in France.

The supply undertakings in the Pyrenees area were grouped together in a central association, with an annual output of more than 600,000,000 units. One main transmission line at 100,000 volts ran from Toulouse to Lannemezan as far as Pau, and supplied power to the important electrified railway of the Midi company, linking up at that point with the main transmission system running between Laurens, Dax and Bordeaux. Under full development, the *massif central* and the Pyrenees should be interconnected through Allei, Le Truel and Monistrol, while main connections would run north to Strasbourg, or link up with Swiss companies and would join the elaborate system already in existence in the Meurthe et Moselle and Alsace-Lorraine areas. In the centre the construction of the main transmission line from Paris to the large water-power plant at Eguzon and thence to Champagnau and Le Truel should complete the system of interconnection, and transform the country into one scientifically developed power zone. In 1927, the consumption of electricity in France was in excess of 11,000,000,000 units, about 45 per cent. of which was supplied from water-power stations.

Italy.—Even more spectacular developments in electricity supply than in France took place in Italy after 1919. While, according to the official returns of the minister of finance in Italy, the consumption of electricity rose from 2,553,000,000 units in 1914–15 to 3,696,000,000 units in 1919–20—an increase of 45 per cent. in five years—it rose from 4,021,000,000 units in 1920–21 to 7,363,000,000 units in 1925–26—an increase in the second five years of 83 per cent.

The capacity of water-power plant installed at the end of 1927 in undertakings accounting for 74 per cent. of the national production was 2,042,000 kw., and of steam-power plant 430,371 kw.—a total of 2,472,371 kw. If we assume that the capacity of generating plant corresponded closely to the state of production, Italy had, at the end of 1927, 3,300,000 kw. of generating plant installed. The important areas which lay north of a line drawn from east to west through Rome represented one of the most highly developed power zones in the world.

In northern Italy, the Edison group of companies, with an annual production of slightly less than 2,000,000,000 units, had been the great co-ordinating force. Allied with it were three main groups, one connected with the *Societa Idroelettrica Piemonte*, the Adamello Group, and the Adriatic Group which was active in Venetia and supplied electricity as far south as Bologna. In the areas supplied by the Edison group, main transmission lines operating at 110,000 volts ran from the Swiss frontier at Campodolcino, north of Lake Como, to Piacenza, Parma and

Bologna. The second system branched out from the complicated group of water-power plants installed north of Piedimulera, with connections into Switzerland, to Novara, ending at Arquata north of Genoa, with a branch stretching between Gozzano and Brugherio outside of Milan, to link up with the system already mentioned.

In the Adamello area, one main transmission line of 110,000 volts ran from the north of Edolo to Gorlago, thence to Parma ending at San Polo d'Enza. In the Trentino a main transmission line of the same voltage went from Milan down the valley of the Adige also to San Polo d'Enza, while in the Adriatic area Belluno in the valley of the Piave was connected to Porto Maggiore and Bologna. Those were the main transmission lines in Northern Italy, but secondary systems operating at lower voltages radiated out to connect the main centres of consumption with the generating stations and transmission systems. Thus the entire region provided a perfect example of a power pool developed on scientific lines.

In central Italy, developments had been less notable, since no considerable industrial area existed. In southern Italy proper, the development of large power schemes on the Sila necessitated main transmission between the main water-power plants at Taranto and Bari, with a secondary line running from that point to Benevento, Naples, with connections leading into Rome, Ascoli, and ultimately Ancona.

The entire country had been accurately surveyed with the result that electricity could be transmitted, if necessary, from the Alps as far south as the toe of Italy, and interchange take place readily between central Italy and the Alpine companies.

A further development lay in the erection of lines of 220,000 volts to supplement those already in existence, while energy was imported in increasing bulk from Switzerland. In Dec. 1927, for example, 16,000,000 units were imported from that country. On the Ligurian frontier interconnection had been effected with the French system operated by the *Energie Electrique du Littoral Méditerranéen,* while the development of power schemes on the Brenner would allow it to exchange energy with Austria.

Switzerland.—In Switzerland the development of electricity supply had not been quite so rapid since the war as in Italy or France, because it was already highly developed. Even so, the total capacity of generating stations at the end of 1926 was 1,905,000 h.p., an increase of 144 per cent. over 1914.

The large public supply company had been established in certain areas, often with high pressure transmission lines. The *Nordostschweizerische Kraftwerke A.G.*, with an annual output of 550,000,000 units, owned an elaborate main transmission system with its centre in Winterthur. From Winterthur main transmission lines operating at 45,000 volts went up to Schaffhausen and thence into Germany, while, to the south-east, it reached Löntsch power station and linked up at Siebnen with the main high pressure system operated by the municipality of Zurich. From Beznau to the west of Winterthur, it constructed a line at 132,000 volts leading to Basle and thence into France.

The second large company, the *Bernische Kraftwerke*, with an annual output of 500,000,000 units, operated due south of Basle with main transmission lines at 45,000 volts connecting Basle and Berne, stretching south to Spiez and thence to the Rhone valley, where it linked up with the system of the Lonza Company. From Berne, the system went north-north-west into France, to feed into the area supplied by the *Electricité de Strasbourg*. Main transmission lines at 150,000 volts connected this system with central Switzerland at Lucerne. A third company, the *E. W. Lonza* (150,000,000 units) operated in the Rhone valley from Naters almost to the head of Lake Geneva. It fed directly at Monthey into the system of the Freiburg company, whose main transmission line, operating at 32,000 volts, joined the Rhone valley system at Neuchatel and that of the French company exploiting the river Doubs. A fourth main system was constructed by the *E. W. Olten-Aarburg* (320,000,000 units) with its centre in Aarau. This company's lines, at 40,000 to 45,000 volts, were connested with Germany via Laufenburg, and fed into France through the frontier at Basle, while, further west, it was linked up with the *Compagnie Lorraine d'Electricité*.

These four companies and the Swiss federal railways were responsible for the greater part of the main transmission system extending over northern and central Switzerland and the Rhone valley, while, in the south, two companies, the *Officine Elettriche Ticinesi* and the *Kraftwerke Brusio* (with an annual production in excess of 250,000,000 units), brought the Swiss Alpine power system into touch with the Italian at Lugano and Campocologno. Further schemes, associated with the *Kraftwerke Laufenburg* (350,000,000 units) and the *E. W. Rybourg-Schwörstadt* (550,000,000 units) were being developed in 1927.

Holland.—The development of a large super-power scheme for the Netherlands was rendered difficult through purely natural conditions; the country did not lend itself easily to the erection of long-distance transmission lines, and developments were confined to the areas of densest population. In 1927 the output of electricity for the whole territory could be estimated at 1,300,000,000 units, with a total capital expenditure of less than £30,000,000. Central Holland had already, in 1927, a main transmission system operating at 50,000 volts, more than 120 miles in length, with extensions in the vicinity of Amsterdam, Nijmegen, Arnhem, and the State coal-mines in Limburg. All these areas were due to be interlinked by overhead transmission lines of 50,000 volts and, ultimately, of 100,000 volts. Outside of this main transmission system, the country was parcelled out into areas corresponding to the provinces, with transmission networks of 10,000 volts.

Other European Countries.—In Sweden, as in Germany, the State itself played an important part in the administration of electricity supply. Out of a total output of 3,500,000,000 units, State-owned power stations accounted for 1,260,000,000 units or slightly more than one-third. Six large water-power stations, interconnected by lines operating at 110,000 volts, at Trollhättab, Aelkvarleby, Motala, Porjus, Lill Edet and Noufours, in addition to a steam generating station at Västeras, accounted for this total. The State system was connected at certain points with those administered by private companies and municipalities, but the initiative in creating the super-power zone lay with the former. The public supply of electricity proper represented rather less than half of the total annual output, while the electro-chemical, electro-metallurgical, paper and cellulose industries accounted for the greater part of the demand. The private companies operating in these industries generally possessed water-power stations interconnected for exchange of energy and for the development of a power reserve which would be available in the event of interruption in supply.

In other countries, notably Poland, Rumania, Hungary and Greece, electrical development had been held up, owing purely to political and financial factors, but, in 1927, strong power finance groups, using British, American or Belgian capital, were constructing large power stations and main transmission lines in all four countries. It was estimated at that time that, within ten years, super-power schemes would be in operation similar in character and efficiency to those in other European countries.

(H. Q.)

Russia.—The Government of the U.S.S.R. has given much attention on the development of the electrical industry. The figure of output in 1913 (in the territory of the present Soviet republics) was 1,945 million kw. and in the financial year 1926–27, 4,100 million kw. The National (or Central) Electrification Scheme includes (a) large district stations, (b) small local stations (often attached to factories) for which grants-in-aid have been given to the local authorities by the Central Authorities who retain control. The programme of the State Electrification Commission falls into three parts:—

Part I. Arrangements for the maximum utilization of existing stations.
Part II. Plans for the erection within 10–15 years of 30 district stations of total output capacity of 1,500,000 kw.
Part III. Supplies to areas requiring only small ad hoc stations.

Part I. was fulfilled in 1925. Work under Part II. was begun in 1922, when eight district electric stations were started, viz.:

Volkhov Station in Leningrad	56,000 kw	using water power
Zemo-Achalsk	13,000 „	
Shatura	48,000 „	using peat as fuel
The Red October (in Leningrad)	20,000 „	
Nizhni Novgorod	20,000 „	
The Kashira (near Moscow)	12,000 „	using coal
Shterov (in Donetz basin)	20,000 „	„ anthracite dust
Kiselov (in the Urals)	6,000 „	using brown coal.

In 1926 the construction of the following district stations with coal as fuel was begun:

Chuguev (near Kharkov), 44,000 kw.
Shakhtinsk (S.E. Donetz basin) using anthracite dust.
Kiev 22,000 kw. and Saratov 11,000 kw.

The progress aimed at by the State Planning Commission can be judged by the following table of district stations:

Station	Power in kilowatts		
	1927	1928	1929
Shatura	48,000	92,000	136,000
Kashira	12,000	34,000	78,000
Balakhan	20,000	64,000	86,000
Red October	20,000	65,000	110,000
Shterov	20,000	42,000	64,000
Kiselov	6,000	28,000	28,000
Chuguev	..	22,000	44,000
Artemovsk	..	22,000	44,000
Total	126,000	369,000	590,000

In 1927 the construction of a third group of 11 stations was initiated:

Five hydro-electric stations:—

Dnieper works: 105,000 kw. to be extended to full capacity, 220,000 kw.
Svirsk, 80,000 kw.
Gizeldon (near Vladikavkas), 21,000 kw.
Rionsk (near Kutais), 21,000 kw. (which together with Zemo Achalsk station will help to feed the Trans-Caucasian Railway).
Dzoraget (Armenia), 21,000 kw.

Of the remaining six stations of this series, three using peat for fuel, have been started at Ivanovo-Voznesensk, 44,000 kw., Bryansk, 22,000 kw.; and Osinovsk in the White Russian Republic, 22,000 kw. A further station has been erected at Chelyabinsk in the Urals, 44,000 kw. burning brown coal, and two others are in process of construction at Novorossisk, 22,000 kw., and Krasnodar 11,000 kw., both to use oil fuel. Additionally, stations at Moscow, Leningrad and Baku are being extended.

The capacity of district stations was by the end of 1927 increased to 500,000 kw., as compared with 1916 figures of 245,000 kw. In fact the plans of the State Electrification Commission are being fulfilled to the extent of 92% and the total programme, it is estimated, will be completed within the specified ten years.

The output of the electrical industry of Russia before the war amounted to about 65 to 68 million roubles; in 1926–27 it was 142 million roubles, and in 1927–28 it is estimated to reach the figure of 200 million roubles. With the centralization of supply, the cost of production has been reduced, the cost of electric current in 1927 being 17% lower than pre-war. (X.)

SCHEMES IN NORTH AMERICA: (1) CANADA

In Canada electrical power development has taken the form of the utilization of large water-power resources. The main transmission systems are to be found in Quebec and Ontario, where three undertakings, the Hydro-Electric Power Commission of Ontario, the Shawinigan Water and Power company, and the Montreal Light, Heat and Power company, have been instrumental in developing super-power zones. The total production of electricity in Canada in 1926 amounted to 11,911,000,000 units from plant with a total installed capacity of 5,000,000 h.p.

The Hydro-Electric Power Commission of Ontario, with a total capacity of generating plant amounting to almost 800,000 kw., had a total output, including purchased energy, of 3,867,000,000 units. The Shawinigan Water and Power company, with a total installed capacity of 406,000 kw., had a corresponding output of 2,558,000,000 units; and the Montreal Light, Heat and Power company, with a total plant capacity of 220,000 kw., accounted for 1,251,000,000 units. In addition, the Dominion Power and Transmission company, with a total output in 1926 of 241,000,000 units, has been active in Ontario. The total capacity of all water-power plant in the Province of Ontario alone was in excess of 1,200,000 kw. at the end of 1927.

The super-power zone served by the Hydro-Electric Commission of Ontario stretches from the outskirts of Montreal to Detroit, with extensions north to Port Elgin and Huntsville. The core of the system is to be found in the area lying between Toronto and Detroit; main transmission lines operating at 110,000 volts go north from Niagara Falls to Toronto, round the shores of Lake Ontario, branch off towards Guelph, go due east to London, St. Thomas and Detroit, where they link up with the system operated by the Detroit Edison company. At Niagara Falls there is interconnection with the system operated by the Buffalo, Niagara and Eastern Power group of companies, so that Lake Ontario is surrounded north and south by a ring of power lines.

Further east, in the province of Quebec, the Shawinigan Water and Power company has constructed 100,000 volts transmission lines to link up the power-houses on the St. Lawrence river with the main centre of demand in Montreal. From the Shawinigan falls, lines operating at from 50,000 to 60,000 volts go north to Quebec and St. Joachim, where they link up with the system of the Laurentian Power company. From the same falls lines operating at similar voltages go due south to Sherbrooke, and form a power system touching on the American Frontier.

The Montreal Light, Heat and Power company owns the system linking up almost completely the two main systems operating in Quebec and Ontario, so that the eastern part of Canada now constitutes one of the most powerful super-power zones in the world.

Further west, similar self-contained areas have been created round Winnipeg by the City of Winnipeg and the Winnipeg Electric company working in co-operation. These two undertakings between them produced in 1926 over 600,000,000 units. Further west still, in British Columbia, a number of undertakings, chief among them the West Kootenay Power company and the British Columbia Electric Railway company with an aggregate output of 740,000,000 units, have also mapped out large high-pressure transmission zones. (H. Q.)

(2) UNITED STATES

In the United States, the development of regional schemes for the service of electricity supply has proceeded with great rapidity until, at the present time, electric current is available in all communities throughout the more densely inhabited portions of the country. The evolution of this service has taken place along lines which have largely been dictated by the economies made possible by the progressive improvements in the technical aspects of the art of the production and distribution of electric energy, as well as by further economies inherent in the organization of business enterprise upon a very large scale.

During the early years immediately following the successful demonstration by Thomas A. Edison and others of the practicability of the generation of electricity and of its delivery to consumers, electric service was confined to small portions of the larger cities. Because it could not be transported to any material distance, electricity had to be produced in the immediate neighbourhood of its consumption. This resulted in the erection of a large number of small, isolated power-houses, conducted by enterprises essentially local in character and usually independent of each other. These earlier years marked an era of competition between struggling and often antagonistic groups, with the usual result of impaired service and occasional financial distress among the undertakings By the year 1900, however, the practicability of the commercial transmission of electricity to points at considerable distances had been conclusively proved and, since then, the voltages (or pressures) at which electricity can be transported have steadily increased. As a result, the radius of transmission has been

proportionately lengthened. The transfer of electric power in large quantities over distances of 200 m. or more became an operating actuality in 1920 and this, in turn, has effected wide-spread and fundamental changes in the organization of the service and in the economics of the schemes of regional supply.

The successful delivery of energy at points remote from its source of supply made possible the abandonment of many of the smaller power-producing plants and their replacement by larger units located at strategic points. It also made possible the utilization of water-powers located at considerable distances from the cities where the power was to be used. This era marked the disappearance of the little, isolated steam-using plants of the former period, the consolidation of many of the numerous competitive urban undertakings into single enterprises, and the inception of a large number of hydro-electric projects in those regions of the country where water-power was available. It was attended by a rapid growth in the size of the power-producing plants and by a corresponding increase in efficiency. As a corollary, it also made possible the production and distribution of electricity at lower costs (and therefore at reduced tariffs) which, again, was attended by a corresponding increase in use because of its added attractiveness to the consuming public.

With the established proof of the economies inherent in production on a very large scale, it soon became apparent that the next step lay in the further extension of transmission and in the additional concentration of production in still larger units. Further progress in the development of regional schemes, therefore, resulted in the inter-linkage of neighbouring enterprises and in the tying together of many different power-producing sources. This concept, known as the "interconnection" of electric service enterprises, has resulted in the evolution of systems of great size and has had a profound effect upon the organization and financial structure of most of the large regional undertakings of the United States. For the proper consideration of the several large enterprises which furnish the bulk of the country's electric service, further mention must be made of the fundamental advantages of the interconnection of electric power supplies and their place in the industrial structure of the United States. In brief, the tying together of separate sources of power under a scheme of unified operation produces:—

(*a*) A marked lowering of the cost of producing power, largely because the great bulk of the energy can be generated in very large plants located at exceptionally favourable central points and distributed in all directions over the several systems.

(*b*) An increased reliability of service, because the failure of one power-plant, through some mishap, will not extinguish the flow of energy to the consumer. Any of the other plants connected to the lines can immediately step in and make up the deficiency. In many sections of the country this is a matter of great import. Many of the water-power plants have been constructed along rivers of remarkable fluctuations of flow and in regions of intermittent (though occasionally heavy) rainfall. A deficiency of water supply, while it may cause the temporary shut-down of such a plant, will not cripple the lines of interconnected systems where other power-houses are available to carry the load. In many cases, where a territory of wide extent is covered, it has been found advantageous to install water-power plants upon different rivers. On these, the increased stream flow from one drainage area will often offset a diminished flow from others. There are several outstanding examples of the successful application of this theory, where power has been relayed from one system to its neighbour and deficiencies in one section of the territory has been remedied by aid from others. In recent years, this has enabled many manufacturing establishments to continue operations when, in times of severe drought, local utilities would otherwise have been faced with drastic curtailment.

(*c*) Again, where a wide area is served, it is often found that the maximum electrical requirements of the various consumers come at different times of the day in different cities. Where they can be served by one unified system, a marked improvement in the continuity of the operation of the power-plant machinery can be effected. A notable example of this is the daily diversity of electrical demand between the manufacturing city of Wilmington, Del., with its daytime industrial load, and the neighbouring seaside city of Atlantic City, N.J., with its great blaze of nightly lighting.

These regional schemes of long distance transmission have had a notable effect upon the general industrial development of the country, inasmuch as they have made possible the location of factories at economic points dictated by markets and materials, with the guarantee of sufficient power no matter where located. Power supply for factory operation has thus become generally available over wide areas, and industry has been relieved of the necessity of locating factories at the point of power generation and has been free to consider other factors. The results of the expansion of these regional schemes are evident in the progressive electrification of industry. At present, 50% of all factory machinery operates on power procured from public service enterprises; the ratio was 44·4% in 1925, 17·4% in 1914, and but 3·3% in 1904.

Typical Regional Schemes.—The United States of America cover an area which is continental in extent. Within its borders are found geographic and topographic features of every description, accompanied by climatic, industrial and social conditions of all types. Each of these has had its effect upon the character and magnitude of the regional electrical schemes serving that particular territory and has accordingly produced systems of various sizes and degrees of complexity. Of these, the more important are located as follows:—

In *New England*, with its compact population and its numerous large industrial cities, the service of electrical supply is carried on mainly by local enterprises serving their own immediate neighbourhood. The larger plants are situated along the sea-coast, where electricity is generated by steam dependent, for the most part, upon fuel-oil or coal transported by water. An interconnected system, however, has been established in a generally east-and-west direction through the middle of Massachusetts, with branches extending southward into Connecticut and northward to the large water-power plants of the upper valley of the Connecticut river, and with the Edgar Steam Plant of the Edison Illuminating Company of Boston as the eastern terminus of a trunk line extending westward through New York State to Niagara Falls.

In *New York State* the regional supply schemes roughly follow the great economic divisions of the State. The metropolitan district of New York city and its suburbs is industrially, socially and electrically unique. Power is produced entirely by steam, in many power-plants of enormous extent and representing, in all probability, a greater concentration of energy than is found in any other area of similar size throughout the world. The electric enterprises within the city, while they are all connected with each other, comprise a self-contained area and are not interconnected with any of the others serving the adjacent territory. The western end of the State, embracing the territory lying between the Canadian frontier and the city of Syracuse, some 200 m. east, is largely dependent upon the water-power of Niagara falls and the bulk of its industries comprise the heavy manufacturing and chemical plants which the availability of this great supply of remarkably cheap power has fostered. This territory is served by the Buffalo, Niagara and Eastern Power Corporation, which procures some 430,000 h.p. of hydro-electric energy from its plants on the American side of Niagara, together with large (but fluctuating) amounts of power from its plant on the Canadian side and from the power-houses of the Hydro-Electric Power Commission of Ontario in Canada. Owing to the restrictions of the international treaty entered into between the United States and Great Britain to limit the amount of water diverted from the Niagara river above the falls, Niagara does not yield a sufficient amount of energy to meet the demands of the territory served and a steam-using power-plant of great size has been built almost within sound of the falls to make up the deficiency. All these plants are interconnected, through transmission lines beyond Syracuse, with those of the New York Power and Light Corporation to the east and these, in turn, with the main trunk line through Massachusetts to Boston. Other lines run south into the Pittsburgh region of Pennsylvania and north-easterly into Quebec, where they tie in with

those of the Montreal Light, Heat and Power Company.

In the *South* there has been developed a regional scheme of great magnitude. This takes advantage of the varied water-powers of the rivers of the Blue Ridge, or southern extension of the Allegheny mountains, supported by fuel-burning plants situated in the heart of the several coal-fields. Beginning at the Government hydro-electric plant at Muscle Shoals on the Tennessee river, the lines of the Alabama Power Company run south-eastward, past the Sheffield and Warrior steam-plants, through the centre of the iron and steel district of Birmingham. Beyond this, they are reinforced by large hydro-electric plants located on the Coosa and Tallapoosa rivers (the Martin dam of 180,000 h.p., the Mitchell dam of 120,000 h.p., Lock Twelve dam of 110,000 h.p., Lock Eighteen dam of 216,000 h.p., still under construction) and at the Georgia State line they connect with those of Columbus Electric and Power Company (leading southward into Florida) and with those of the Georgia Power Company. Passing eastward through the territory of the latter company, these lines connect on the north with those of the Tennessee Electric Power Company (whose operations include large hydro-electric plants at Hales Bar and others along the upper Tennessee) and with the Georgia company's water-power plants on the Tallulah and Tugalo rivers. At the South Carolina boundary the lines are interconnected with those of the Duke Power Company, which serves the larger part of the States of North and South Carolina and operates hydro-electric plants on the Broad and Wateree rivers. In the eastern part of North Carolina the Duke Power Company connects with the system of the Carolina Power and Light Company, which, in turn, is tied into a great trunk line leading north-westward through the western tip of Virginia, through West Virginia, etc., to the industrial region of Ohio and western Pennsylvania and served by many large fuel-burning plants located in the heart of the more northerly coal-fields. The presence on this regional scheme of the many and varied water-powers, extending over a mountain area some 300 m. long, and the support of the coal-burning plants interspersed throughout the system, has made possible the furnishing of great volumes of continuous power at comparatively low tariffs and has thus aided to a large extent in the attraction of much industry into this region during recent years.

In the *Chicago district* the regional scheme of electricity supply has taken the form of a ring of high-tension transmission lines around the city, with the installation of large steam-using plants within the city itself and at strategic points to the north, east and south-west of the ring. The close proximity of this region to the large Illinois coal-fields to the south has resulted in the establishment of an industrial zone of great importance throughout this area, in which the manufacture of iron and steel products predominate and which, in turn, has resulted in the demand for great volumes of electric energy. In this district are to be found the largest of the power-plants of the country (Waukegan, 350,000 h.p., Crawford avenue, 434,320 h.p., Powerton, 500,000 h.p., under construction; State Line, 1,000,000 h.p., under construction). The three great plants at the extremities of the ring are in turn, interconnected with trunk transmission lines tying-in to other systems. Waukegan, to the north, is linked with the lines leading through Milwaukee to the hydro-electric plants of northern Wisconsin. Powerton, to the south-west, connects with lines traversing the Illinois coal-fields and reaching the City of St. Louis. State Line, to the east, constitutes the western terminus of a trunk-line passing eastward across northern Indiana, through Ohio and connecting with the Pittsburgh industrial district to the east and with the southern regional scheme (already described) to the south-east.

On the *Pacific Coast*, the regional schemes have largely taken the form of diverse hydro-electric developments through the mountainous areas, with transmission lines to bring this energy into the populous districts bordering the ocean. The topographical characteristics of this territory embrace, primarily, a comparatively narrow coastal plain, beyond which numerous ranges of high, snow-capped mountains parallel the sea. The water-power plants are essentially those utilizing a high "head" (or fall) with a comparatively small amount of water and are admirably suited to a régime where the annual precipitation of moisture is relatively small and located, for the most part, at high altitudes. In the North-west the lines of the Montana Power Company utilize the water-powers of the upper Missouri and, after supplying the copper smelters of Anaconda and Silver Bow, lead westward across the northern tip of the State of Idaho. Here they connect with those of the Washington Water Power Company, operating in the flat country of the Columbia Basin and, in turn, connecting to the west with those of the Puget Sound Power and Light Company. The water-powers of this enterprise are located on the western slopes of the Cascade mountains and tie-in, to the north, with those of the Western Power Company of Canada, similarly located in British Columbia. Turning south, the general scheme of supply parallels the Pacific ocean as far as the Mexican boundary. In California, this type of high-head power supply has reached a state of intensive development. The Pacific Gas and Electric Company operated in 1927 some 32 hydro-electric plants of various types and sizes, with a total capacity of some 630,000 h.p., and supported by three steam-plants with a total capacity of 180,000 h.p., located at tidewater and burning the fuel oil which the southern part of the State has developed in great quantities. Interconnected to the north are the lines of the California-Oregon Power Company (which, again, tie-in with other enterprises and eventually reach those of the Puget Sound Company mentioned above) and, to the south those of the Great Western Power Company and the San Joaquin Light and Power Corporation, both operating water-power plants of the same general type. The San Joaquin enterprise is, again, in contact on the south with the properties of the Southern California Edison Company. This organization operates the largest individual water-power plants in the West. At the end of 1927 it had in service some 20 hydro-electric plants with a total capacity of 475,000 horse-power. In this connection, however, the changing relationship between the cost of steam-power and hydro-electric energy is well illustrated by the fact that this enterprise is finding it more economical to install fuel-burning plants at tidewater, at the centre of the market, rather than to bring in electricity over long transmission lines from the High Sierras at least 200 m. away. The Long Beach steam-plant of this company contained, early in 1928, 400,000 h.p., operated on the fuel-oil and natural gas produced practically at the doors of the plant.

BIBLIOGRAPHY.—For interconnection in general, with maps, see *The Annalist* (May 14, 1926 and June 1, 1928) and *Bulletin of the National Electric Light Association* (July 1928); New England, *The Annalist* (June 11, 1926 and July 20, 1928); Middle Atlantic States, *ibid.* (July 16, 1926). Both of these are also treated in the *Report of the North-East Super-Power Committee* (May 1924). The Pittsburgh-Ohio area, *The Annalist* (Sept. 17, 1926); the South, *ibid.* (Oct. 15, 1926); the Chicago-Detroit-St. Louis Area, *ibid.* (Dec. 17, 1926). Details of the growth of the industry, with statistical exhibits, are found in the *Handbook of the National Electric Light Association*, published annually. (W. M. CA.)

ELECTRICAL POWER GENERATION is accomplished almost entirely in two ways; utilization of power obtained from burning fuel, generally for steam generation, and the utilization of natural and created sources of water-power for hydro-electric generation.

I. GENERATION FROM FUEL

The term electric power applies to a continuous supply of electric current through wires from central generating points in quantities sufficient for the operation of motors, heaters, lights and equipment for doing work electrically. This power may be in the form of direct current, *i.e.*, that which flows always in the same direction around the circuit, or in the form of alternating current, which rapidly reverses in direction of flow. Each has its special uses in industry, in homes and on the farm. The generating points of electric power are termed power plants, generating stations or central stations, and are commonly located in large cities or at other points close to large centres of use. The power requirements which they satisfy are termed the "load." In the generation of electric power from fuel, the heat energy of the fuel is first converted into mechanical power by a prime mover, and then into electrical power or current by a generator. The

principal prime movers in use in 1928 are the steam turbine and the hydraulic turbine (*see* TURBINE, WATER). In isolated plants of small capacity, and in marine plants, primary power is often derived from oil and gas engines, and it is possible to obtain it from various other prime movers such as windmills, tide machines, etc., although these latter are inefficient and cumbersome and therefore seldom used.

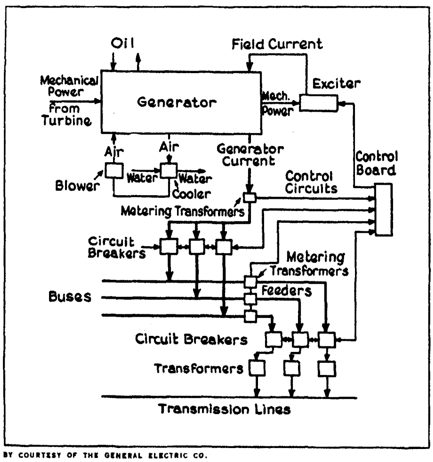
Development.—In the United States the steam turbine generates about 60% of the total electric power, while most of the remainder is derived from water-power (*see* below under "Hydroelectric Generation"). In other countries the ratio is different, depending upon the available supply of commercially useful hydraulic energy and upon relative fuel costs. In the early steam station reciprocating engines were used exclusively, and the power was generated by direct-current dynamos. At about 10,000 h.p. both the reciprocating steam engine and the direct-current machine reached their practical limit of size, and a serious question arose as to how the output could be increased at reasonable cost. Engineers then turned their attention to the steam turbine, which Parsons in England had used successfully in 1897 to drive a British naval destroyer. In 1903 a Curtis turbine was installed at the plant of the Chicago Edison Company and there successfully drove a generator of 5,000 kilowatts (6,700 h.p.) capacity. The problem of greatly increased power in less space was thus solved by the turbine, which was even then as efficient as the reciprocating engine. The use of alternating current, also, made possible the economical transmission of power over considerable distance, thus bringing electric service to communities far from the generating point. Since 1903 both turbines and generators have been greatly improved in design, until to-day single units of 280,000 horsepower are practicable and are being built. (*See* ELECTRIC GENERATOR.) In general no limit to capacity can be set. Economic considerations lead to generating units of very large capacity, few in number, rather than to many small machines, but in each case the local conditions determine just how large a single machine should be. Every central generating station is an individual case, and its design depends upon local conditions, such as amount and character of land available, kind of fuel, source of condenser cooling water, and the kind of electrical load served. In addition to steam generating equipment (*see* STEAM GENERATION, BOILERS), stations are structurally divided into (a) generating room, (b) bus structure, (c) switching and transformer equipment, and (d) control room. These elements will be discussed in the following paragraphs, after which a description of an actual modern central station will be given in order to illustrate the principles involved.

Generating Room.—The generating room runs the full length of the station, and is comparatively narrow (*see* Pl. I., fig. 3). The turbine-generator units are installed side by side with considerable space between them, and are completely enclosed in steel casings. A travelling crane, resting on heavy I-beams, gives a lift of 50 ft. or more, so that the casings and rotating parts of the units may be lifted clear for repairs. Often the end walls of the room are of steel-sashed glass and occasionally the entire roof is made a skylight to bring full daylight into the room. There is a note of clean simplicity about the place which is far removed from the usual suggestion of griminess and complication which clings to machinery. The turbines are fed by heavily heat-insulated steam pipes, which come through from the boiler room. The electrical output of the generators is carried to the bus room by cables placed in ducts beneath the floor of the room. In most instances there is little other equipment on the generating room floor besides the main units, although in some cases small separate turbine-generating sets are installed there to supply current for station auxiliaries and lighting circuits. Directly beneath the generating room the condenser well is located, the condensers themselves being bolted directly to the under sides of the turbines or connected to them by flexible joints, although in many stations this well is part of the main room, the turbine units are installed on platforms built above the condensers. The well usually contains the circulating pumps, air and hot-well pumps, and feed water heaters, together with the air-cooling system for the generators. Boiler feed pumps and evaporators are placed between the condenser well and the boiler room.

Bus Structure.—The bus structure is composed of heavy copper conductors supported on insulators and installed in concrete cells. It is the concentration point for all generated power, from which it is drawn by branch lines called feeders, going to the various points of use. Practice differs widely as to the number and arrangement of the buses, but the principle is that of pooling the output of several machines so as to give the greatest flexibility. Each generator is provided with several oil switches, by which it may be connected to any bus desired. During its passage from the generators through the buses the current is passed through small transformers which are connected to groups of meters in the control room. In this way the output is measured without interruption or change in magnitude.

Switching and Transformer Equipment.—If the station is supplying nearby load, the feeders will pass directly from the bus structure to the pole lines or underground cable ducts, delivering electrical service at generated pressure. Groups of switches are used to connect the feeders to one bus or another for most economical operation according to load. If the station output is to be transmitted to distant load centers, the electrical pressure must be raised in order that the reduced currents which result, may cause a smaller resistance loss. As the pressure is increased the current is proportionally reduced for the same power. This permits the use of smaller conductors and at the same time causes lower losses, with consequent saving both in construction and operating costs. To effect this raise in pressure (voltage) large power transformers are used, and these may be connected between generators and buses, or between buses and feeders. For this type of service, switching is usually done between transformers and transmission lines by high-voltage oil circuit breakers.

Switching and transforming equipment is often installed out-



BY COURTESY OF THE GENERAL ELECTRIC CO.

FIG. 1.—ELECTRIC CURRENT FLOW DIAGRAM

doors and is designed to withstand any weather conditions. Stations in congested districts, such as New York City, usually have indoor switchhouses, feeding into underground cables.

Control Room.—This is the operating headquarters of the station. Here the meters and instruments which indicate and record the electrical flow in all circuits are mounted on an easily accessible switchboard, and here are located the switches for controlling the circuit breakers, and the lamps which indicate to the operator the condition of every piece of apparatus. By means of signal buttons and telephones, orders are transmitted from the control

room to the boiler and generating rooms, so that the attendants may be instructed to carry out the operations not included in switching. In some stations there is no control room as such, the meters and control switches being located on vertical boards placed in a gallery above the generating room.

The progress of power through the station, then, is briefly as follows (*see* Flow Diagram): Steam flows to the turbines, generates rotating power, is exhausted into the condensers and is returned as water to the boilers. The generators change the rotating power to electric current, which is measured, concentrated on buses, and switched to the proper circuits. These circuits either distribute directly to nearby loads, or carry the currents to transformers which *step up* the voltage for transmission to distant points. Control and supervision of all station operations is centred in one room.

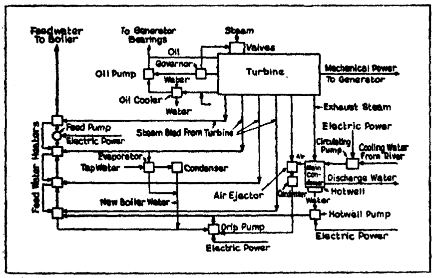


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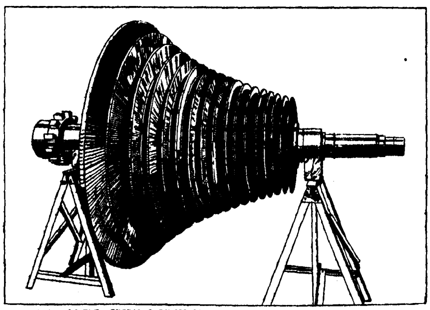
FIG. 2.—STEAM FLOW DIAGRAM

Steam Flow Through the Station.—In general principle the turbine (*see* STEAM TURBINE) is a highly efficient windmill. Steam issuing at high velocity from nozzles impinges upon the blades or buckets on the turbine wheels, thus causing the latter to revolve. In order to gain the greatest efficiency the speed of the buckets must be a definite fraction of the speed of the steam. To utilize this velocity on a single bucket wheel would require bucket speeds beyond the strength of materials available. Therefore the steam is expanded in stages, through successive sets of nozzles, each of which transforms part of the steam pressure into a moderate velocity. This velocity is then absorbed by a bucket wheel, and the steam goes on to the next set of nozzles and the next wheel. This arrangement is called pressure staging and it permits the many rows of buckets on the turbine wheels to absorb the steam's energy at high efficiency. The expansion of the steam cools it and reduces its pressure. When all of the recoverable energy has been extracted, the steam is released into the condenser and is changed back to water for return to the boiler. The steam entering the turbine is at a high pressure, and occupies a small space, so that the first stage blades may be no more than ½ in. long. In doing its work upon the blades the steam expands as it does in the cylinder of a steam engine. Thus each successive stage has larger blades than the last, and at the exhaust end of the turbine the blades may be two ft. or more long (*see* fig. 3). The blades are arranged radially upon the circumferences of wheels fastened to the turbine shaft and these wheels increase in overall diameter in the big machines from perhaps 4 ft. up to 11 ft. or more. The steam pressure at the start may be from 300 to 600 lb. per sq.in., and several installations are using pressures as high as 1,200 pounds. The initial temperature in most recent installations is 700° or above, this limit being set by the physical properties of present-day metals and alloys. About 200° of this is superheat above the boiling temperature at the pressure used. Superheat is important because of the much higher efficiency of the heat cycle and because more stages of the turbine can then operate on dry steam. The exhaust from the turbine is of large volume when it enters the condenser. Contact with the cold surface there subtracts just enough heat units to change the steam to water without lowering its actual temperature appreciably. Condensation involves a 400 to 1 reduction in volume, and a vacuum is created in the condenser which is of the order of ½ lb. per sq.in. absolute. This vacuum is usually expressed in inches of mercury of the barometric column, 28 to 29 in. being the common value for large turbines. The 13 lb. drop below atmospheric pressure thus gained makes it possible to obtain almost 60% more power from the steam than in a non-condensing installation. The turbine casing which holds the circular rows of stationary blades is circular in cross-section and somewhat conical in shape to accommodate the tapering construction of the rotor. A heavy steel shaft passes through the length of the turbine and is supported in self-aligning bearings. One end of the turbine shaft is connected to an end of the generator shaft. Since one end of the turbine is under high pressure and the other under high vacuum, packing glands are necessary around the shaft to reduce leaks to a minimum. In addition, a series of circular ribs on the pressure end of the shaft engages with similar ribs in the casing, forming a labyrinth. The little steam leaking through this is turned back into the turbine at about atmospheric pressure. A water seal is also provided on the atmospheric side to prevent steam leaking out. A similar water seal on the exhaust end prevents air from leaking into the condenser.

The Condenser.—The condenser carries out the reverse function of the boiler, reducing steam to water. It consists generally of a large number of parallel bronze tubes set in a vacuum-tight casing. Cold water is pumped through these tubes and the exhaust steam is condensed against their outside walls, falling to the bottom of the casing into a chamber called the hot well, whence it is pumped back to the boiler.

Steam Auxiliaries.—In addition to the turbine and condenser there are various auxiliaries necessary for satisfactory turbine operation. They are, chiefly: (a) Steam strainers and valves, (b) turbine governor, (c) bearing oil system, (d) air pump, (e) circulating pump, (f) hot-well pump, (g) feed-water pump, (h) drip pumps, (i) feed-water heaters, and (j) evaporators. The various elements will be taken up in the order of their use.

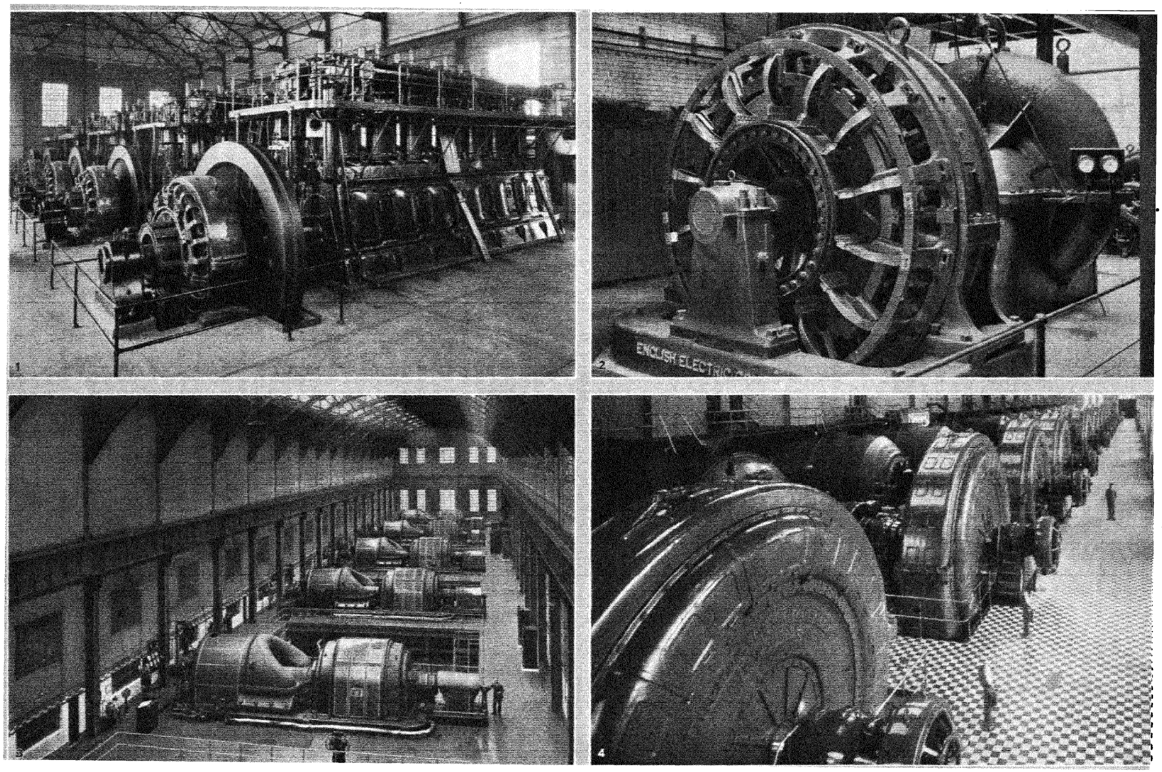
Strainers and Valves.—A metal screen is placed in the main steam supply pipe to catch foreign material which may be in the system. The steam then passes through a hand-operated throttle valve into the turbine. This valve is used for starting and stopping only.



BY COURTESY OF THE GENERAL ELECTRIC CO.

FIG. 3.—SEVENTEEN STAGE ROTOR FOR CURTIS STEAM TURBINE

Governor.—It is necessary to have a mechanism to provide the turbine with an amount of steam just sufficient to enable it to carry the desired amount of load. This is called the governor, and operates, through a hydraulic system, a series of valves admitting steam to the turbine nozzles. By adjusting the governor to admit more or less steam, the machine will attempt to run faster or slower than standard speed, but will be held to this speed by its generator which will automatically take a larger or smaller share of the electrical load of the system.



BY COURTESY OF (2) THE ENGLISH ELECTRIC CO., LTD. (3) THE GENERAL ELECTRIC CO., LTD. (4) THE SWEDISH TRAVEL BUREAU

LARGE ELECTRIC GENERATORS AND MOTOR-DRIVEN PUMP

1. Oil electric power plant in Kansas. Five 6-cylinder, 1,000 H.P. Diesel oil engines shown connected to direct current generators. 2. Direct current electric motor operating a rotary pump in a dockyard. From left to right: the outer bearing; commutator surrounded by brushes in circular frame; frame or field structure, holding field windings, within which armature revolves on shaft. Right, rotary pump with gauges. 3. Municipal power station, Birmingham, England. View of five turbo-generators supplying alternating current to city. Left to right of machines: steam turbine on same shaft as high speed generator (centre) and small exciting generator to right of unit. Other machines similar. 4. View of thirteen hydro-electric generators at Trollhattan, Sweden. Falls of the Göta River, 108 ft. fall, produce 165,000 kilowatts per hour

Bearing Oil System.—Turbine bearings are of the cylindrical type and are lubricated and cooled by oil which is forced through them by a pump geared to the turbine shaft. A separate steam-driven pump is usually employed during the starting up period. To dispose of the heat in the oil, coolers are provided in which water is made to circulate, the heat sometimes being delivered later to the feed-water system. A large oil reservoir is usually built into the base of the turbine.

Condenser Pumps.—In the design of the modern power station the matter of a plentiful supply of cooling water for the condensers is of prime importance. It is necessary to locate the station close to a river, harbour or lake, because the quantity of water needed is very large. In the big stations, as for instance the Richmond Station in Philadelphia, where the installed capacity is 160,000 h.p., a flow of condenser water of about 160,000 gal. per min. is required. This water can be used only once since it becomes ineffectual as a cooling medium as soon as its temperature has been raised by passing through the condenser. It is therefore pumped through the system and then discharged into the river. Centrifugal pumps are employed for circulating the cooling water, and these are driven by electric motors or small steam turbines. Each condenser has its own pumps, usually in duplicate, so that an accident to one pump will not rob the condenser of water and thus force the turbine to be shut down, because of lowered efficiency. Turbines are provided with atmospheric exhaust valves, but these are used only to avoid blowing up the machine in cases of condenser failure. The cooling water circulates through the bronze tubes of the condenser where it receives the heat from the steam and leaves the condenser about 15° higher in temperature than on entering. In regions where there is wide variation between summer and winter temperatures and consequent warm cooling water supply in summer, the vacuum will be reduced and the turbine efficiency cut down. An ejector or vacuum pump is connected to the condenser to remove air and other gases which do not condense and which tend to destroy the vacuum. These gases have either leaked into the turbine through the packing glands, or else have come through with the steam from the boiler. A hot well or sump is located at the bottom of the condenser to catch the water. A pump is placed here to start the water on its journey back to the boiler. There may also be other pumps in connection with certain steam auxiliaries, as for instance the drip pumps, which take the condensed steam from the feed-water heaters and evaporators and return it to the hot well or feed-water line.

Feed-water Heaters.—The simplest steam power cycle passes the steam through the turbine and exhausts it into the air, an inefficient method which uses less than 10% of the heat energy in the steam. By adding a condenser and returning the water to the boiler the efficiency of the cycle can be doubled. But there is still a large quantity of heat lost in the condenser to the cooling water. It is possible to capture some of this heat before it reaches the condenser by extracting a certain quantity of steam from the turbine at various stages of its expansion and while it yet contains considerable heat energy. This extracted steam is used to heat the boiler feed-water. The principle of interstage feed-water heating is that of using the heat energy of the steam at high temperatures rather than of allowing it to escape into the condenser where the temperature is so low that feed-water heating cannot be accomplished. The boiling point of water rises with a rise in pressure and for this reason the temperature of the boiler feed-water can be very much higher than the atmospheric boiling point (212°). The water coming from the hot well of the condenser is usually between 70° and 100° F and may be heated to 300° or 400° before entering the boiler. The process is carried out in heaters consisting of casings containing nests of pipes surrounded by steam extracted from the turbine. It is common practice to have several heaters in series, each one contributing perhaps 50° to 100° to the temperature of the feed water. The steam used in these heaters must be hotter than the water heated, and the feed-water progresses from heaters of lower temperature to those of higher. The supply for each heater is therefore taken from the turbine at a point where the necessary steam temperature exists. By careful calculation it is possible to determine an arrangement of heaters which will give the maximum use of the heat sent into the turbine in the steam. The number of heaters ranges from one to five, and the steam they use may be as much as 25% of the total supplied to the turbine. The heating steam condenses in each heater and goes to the heater unit of the next lower temperature, and finally to the drip pump and into the feed-water line.

Feed Pumps.—The water is forced into the boilers by feed pumps located somewhere along the line between the hot well and the boiler. These pumps are usually of the centrifugal type, driven by electric motors or by steam turbines.

Evaporators and De-aerators.—There is, inevitably, a slight loss of feed water from the system. This loss may be made up by pure water supplied by evaporators. These are stills heated by steam drawn from the turbine. Raw water is evaporated in them and passed to a small condenser whence it is discharged into the feed water line. A small amount of dissolved air is also carried out of the condenser by the water, and may be removed by a de-aerator before it reaches the boiler. (For a fuller description of these boiler auxiliaries, *see* STEAM GENERATION.)

The steam apparatus commonly used in the modern generating plant is subject to many variations. In very large turbines the volume of the steam may be so great that it is sent into them at the middle, passing out at both ends. This is called the double-flow turbine. Mechanical limitations may make it impossible to build a single turbine which can handle the volume of flow required for very large powers. In this case two separate turbine cylinders are used, each with its own rotor. One unit operates on high pressure and exhausts into the other. Both are on the same shaft, and drive a single generator. This is called a tandem compound machine. The largest turbine in the world, rated at 280,000 h.p., being constructed in 1928, is of the cross-compound type. It is virtually three separate turbines; a high-pressure unit receiving steam from the boiler, and sharing its exhaust between two low-pressure units. All three have separate shafts and separate generators. It is becoming the practice with compound turbines to pass the steam exhausted from the high-pressure unit, through a resuperheater in the boiler, to regain the initial temperature without raising the pressure. This gives the important advantage of dry steam throughout all the turbine stages.

Electrical Flow Through the Station.—In the central station electric current is produced by a machine called a generator. Mechanical power is produced by the turbine from steam, and is used to turn the rotating member of the generator, which, by utilizing the action of magnetic forces upon coils of wire (*see* ELECTRIC GENERATORS), produces electric current which may be sent out to supply the station load.

Development.—The fundamental factor in modern electric power generation and transmission is the use of alternating current. In the early days it was thought necessary to produce and sell direct current, and for this purpose direct-current machines were built exclusively. They were large and costly because of the provision which had to be made to change the alternating current generated within the machine to uni-directional current for outside use.

During the later '80s alternating current was strongly championed by George Westinghouse who, with the aid of William Stanley, produced in 1886 a commercially practical transformer and thus opened the way to alternating-current electrical distribution. Since 1890, central station development has been along alternating-current lines, with the exception of a few installations in Europe where direct-current generation and transmission is used. For certain purposes, such as for trolley or tram cars, direct current is universally employed, as also in many railroad electrifications. This current, however, is obtained by feeding alternating-current power from the central station to outlying substations, where special machines (called synchronous converters) convert it to direct current. In a number of districts the original Edison three-wire direct-current distribution system is still used, the supply being derived from substations which have large installations of storage batteries for use during severe

peak loads or in emergencies.

The Generator.—The alternating-current generator (*see* ELECTRIC GENERATORS) operates on principles discovered about 100 years ago (*see* ELECTRICITY). A hollow cylindrical steel element, the armature or stator, contains groups of insulated copper conductors. Within this armature a cylindrical rotor is placed, called the field. The field contains a series of coils so arranged that the passage of a direct current through them produces on the surface of the rotor or field a series of magnetic north and south poles. Thus a two-pole generator has one north and one south pole, a four-pole machine, two of each kind, and so on. As the rotor revolves the magnetic flux at the poles sweeps around the cylindrical inner surface of the armature, cutting the armature conductors with magnetic lines of force. Currents are generated in the conductors of the armature, depending for their magnitude, voltage and rate of change (or frequency) upon the speed of the rotor and the number of its poles. A complete alternation of current in the armature conductors is called a cycle and is obviously the result of one whole revolution of a two-pole rotor, or of one-half revolution of a four-pole rotor, etc. In order to give satisfactory service the rate of alternation or frequency of the generated current must remain essentially constant, and this is done by regulating the rotating speed by the turbine governor. Twenty-five, fifty and sixty cycles per second are the frequencies to-day.

Modern central station generators are designed to give current at the highest voltage or pressure consistent with safety of insulation. Ten to 14 thousand volts is common practice. Early generators delivered current from a single set of conductors into a single external circuit, requiring two wires. It is the modern practice to put three windings on generator armatures, so connected that there are three external wires, of which any one pair is carrying current independently. In other words, each wire belongs to two different circuits and is carrying two different currents at the same time. It is thus possible to generate and transmit about twice as much power with three wires as with two. This is called the three-phase system. Certain classes of machinery, such as converters, may employ as many as twelve phases, though the economic advantage for transmission is practically exhausted with three.

House Service Generators.—The present tendency in central station design is to drive the auxiliaries such as pumps, etc., by electric motors. Current for this purpose is provided by service generators, which are small low-voltage machines built on the main generator shafts. Thus each main unit has its service generator, so that when the turbine is running it supplies its own auxiliaries and is independent of outside sources of supply. For starting up, the auxiliary motors are connected to a current supply generated by other turbines already running, or provided from sources outside the station.

Exciters.—The direct current for the rotating field is supplied by a small generator called the exciter, which is usually built integrally with the main generator on the end of the latter's shaft. By manipulating this "exciting" current (which is relatively small and of low potential) very close control of the main generator voltage is obtained with simple equipment which is usually located in the control room.

Cooling.—The conductors in the generator are made as large in cross-section as is possible in the space available, so that they are of very low resistance. However, the flow of current through any conductor whatever causes some resistance loss, which appears as heat in the conductor. Furthermore, some heat is generated in the iron of the core by the rapid changing of the magnetic flux (*see* ELECTRICITY). This heat amounts to only about one per cent of the generator output, but is numerically large in large machines. In a 60,000 kilowatt generator, for instance, the loss might amount to 600 kilowatts—enough to run a small factory or light a whole street of private homes. The heat losses may be dissipated by placing a fan on the end of the shaft to circulate air through the spaces between armature and rotor. With large machines it is now general practice to enclose the machine entirely and to force air through it with external centrifugal blowers. A recent design returns the warmed air to a cooler known as a surface air cooler, in which water circulates in a nest of pipes similarly to the steam condenser. This permits the same air to be used over and over again, thus avoiding the large quantities of dirt likely to be brought in by new air. Still higher cooling efficiency is expected from a scheme now under development, using a single gas such as hydrogen instead of air. This is based on the fact that more heat can be absorbed by hydrogen than by an equal volume of air. Less gas therefore can be used, thus cutting down the size of blowers, coolers, etc., and reducing the friction loss occasioned as the gas passes over the surfaces to be cooled. Blowers are usually driven by electric motors, and installed in duplicate to assure dependability.

Lubrication.—The bearings of the generator are of the same self-aligning type as those of the turbine. They are lubricated and cooled by the same oil as for the turbine and are included in the same piping system.

Fire Protection.—The compounds with which the generator insulation is impregnated are somewhat inflammable, and if electric arcs are accidentally started within the machine a destructive fire may develop. There are various automatic schemes for warning the station attendant of a generator fire and for spraying water on the windings, or for replacing the circulating air by CO_2 or some other inert gas which will smother the fire. The temperature of the windings is also carefully watched upon an indicating meter on the switchboard. This meter is connected to small coils within the machine, which are carrying a steady current. A rise in temperature of the main windings changes the resistance of these coils and causes the meter to indicate it. (*See* THERMOMETRY, *Electrical resistance type.*) Temperature indicators are sometimes arranged to give audible warning of excessive heating or even to shut down the generator by automatic means when the danger point is reached.

Handling the Current.—The current from the various generators is pooled upon a conducting structure known as the bus system. There are usually several buses, so connected as to provide a star, or ring-shaped, path for the current. The generators are attached to the bus system by individual lines so arranged that in case any section of the bus becomes inoperative the generators feeding that section can be reconnected through alternative paths to the portion of the bus still in service. In the larger stations the buses are elaborately sectionalized, the sections being installed in separate fire-proof vaults. Trouble on any section is met by disconnecting that section completely, and shifting the load upon it to some other section. The buses and bus sections are connected together through oil circuit breakers, and the generators are connected to them in the same way. These circuit breakers are operated by small electric motors or solenoids, which are set in motion by switches in the control room. They are usually equipped with tripping relays which cause the breakers to open their circuits when dangerously heavy currents flow in times of accident. In many stations the feeder circuits are provided with current-limiting reactors which prevent the flow of destructive short-circuit currents and the consequent lowering of the voltage over the whole system. They have no appreciable effect upon normal power currents. Reactors are also frequently used between bus sections. A bus is composed of a group of heavy copper bars or cables rigidly supported on insulators, one conductor for each of the three phases. Modern practice is tending toward the isolated phase arrangement, in which each conductor is installed in a separate concrete room or gallery, often on a separate floor of the building from the other phases. Isolation is also sometimes effected by enclosing each bus in a grounded metal shield. These elaborate precautions are taken to avoid the spread of electrical fires starting from burnouts or short circuits, and thus to increase the reliability of the station.

Metering Transformers.—The load currents are too large and of too high a potential to allow of their being sent directly through meters. To get around this difficulty, small transformers are connected into each generator circuit and each feeder circuit, the secondary windings of which supply to the meters small low-voltage currents, which are proportional to the load current and voltages. (*See* TRANSFORMERS.) These transformers

are designed to operate without consuming an appreciable amount of power. The current transformer consists of an iron core and secondary winding associated with a straight heavy conductor which is part of the main circuit. The potential transformer is a miniature power transformer with a primary winding placed across a phase of the main circuit and the secondary winding feeding the meter. Both types operate on the principle of a current induced in a winding by the action of a fluctuating magnetic field.

Control Room.—The switching of the generators and feeders and the apportioning of the load among them, is managed from a central switchboard. This consists of a number of vertical panels upon which are mounted the meters and recording instruments for reading current, voltage and power. A desk (*see* Plate I. fig. 3) or horizontal portion in front of the board is provided with rows of pull-button switches, which are connected through low-voltage circuits to relays on the various circuit breakers. When energized by pulling out the buttons, these relays connect the electric operating mechanisms of the breakers to a power supply circuit and open or close them as the case may be. Red and green lamps on the board are associated with each relay so that an indication is given of the condition of the breaker.

A signalling system, somewhat similar to that employed on shipboard between bridge and engine room, is installed between the control room, boiler room and generating room. If the operator wishes a generator started up he presses the proper button, which actuates a signal beside that generator. The attendant starts the machine and, when it is up to speed, the operator synchronizes it with the system with the aid of a synchronizer. When the incoming generator is "in phase" it is switched onto the desired bus. The turbine governor is then adjusted by means of remote control so that the generator will take whatever amount of load the operator wishes it to carry.

The operation of all station equipment is correlated in the control room, so that the station as a whole produces and sends out power when and where it is needed. By means of a totalizing instrument the sum of all the outgoing feeder currents is indicated on the switchboard, so that the operator can start up machines or stop them as the load-demand requires. An indication of the totalized demand is also given in the boiler room, to assist the fire-room attendants in supplying enough steam, and in anticipating changes in station output.

With the enormous quantity of energy required in the present day metropolitan area, it is usually necessary to join a number of central stations together on a single network, often backing them up by hydro-electric power sent in from a distance over transmission lines (*see* ELECTRICAL POWER TRANSMISSION). In such a system, the control room of any one station is but a subordinate point, the real control resting with the "chief load dispatcher," whose office may be at any convenient location in the district.

Like the railway train dispatcher, the power dispatcher has executive charge of the movements of great quantities of power. He has before him a board on which are plotted the various stations, trunk feeders and interconnections with other power systems. With the aid of telephones and signals he commands the units of power generation and coordinates his own system through interconnection points with other systems, constituting a great network which may distribute power over a radius of hundreds of miles.

The Arrangement of a Large Generating Plant.—In order to unify the discussion of the various details in the foregoing paragraphs, a description of the 160,000 h.p. Richmond Station of the Philadelphia Electric Company is given below. This station is an excellent example of standard practice, embodying no extremes, and yet combining simplicity of arrangement with high efficiency.

Richmond Station is located in Philadelphia on the Delaware River where an adequate supply of cooling water for condensing purposes is always available. The boiler house, generating room and switch house are located in adjacent buildings, the boiler house being next to the river. Next is the generating room and beyond that, the switch house. Cables carrying the electrical energy away from the station run from the switch house to large industrial customers and to the company's distribution substations, also to an outdoor transformer and switchyard located at some distance from the main building.

Boiler House.—Twelve boilers are arranged in two rows of six each, with a firing aisle between. Coal is received at the plant in river barges, from which it is hoisted by grab buckets. It is passed through crushers to belt conveyors on which it is weighed and then distributed to overhead bunkers located between the two rows of boilers. It is then fed by gravity through pipes to the stokers which are driven by variable-speed electric motors. These stokers force the coal into the furnace underneath the fire in the required quantities. The ash, on leaving the furnace, is broken up into small particles by grinders driven by the stoker motor, and then drops into hoppers which are emptied into ash cars running on a narrow gauge railway on the basement floor (for description of other methods of handling ashes, *see* ASH HANDLING, MECHANICAL HANDLING). The cars in turn are emptied into an outdoor pit, from which the ashes are removed by a grab bucket and loaded on freight cars, trucks or river barges for final disposal.

Air for combustion is provided by a forced draft fan located on the top of the boiler. This fan forces the air through preheaters, where it is heated to a high temperature by hot flue gases, and then into the furnace. Two induced draft fans draw the gases from the furnace and direct them up the stacks.

An instrument board is provided adjacent to each boiler, on which are mounted instruments which indicate to the operator the amount of water being fed to the boiler; the pressure of steam; pressure of the air being supplied to the furnace for combustion; the pressure of gases in the boiler; the stoker speed (which indicates the amount of coal delivered to the boiler); and the amount of air being supplied for combustion.

Generating Room.—This is a large, well-lighted vaulted room next to the boiler house. The main generating units—two 60,000-kilowatt, 13,800-volt, three-phase generators driven by 20-stage General Electric turbines—are installed on platforms or "islands" about twenty-seven feet above the ground floor. The main steam pipes come in from the boilers beneath the platform floors, and the throttle valve control wheels extend above the floor. The turbine bases contain the oil reservoirs, and groups of large pipes lead the oil to the three main bearings of each unit. The governor mechanism is located at the boiler room end of the turbines, and the controlling inlet valves are located beneath the floor.

The condenser for each of the generator units is placed directly beneath the turbine, and is supported on concrete foundations through counterweighted levers which compensate for expansion. On one side of the condenser, on the basement floor, are located the duplicate motor-driven circulating pumps which take water at the rate of 78,000 gal. per min. from concrete intake tunnels extended under the boiler house to the Delaware river, and force it through the condenser and back to the river. One pump supplies sufficient water for the condenser, the second being a reserve pump.

Duplicate motor-driven fans, located adjacent to the generator foundation, provide cooling air for the generator. This air circulates through the generator over and over again, being cooled each time before entering the machine by a surface air cooler supplied with water by the condenser circulating pump.

The steam which has passed through the turbine is exhausted into the condenser, from which it is drawn in the form of water by means of condensate pumps. This water is then delivered through a series of heaters back to the boilers where it is again transformed into steam. On a platform beneath the turbine floor the first feed-water heater is located, taking steam from the 18th stage of the turbine. Just beneath this is a Radojet air ejector which assists in maintaining a high vacuum in the condenser. The steam used in the jet is later made to heat the feed-water. The water is then piped to a gallery between the generating room and the boiler room, where it passes through two more feed-water heaters supplied with steam from the 12th and 15th stages of the turbine, and finally through the boiler feed pump. This pump is of the centrifugal type, operating at about 500 lb. pressure, and

driven by an electric motor. In this gallery also, the evaporators are located, arranged to be cut in and out of service as additional water is required for the system. Above the heaters on a high platform there is a surge tank for each unit—a device to equalize the variations in supply to the feed-water system.

Generators.—Each generator is installed on a common base with its turbine and is totally inclosed. Each machine has its own exciter carried on the end of the shaft. Instead of the small service generator attached to the turbine shaft, as mentioned previously in this article, the source of power for auxiliaries essential to the continuous operation of the station, is provided by a transformer bank connected to the main generator terminals in such a way that the generator may be disconnected from the buses without interrupting the supply to the auxiliaries. These transformers, together with other transformers which supply the less essential auxiliaries from the main station buses, are situated outdoors in an areaway between the generating room and the switch house. An emergency service set consisting of a small turbine-generator is provided, being installed in one corner of the generating room.

Switch House.—Beyond the generating room is the switch house which is housed in a four-story structure and is an example of the isolated phase system. The three phases are placed each on a separate floor, phase "A" being at the top. Generator and feeder oil circuit breakers are grouped in concrete cells with asbestos doors which are kept locked. The circuit breakers and their disconnecting switches are operated by vertical rods coming up through the floors. The operating mechanism for each breaker and the handle controlling the disconnecting switches are installed on the ground floor below phase "C." There are two buses separated from each other by a longitudinal wall, and each bus is divided into two sections. Each generator and feeder circuit is provided with a main oil circuit breaker, and through another oil circuit breaker, known as the "selector" breaker, may be connected to whichever main bus is selected for operation. The feeder circuits are carried through current-limiting reactors and thence by cables in concrete ducts to the underground distribution system and to the transformer yard.

Transformer Yard.—This is a fenced enclosure situated at some distance from the station proper. The feeders from the switch house connect to two transformer banks which change the voltage from 13,800 to approximately 66,000 volts. From the transformer banks, the energy is supplied to the Philadelphia Electric Company's 66,000-volt system and to neighbouring utility companies.

Control Room.—The control room is located on the fourth floor of the power house over the transformer areaway between the generating room and the switch house. It has a wide bay-window which affords the station operators a clear view of the generating room. The operator sits at a desk, in telephonic communication with the system load dispatcher in the city, and with the generating room and the boiler room. The system load dispatcher determines the amount of load which the station is to carry, and issues directions for any major switching operations. In addition to telephonic communication between the control room and the generating room, a hand-operated indicating telegraph is provided for each generating unit for signalling between these points when placing a unit on the line or taking it off.

Before the operator are three switchboards, arranged in a semi-circle, one behind the other. The first is a bench-board or desk-like structure, divided into panels, each panel controlling a generator or several feeders. On this board are groups of small switches by which the operator opens and closes oil circuit breakers, adjusts the load and excitation of the generators, etc. The second board is a series of vertical panels, on which are mounted all meters and instruments for the generators and feeders. The third is the relay board and on it are mounted protective relays which automatically disconnect from the buses any circuit in which trouble may have developed. On this board are also located small switches and fuses for the low-voltage circuits from which the oil circuit breakers are controlled.

On each side of these three main boards there are 2,400-volt panels with control switches, meters and relays for controlling and metering the house-service circuits. One of these panels controls the steam-driven service generator.

Below the control room is a conduit or "pipe" room, in which all conduits carrying control and metering wires converge from all parts of the station. On the floor below the pipe room are the direct-current power rooms, in which are located motor-generator sets and storage batteries which supply power for energy excitation of the generators, emergency lighting, and for the operation of stoker motors and oil circuit breakers.

These are the main features of the Richmond Station. In the future two more units will be installed in this building, and later, two more buildings like the present one will be built, bringing the total up to 12 generating sets with 72 boilers, and a total output of probably 700,000 kilowatts. (D. O. W.)

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II. HYDRO-ELECTRIC GENERATION

The extent to which the water powers of the world have been investigated and developed since 1910 forms one of the striking engineering features of the period. Although falling or flowing water formed the earliest of the natural sources of energy to be utilized for providing power, some two-thirds of the water power at present in use has been developed since 1910. The reasons for this are partly technical and partly economic. The technical development of the hydraulic turbine has rendered it possible to utilize any head from 10 feet to 5,000 feet with a high degree of efficiency and at such speeds of rotation as enable a reasonably cheap electric generator to be used. The development of high tension transmission at pressures up to 220,000 volts, has enabled the energy to be transmitted efficiently for considerable distances—up to 200 or 300 m. in some cases—so that it has become commercially possible to develop large water powers at sites far remote from any centre of industrial activity, and to transmit the energy for long distances to the nearest convenient centre. Technical developments in electro-chemical, electro-physical and electro-metallurgical processes, most of which require relatively large amounts of cheap electrical energy, have created a demand for large blocks of cheap power which can, under favourable circumstances, be satisfied more readily from a water power installation than from any other source. For a water power installation to be economically possible, it must in general be able to generate energy more cheaply than a steam plant. Even in countries which have an adequate supply of cheap fuel this is possible in many instances, while in countries which are normally dependent on imported fuel and which are favourably circumstanced as regards water power, the latter source of energy becomes all important.

The urgent demand for energy to supply the abnormal requirements of the war period, combined with the increased cost of fuel, was responsible for an unprecedented rate of development in many countries—notably in France, Italy and Canada. In France about 3,000,000 water h.p. is now developed as compared with 750,000 h.p. in 1914. In Italy the total output will shortly amount to 3,000,000 h.p., while the installed capacity of the water power plants in Canada is now almost 5,000,000 h.p. Japan which only lately began to investigate its water powers has, since 1916, developed over 1,200,000 h.p. In most of the other countries of the world, and notably in the U.S.A., Spain, Sweden, India, Brazil and Chile, hydro-electric development is actively taking place, at a rate which shows little sign of slackening in the near future.

Available Water Power.—While any estimate of available water power can only be of the most approximate kind, the following table affords some indication of the amount of water power respectively available and developed in some of the chief countries of the world.

Millions of Horsepower	Available	Developed
Great Britain	0·9	0·25
Canada	32·0	4·8
Remainder of British Empire including Australia, Africa (East), Africa (South), Africa (West), British Guiana, India and Ceylon, New Zealand, Papua	35·0	0·9
Austria	3·7	0·3
South America	54·0	0·6
Dutch East Indies	8·0	0·1
France	5·2	3·0
Germany	1·5	0·8
Italy	7·0	2·7
Japan	6·4	1·6
Norway	13·3	1·8
Russia	3·0	0·9
Spain	6·0	1·4
Sweden	8·8	1·6
Switzerland	4·0	1·6
United States	55·0*	11·7*

*Estimated on the basis of steam-flow available 50 per cent. of the time.

From these figures it appears that some 240,000,000 h.p. is available, of which approximately 30,000,000 is at present developed or in course of development.

Uses of Hydro-electric Energy.—While a large proportion of the energy developed from water power is utilized for industrial purposes and for lighting and traction, an increasing proportion is being used for pulp and paper making and electro-chemical and electro-metallurgical processes; indeed the chief outlet for hydro-electric power in the near future is likely to be in connection with such processes and, probably, railroad electrification. The amount of power already used in these ways is large. Thus in the U.S.A. and Canada alone the power absorbed in the pulp and paper industry is approximately 2,750,000 h.p. Again, the world's production of calcium carbide requires some 500,000 h.p. and when it is remembered that such products as aluminium, carborundum, chromium, cyanamide, caustic soda, chlorates, magnesium, phosphorus and silicon are only rendered commercially possible by such processes, it will be realized that the future demand for energy for their manufacture is certain to be large. Nitrogen fixation is also likely to make considerable demands. In Norway alone some 400,000 h.p. is available for this purpose, and in view of the rapid depletion of the natural nitrate deposits, from which four-fifths of the world's nitrogen consumption has hitherto been supplied, and of the diminution in fertility of many of the great wheat and cotton growing areas of the world, the production of artificial fertilizers by one or other system of nitrogen fixation must, in the near future, become a question of great importance.

The electrification of railroads has made rapid strides of recent years, and while railroad electrification is not necessarily dependent on hydro-electric power, it is noteworthy that all the large trunk line electrification systems are operated from hydro-electric stations, except certain developments in the eastern part of the United States. In the United States some 3,500 m. of track have been electrified, while the Chicago, Milwaukee, St. Paul & Pacific has an electrified section of 850 m. which is supplied from hydro-electric stations. In France, much of the track of the Compagnie du Midi has been electrified with the aid of the water power of the Pyrenees, and it is anticipated that the whole system of about 3,000 km. will be electrified within 10 years. The plants supplying these lines have a capacity of close upon 300,000 h.p. The Orleans railway has a scheme for electrifying some 3,000 km. of its line, part of which is to be supplied from hydro-electric stations having a capacity of about 210,000 h.p.

In Austria some 2,000 km. of line is in process of electrification, and in Germany about 1,200 km. is now electrified, the power in each case coming mainly from hydro-electric stations. The Swiss railways are supplied from hydraulic stations built mainly for this purpose, and the ultimate programme of development comprises the electrification of the whole system by this means. Spain, Mexico, Brazil, Sweden and Japan also have a number of such schemes in hand, and these and similar developments will provide a very large field for the utilization of water power where this is available.

Much energy is now being utilized in the United States of America for purely agricultural purposes. In California, for example, there is in effect one vast system of electrical supply extending over a distance of 800 m. with 7,200 m. of high-tension transmission lines. This is fed from 114 hydro-electric stations interconnected with 30 steam plants, to give a total installation of 2,510,000 kw. A large proportion of this power is used in agriculture, a survey having shown a connected agricultural power load of nearly 636,000 h.p. in California in 1925. The Californian rice industry is almost wholly dependent on irrigation made possible by electric pumping, whilst many of the mechanical processes involved in farming are being performed by electric power.

In Sweden it is estimated that the power absorbed in the farming industry is now about 270,000 kw. The annual consumption is about 120 million kwh. or approximately 30% of the output of the State hydro-electric stations.

The economic development of many of the tropical dependencies of the British empire, whose latent wealth is practically untapped, is directly interconnected with the development of their water-power resources. Not only would an abundant supply of such power enable railroads to be operated, irrigation schemes to be set on foot, and mineral deposits to be tapped and worked, but it would go far toward solving the labour problem which promises to be one of some difficulty in the future.

While those outlets for electrical energy which are now in sight promise to absorb all the energy which can be cheaply developed for many years to come, there are many other probable directions in which such energy might find a new and profitable outlet. Among these may be mentioned the purification of municipal water supplies; the dehydration of food products; and the preservation of timber.

Lay-out of Hydro-electric Schemes.—The possibilities of hydro-electric development in any country depend essentially on its physical characteristics. Adequate rainfall is the first essential. A boldly contoured region has many advantages, in that it is often possible to find elevated sites at which water may be collected and stored in close proximity to sites at a much lower elevation, to which the water may be led and utilized under the head corresponding to the difference between the two levels.

Since the horse-power which can be developed by each cubic foot of water depends directly on the working head, a high head installation requires a much smaller volume of water than a low head installation of the same power, so that the pipe lines and the turbines are smaller and the installation is in general cheaper. Moreover, the volume of water which requires to be stored in wet weather in order to enable continuous operation to be carried out throughout the year is also smaller, and a comparatively small reservoir will often enable sufficient storage to be obtained at a reasonable cost.

For these reasons such countries as Norway, France, Switzerland and Italy, which have mountainous regions subject to heavy rainfall in close proximity to industrial regions capable of absorbing large amounts of electrical energy, are very favourably circumstanced for hydro-electric development. One development in Switzerland—at Lac Fully—utilizes the highest head on record. This is 5,412 feet, and the pressure of the water in the pipe line adjacent to the power house is 2,260 lb. per sq. inch.

In these high head schemes the water is normally brought from the supply reservoir through an open canal at a very flat gradient to a small chamber or forebay on the hillside above the power house, whence a short steep pipe line conveys it to the turbines. In one high head type, if a sudden closure of the turbine gates occurs, the water momentum in the pressure tunnel is absorbed in causing a surge up a surge tank, instead of in producing a heavy pressure wave in the pipe line. A noteworthy development of this general type is to be found in connection with the installations supplying electric power to Bombay from hydro-electric stations drawing their water from reservoirs on the eastern side of the Ghats.

But although high head sites offer many advantages, they are not essential for the successful development of hydro-electric energy. The great majority of those water powers of the world which are in reasonably close proximity to industrial communities, are indeed in regions in which the gradients are medium, and the aggregate power developed from medium and low heads is vastly greater than that from high head installation.

Low head schemes, utilizing heads up to 40 or 50 feet, are usually located on rivers in which the gradient is small. In some cases a natural head is available owing to the presence of rapids or waterfalls, the water being diverted and led through a flume or canal to the turbines from which it is discharged into the low-level reach of the river. In other cases it is necessary to make an artificial head by means of a dam. A dam, by raising the natural level of the water, provides a certain amount of storage, but seldom more than is sufficient to store the night flow of the river for use during the day. A river scheme of this type can therefore only give a continuous output equal to the dry weather flow of the river. It is usually however, found economically sound to install hydraulic plant of a capacity greater than that corresponding to the minimum dry weather flow, and to install, as an essential part of the scheme, a steam plant capable of maintaining the output when the supply of water is inadequate.

Various types of low head development are adopted as they best fit the conditions encountered at the power site. Where a dam is built, the power house is often constructed on one flank of the dam with a short head race or tail race as is most convenient, and the dam itself is used as a spillway over which excess water is discharged in times of flood. Where the river flows in a narrow and steep gorge the powerhouse may sometimes with advantage be constructed in the dam itself, which now consists of a hollow reinforced concrete structure. Where the river forms a long bend, it is often possible to cut across the neck of the bend and to utilize the head between the two points.

In medium head schemes—utilizing between 40 and 200 ft. head—the layout is usually similar in broad outline to those involving either high or low heads. Where such a scheme involves the use of a long closed supply pipe to the turbines, having only a small gradient, somewhat special treatment, however, becomes necessary. Owing to the large inertia of the column of water in the pipe line, any sudden demand for water caused by opening the turbine gates on an increasing load causes a relatively large drop of pressure at the turbines, which renders governing very difficult. To reduce this difficulty, a surge tank is fitted to the pipeline at a point as near to the turbines as possible.

Turbines.—With the exception of the new low-head propeller-type turbines, the inward flow pressure turbine and the Pelton wheel are the only types of turbine used in modern hydro-electric schemes of any size. The type to be adopted depends largely on the available head. The Pelton wheel is a slower running machine than the pressure turbine and is therefore better fitted for very high heads. It has the further advantage for such heads, that since the water is discharged through one—or at the most two—nozzles, these may be of reasonable size when dealing with the small volumes of water normally available in high head schemes. The pressure turbine on the other hand with its full peripheral admission of water is well adapted to utilize the large volumes necessary in low head schemes, and its higher speed of rotation is also a great advantage in low and medium head plants, in enabling the cost of the electrical generators to be reduced. Broadly speaking, the Pelton wheel is more suitable for heads above about 700 ft.; the pressure turbine for heads below about 250 ft. in small units and below about 500 ft. in large units; while over the intermediate range of heads much depends upon the size of the units and the special circumstances.

With the exception of the new propeller-type turbines, all modern pressure turbines are of the mixed flow type, having inward radial flow through guide vanes surrounding the runner, and axial discharge. Pivoted guide vanes are universally used, speed regulation being attained by simultaneous rotation of these about their axes. Low head turbines—up to about 40 ft. head—are usually set in an open forebay. Either vertical or horizontal shaft machines may be used, but the former are becoming more common, especially for large units. For higher heads the water must be supplied through a pipe-line and the turbine is enclosed in a spiral casing so designed as to distribute the water evenly around the periphery of the guide vane ring. For heads up to about 120 ft. this casing may be moulded in concrete, but for higher heads and pressures a metal casing becomes necessary. This may be of cast iron, cast steel, or of steel plate construction, and in order to give rigidity and increased safety in case of pressure surges is sometimes embedded wholly or partially in the concrete of the substructure. Modern development is tending in the direction of units having a single runner and a vertical shaft on the top of which the electrical generator is mounted. The weight of the shaft, runner and generator is then carried from a single thrust bearing of the Michell or Kingsbury type. This type lends itself to a simple and efficient form of setting, while the friction losses are extremely low.

One of the great drawbacks of the low head turbine in the past has been its relatively slow speed of rotation, which necessitated either a slow speed and costly generator or expensive gearing. As a result of experiment it has, however, been possible so to modify the form of the runner as greatly to increase the speed of rotation under a given head without seriously reducing the efficiency.

Such runners are characterized by their small number of vanes—often not more than four being used—which approximate in form to those of a marine propeller. In one of the latest types, the Kaplan, the vanes are capable of rotation about their own axes so as to enable the vane angles to be adjusted to suit the varying flow of water at part loads. Further developments in the direction of increasing the speed are in active progress and promise to give important results. At the present time, however, turbines are in existence which are capable of efficient operation at speeds at least three times as great as would have been thought possible 10 years ago.

The pressure turbine is now built in units capable of developing upwards of 100,000 h.p., and this size could readily be increased if necessary. If well-designed and installed in a suitable setting the efficiencies are remarkably high. Efficiencies of 93% have been obtained on tests of vertical shaft turbines at Niagara and values approximating 90% are quite common. In a medium head plant the following are typical values:—

Fraction of full load . . .	·25	·5	·75	·90	1·0
Percentage efficiency . . .	70	82	88	90	88

Pelton wheels are almost invariably built as horizontal shaft units with one or two nozzles, thus far in sizes up to 40,000 kilo-watts. Speed regulation is usually performed by a deflector which cuts off the jet from the wheel, acting in conjunction with a central needle or spear which slowly reduces the size of the jet while the deflector returns to its original position. The mechanism is operated by a relay cylinder supplied with pressure water or oil through a pilot valve actuated by the governor. In a well-designed plant the instantaneous speed variation corresponding to a sudden application of full load should not exceed 12 to 15%. The difference between the initial and final steady speeds should not exceed 2% between full load and no load.

At constant speed the efficiency of a Pelton wheel falls off comparatively slowly as the load is diminished. A well-designed wheel

should have approximately the following efficiencies:—

Fraction of full load	·25	·50	·75	·90	1·0
Percentage efficiency	77	83	85	86	83

Pipe-lines.—The lack of a suitable pipe-line has, until recent years, tended to retard the development of plants for very high heads. Under such heads the necessary wall thickness, even with a moderate pipe diameter, becomes too great to permit of the use of riveted joints. Recent developments in electric welding and oxyacetylene welding have, however, rendered it possible to construct suitable welded pipes and by their aid, and by the use of banded or solid drawn steel pipes in extreme cases, it has been found possible to harness the highest available heads.

The pipe-line for a water-power plant may be constructed of steel, reinforced concrete or wood. Steel is the most usual, riveted pipes being suitable for all but the highest heads. For heads up to about 200 ft., reinforced concrete pipes are suitable and have the advantage of not deteriorating appreciably with age. As compared with steel pipes the materials are more easily transported and the friction losses are less. Large pipes are moulded in site, and as the bulk of the material is usually obtained locally, only the cement and reinforcement require to be transported for any distance. For small diameters, pre-moulded concrete pipes with loose-sleeve or spigot-and-faucet joints are often used.

For moderate heads, wooden pipes are extensively used in countries where suitable timber is cheaply available, and under favourable conditions have a useful life of at least 25 to 30 years. They are built up of wooden staves about 6 in. wide, shaped to the correct radius and joined end to end by thin metal plates driven into saw cuts on both the abutting ends, covering the joint. The staves are so arranged that the circumferential joints are not continuous. They are held together by circumferential steel bands which resist the bursting pressure, and whose diameter and spacing depend upon the pressure to be anticipated in each section of the pipe. The materials are easily transported and neither erection nor repair require any great degree of skill. If suitable timber is available the mill can be set up on the site and only the bands and shoes require transporting. As heads and diameters increase, the amount of steel necessary for the bands increases until it becomes comparable with that required for a steel pipe for the same duty.

In order that the walls of a wooden pipe should not decay it is essential that they should be kept saturated with moisture, and for this a certain minimum internal pressure is necessary. For this reason such a pipe is not suitable for heads less than about 20 ft., while the maximum suitable head is about 200 feet. Such pipes have been constructed in sizes up to about 18 ft. in diameter.

Generators.—Generators to be driven by hydraulic turbines range from the simple open-type machine, which is often applicable to small units, to constructions very similar to those of steam-turbine-driven alternators which are necessary for the largest high speed machines. On account of the very large outputs required in modern plants from a single unit running at the high speeds characteristic of the hydraulic turbine, the output per pole of the generator at normal frequencies is very large, and the cooling surfaces are small in comparison with the amount of heat to be dissipated. Special attention therefore needs to be paid to efficient ventilation of the rotor, which can only be obtained by a carefully arranged system of forced draught. Mechanically the rotor must be designed to withstand the rotational forces accompanying the "runaway" speed of the turbine, which may be from three to four times the normal centrifugal forces.

At the present time the energy is almost universally generated as alternating current on account of the simplicity and reliability obtained with a moderate generating pressure, which is readily transformed to the highest pressures which may be required for economical transmission. Of the two types of alternating current generator, the synchronous and the induction types, the latter has come largely into use of recent years on account of its robustness of construction and simplicity in operation.

Occasionally the advantages of high-tension direct current may outweigh the essential difficulties of its generation, in which case the Thury system may be used. In this system all generators and motors are in series, the current remains constant, and the voltage is varied according to the power demand. All generators are series wound, each having a governor which either varies the speed of the turbine, or, if the speed of the latter must be constant, shifts the brush rockers. The maximum voltage per commutator so far constructed is 5,000. By using a large number of generating units, connected in series, the system pressure may be as high as 80,000 or 100,000 volts. All generator frames are insulated from earth and it is usual to surround the machine with a wide insulated platform to ensure the safety of the operators.

Maintenance of constant speed is not of great importance, and the system therefore offers some advantages for such an installation, for example, as a tidal power scheme where the working head is continuously varying within wide limits.

Frequencies.—The question of the most desirable frequency of alternating current is simplified by the fact that in most countries two frequencies—a high and a low—have become recognized as standard. In the U.S.A. and Canada, either 60 or 25 cycles per sec. is most commonly used for general utility purposes and 25 cycles for railway power, although other frequencies (notably 50 cycles) are also used to a considerable extent. On the Continent 50, 16⅔ and 15 cycles are standard; in Great Britain and South America 50 and 25 cycles. As regards the number of phases there is little freedom of choice, the question being largely determined by the nature of the load. Single phase supply, though offering some advantage in simplicity of equipment, involves increased losses in the generators and generally less reliable performance. This system is only used where absolutely necessary, as for direct supply to alternating current railways using commutator motors. Of the polyphase systems, three-phase is preferable to two-phase for general power purposes, since the plant is more fully standardized and therefore cheaper, while rotary converters are smaller, more efficient, and give better commutation on three-phase than on two-phase systems.

Voltage.—For distribution within a short radius of the power-house the voltage of generation and transmission will be the same as that required for the supply to consumers; but for transmission to greater distances, for which the voltage is stepped up, there is a wide choice of the voltage of generation. An unduly low voltage involves heavy and expensive bus-bars and switch-gear, and in large units presents difficulty in the construction of the stator windings of the generators. A very high voltage, on the other hand, requires a winding with many windings in series per slot, a greater thickness of insulation, and involves a generally reduced reliability. From the point of view of the construction of the generator it is desirable to have two conductors per slot, and the stator current should then vary from about 300 amperes in the smallest to 1,000 amperes in the largest machines. It may therefore be shown that the most suitable voltage of generation, when not otherwise restricted for a three-phase machine, should vary approximately as follows:—

Output (kw)	200	500	1,000	2,000	5,000	10,000	15,000
Pressure (volts)	450	900	1,500	2,500	5,000	9,000	11,000

The power factor is here assumed to be 0·8. For two-phase machines the pressure should be about 0·9 times the above values. One of the most important modern developments in transmission has been in the direction of reducing the losses by increasing the voltage of the transmission lines.

General Arrangement of Hydro-electric Stations.—The character of the development has a direct bearing on the general lay-out of the hydro-electric station. In a low head station, incorporated in a dam, the available space is limited by the width of the dam, and this in turn may be determined by the space required for the turbines. In consequence it is usual in a low

head plant to locate the switch gear and transformers either on floors above the machine room, or, as is becoming more common, in a separate building on the river bank.

There is a growing tendency to install all transformers and high tension switch gear out of doors. Isolated examples of this already exist in Norway, France, Italy and Spain, and the practice is becoming standard in the United States. It has even been proposed to place the whole generating plant outside, merely providing a portable shelter for use during repair work, and such open-air stations will no doubt arrive in the near future.

Conditions vary so much that no general rule can be made that can govern or guide all hydro-electric station design. It is evident that the generating plant itself, water wheels or turbines and generators should be located where the greatest advantage can be taken of the available head of water. This condition, however, is not sufficient to guarantee the most economical power generation at the given site. The cost of construction of the plant as a whole must be estimated for different settings and arrangements, and the one chosen that will result in maximum overall economy. The other component parts of the complete station, the transformers, switch-gear, lightning arrestors and the transmission line terminals must be fitted into the available space in the best possible manner. We find these installed in the structure and on the top of the dam in one station and removed to a nearby hill in another if sufficient space is not available nearer the generating plant. Every power site presents a complete new set of problems.

Many medium head plants operate with vertical shaft units. For a low or medium head station, in which the variation in tail race level may be great, the vertical unit has great advantages in that it enables the generators to be placed above the flood level while leaving the turbines free to be arranged at any convenient and suitable height above the tail water.

For small units the horizontal shaft machine has some advantages. Small electric generators are more economically built as horizontal shaft units since this allows of the simplest scheme of ventilation, and often enables a standard engine-type of machine to be used. In larger sizes again the horizontal type will often be preferable where, owing to governing difficulties, the shaft has to be provided with an additional flywheel. In high-head stations, if turbine equipment has been found suitable, the horizontal shaft machine is almost universally used, largely because of its accessibility.

For the highest heads water wheels such as the Pelton wheels are installed. These belong to the horizontal shaft type of machine. Pelton wheels have been built in units composed of two water wheels with the electric generator between them, so that only two bearings are required.

Automatic Generating Stations.—The automatic generating station is especially suited to systems where numerous small-power falls are available. In such a case the expense of an operating staff at each would be prohibitive, but if each station can be made automatic, and all are linked into a common distribution system, the labour cost is reduced to a minimum. The first of such stations was set in operation in 1917. This is on the system of the Iowa Railway and Light Co., where it operates in parallel with a steam plant situated about two miles away. The automatic station contains three 500 kw. generators driven by Francis turbines operating under a head of 10 feet. Normally the starting and stopping of these sets is accomplished automatically through the medium of float switches actuated by the change in the level of water above the dam. Provision is also made for controlling these operations as well as the gate openings of the individual turbines by push buttons in the central power-house.

Another system of automatic control is used in a station recently opened by the Adirondack Power and Light Co. This is capable of developing 7,300 kw. at 6,000 volts. The control is arranged by a switch in the high-tension line some miles away. To start the plant this transmission line switch is closed. This energizes a series of solenoids one of which is connected to the pilot valve of the governor and one to an interlock on the turbine gate; while two others release the water pressure brakes. The turbine gates are balanced at about 30% gate opening, and so automatically open when released. The speed of the unit then increases until at about 95% of synchronous speed a relay closes the circuit breaker connecting the generating unit to the transmission line. The unit then comes into synchronism and the field switch closes. The unit is now excited and under governor control and takes the load corresponding to the governor setting. There are a number of protective relays and devices, and any kind of trouble causes the unit to shut down.

The development of automatic generating stations is proceeding steadily and this method of operation promises to do much to render it economically possible to utilize many low-head river sites which have hitherto been neglected.

Combined Operation of Hydraulic and Steam Plants.—Except where a large amount of storage is provided the variability of river flow makes it impossible to utilize more than a fraction of the total available energy unless generating machinery is installed which will have to be idle during the greater portion of the year. Broadly speaking it is found that the most economical results are obtained when the capacity of the turbines is such as will enable them to be run at full load for about six months in the year.

By operating a steam plant in conjunction with the hydraulic installation, it becomes economically possible to increase the capacity of the hydraulic plant, the defect of its output at times of less than normal flow being made good by the steam installation. The latter also serves as a stand-by in case of a breakdown of the hydraulic plant. (*See* SUPER-POWER.)

Most large hydro-electric power systems in 1928 included one or more steam plants as part of the system. The best method of operation of such a combination depends upon the type of load, the storage capacity of the hydraulic system, etc., and can only be determined by a consideration of the special circumstances of the individual plant. In general, since for maximum economy a steam plant requires to operate at something approaching its normal capacity, at times of low water the steam plant operates continuously, carrying the base of the load, while the peak of the load is taken by the hydraulic plant. On the other hand, in a system having a very long transmission line it has been found more economical to let the hydraulic plant carry the base of the load, working at a reasonably high load factor, and to carry the peak of the load by the steam plant. In this method of operation the cost of the transmission line is less than if the reverse method were adopted, and the saving in this respect may more than counterbalance the extra expenditure due to the less economical operation of the steam plant.

While in the early days of hydro-electric developments criticisms were justly leveled at the inaesthetic nature of such developments, much attention has been paid of recent years, more especially in Switzerland and in Italy, to the architectural possibilities of the hydro-electric plant. These plants stand at the foot of the mountains overlooking the plains or in a setting of rock at the mouth of a narrow gorge; nearly always are they located where the architect should be impelled to add beauty to usefulness even without the fear or the pressure of criticism. (*See* also TURBINE, WATER.)

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ELECTRICAL POWER IN AGRICULTURE. Great strides have been made in the application of electricity to agriculture. Already, many farmers are using electric light and power. With the growth of regional electricity schemes we may expect to see agricultural operations everywhere modified by the use of electric energy. Good light is as beneficial in a farmhouse as in an urban dwelling, in a cowstall as in a factory. The electric motor is simple, robust and easy to start and stop; it gives a steady pull, and, with the usual charge ranging in Great Britain from 1½d. to 3d. an electric unit for power, it is cheap to work.

Barn Machinery.—Most English farmers rely on an oil-engine which is used (roughly in proportion to the acreage of the farm) to drive barn machinery, *i.e.*, chaff-cutters, root-pulpers,

cake and oat crushers, etc. These machines absorb from 1 to 5 H.P. according to size. On a grass farm, the engine, perhaps 1½ to 3 H.P., may work only two or three hours a week in winter and be hardly used in summer when all the stock is out on the pastures. The annual consumption may be something like 1 H.P. hour per acre of land or, say, 600 H.P. hours per square mile of country, equivalent to 450 electric units or kilowatt hours. On an arable farm, where there is much preparation of food, including perhaps the grinding of barley-meal, an engine of 5 to 8 H.P. may work several hours a day, and the annual consumption amount to about 12 H.P. hours per ac., that is, about 7,000 H.P. hours or 5,000 electric units per square mile.

Cultivation.—The greatest consumption of power in agriculture is in field cultivations such as ploughing. On most farms, this work is still done by horses. The only places where they have been replaced successfully by mechanical power are in flat areas with large arable fields. There ploughing can be done more economically by tractors on light land and by steam tackle on the heavier clay. On a farm where three quarters of the area is arable land, the annual consumption of energy in ploughing may amount to 15,000 to 20,000 H.P. hours per sq.m., and half as much again may be used for other cultivations, a total of 22,000 to 30,000 H.P. hours per square mile. Thus, on arable farms the energy needed for field work is considerably greater than that required to drive barn machinery.

Electric Ploughing.—Electric ploughing has been tried in France, Germany, Italy and elsewhere, and is generally carried out by contractors. The most usual method is to haul the plough backwards and forwards by means of a wire rope pulled by a motor mounted on a wagon at each side of the field, just as in steam ploughing. In a modification of this method, a single motor only is used, the wire rope passing round four anchored pulleys, two of which are moved as the plough proceeds. Experiments have also been made in which the motor is placed on a carriage attached to the plough, and current supplied to it through an insulated, flexible cable, which is unwound as the carriage and plough move one way across the field and wound up again as they move back in the other direction.

Costs.—It is difficult to get comparable figures of costs. A committee of the Institution of Electrical Engineers (Aug. 1925) quoted the prices of French contractors for ploughing to depths of 6 to 14 inches at sums equivalent to 16s. to 32s. per acre. The quotations of East Anglian contractors for steam ploughing range from 17s. to 25s. per ac. according to depth (say 8 to 14 in.) and soil. The cost to a farmer of ploughing with horses is generally reckoned at about 15s. for light and 28s. for heavy land per ac. but, if this too were done by contractors, something must be added for profit.

Both steam and oil engines have the great advantage of being self-mobile; they can move about the roads and on to the field under their own power. With electric ploughing, the need of taking wires to each field, the great weight of the motors and carriage, and the cost of hauling them about with horses or tractors, militate against its success. It seems likely that, unless some new method or improvement is applied, electric ploughing will make no headway, and that the use of electric power in agriculture will be restricted to the driving of stationary machinery.

Special Machinery.—Besides the ordinary barn machines, less common implements must be brought under review. For threshing corn, smaller farms mostly rely on travelling threshing machines worked by steam traction engines. Some larger arable farms, however, have their own threshing plants. Where current is available, the machine can well be driven electrically with a motor of from 12 to 15 H.P. according to size. It is stated that, owing to the steadier pull of the electric motor, better threshing is done than with a steam-engine. On certain farms, power is used in other special ways. For instance, where a tower silo is installed, power is wanted to cut up the fodder and to lift it into the silo. Ensilage is sweet or sour chiefly according as it is made above or below a temperature of 47° C., and German experiments show that it may possibly be worth while to heat the fodder artificially, by passing an electric current through the silo.

Perhaps the greatest advantage of electric current is that power need only be used to the amount actually required. Motors of quite small size are made which will drive light dairy machinery, horse-clippers, fans for incubators, and other implements which absorb too little power to make it worth while to start an oil-engine to run them. The number of such implements is sure to increase as electric supply becomes more common. As regards dairies, milking-machines and also separators, clarifiers and butter churns are very suitable for electric drive. Dairymen, and perhaps fruit-growers, may find it profitable as time goes on to install refrigerating machinery. This may give another demand for power on certain specialized farms.

Poultry.—To turn on electric light in poultry houses on winter evenings and give the birds an extra feed is found to increase the number of eggs laid. The rise in the total number laid throughout the year is insignificant, but, since eggs are worth more in winter, the redistribution more than pays for the cost of light, food and extra labour. Incubators can more conveniently be heated electrically than in other ways; by passing heated air through the apparatus by means of an electrically driven fan, uniform temperature and efficient ventilation can be secured.

Plant Growth.—Experiments indicate that plant growth is stimulated by a high voltage current of some milliampere per ac. passing as a discharge to the crop from a network of overhead wires, which are kept at 20,000 to 60,000 volts above the potential of the earth. Application for six hours a day for one month early in the growth of the crop seems quite as effective as a longer treatment. With certain cereals, an increase in yield of 20% has been obtained, but the results are not always assured, and the matter is still in an early experimental stage. Other experiments, carried out in America and elsewhere, show that electric light, both arc and incandescent, in greenhouses, has an effect in accelerating the germination of seeds and hastening the growth of certain vegetables, the effect depending somewhat on the colour of the light.

Electric Supply.—In the neighbourhood of towns, and in industrial and mining areas, many English farms are supplied with current from central power stations. Most of these stations now produce three-phase alternating current, and the corresponding squirrel-cage type of motor is very suitable for farm use. Further developments of this kind may be expected, but the purely agricultural demand is not enough to carry a network of mains over the countryside with the high costs of erection prevalent in Great Britain. Experience shows that the demand for light and power combined varies from 1,000 to 6,000 electric units per sq.m., in good agreement with the estimate for power alone from oil-engines, as given above. In towns, the consumption may be a thousand times more. Again, for long distances, in order to economize copper, high voltages must be used; these are dangerous, and must be transformed to lower pressures for domestic or industrial purposes. Transformers are expensive, and no ordinary sized farm consumes enough power to carry the cost of a high voltage transformer. Hence arises the apparent anomaly that a farm with high voltage mains running through it may be unable to get power. But, where a chain of villages creates a considerable demand along a definite line, or where pumping or irrigation needs a steady supply of power, the distribution of central station current in rural areas may become possible, especially if produced by cheap water power.

In many other countries rural electrification has been developed further than in England, partly owing to the less expensive standard exacted by legislation for the erection of overhead conductors. As an example of what has been done in a country often cited as a model, the following details of electric supply in an agricultural area in the south-east of Sweden may be given. The total area is 194 square miles, containing 161 square miles of arable land, with a population of 157 to the square mile, of whom 60% are dependent on agriculture. The district is supplied from a transformer on a high tension main; from this station current is distributed at 20,000 volts and transformed down by steps to 220 volts. There are 2,600 consumers in the whole area, and the total annual consumption is about 1,050,000 electric units (kilowatt-hours). This is equivalent to 404 units per consumer, or 33 units

per inhabitant; 5,400 units per square mile or 8½ units per acre. The total cost of installation of the country lines and transformers was about £60,000. The average charge for energy is 3¼d. per unit, which, with meter rents, gives a revenue of £14,300. This is found to cover the total costs and leave a small profit.

It will be seen that the consumption of power is about the same as that estimated above for stationary farm machinery in corresponding areas in England. The advantage held by Sweden is not that more power is used, but that the costs of construction and distribution are less.

The establishment in 1927 of an Electricity Commission for Great Britain will lead to greater uniformity in voltage and frequency, to a decrease in the number of generating stations, and, it is hoped, to a cheapening in costs.

Where current from a large power station is not available, a village supply may be feasible; a considerable number have been successfully installed in England, some worked by small waterfalls, others by oil-engines. If water be plentiful, turbines and dynamos may run day and night, and a very cheap supply be obtained; but in other cases the energy must be stored in batteries of accumulator cells, which are costly and short lived. Whenever cells are to be charged, alternating current is, of course, inapplicable, and direct or continuous current must be used.

When no public supply can be obtained, there remains the question of a private installation. If occasional power to drive barn machines alone is wanted, it is obviously better to drive directly from a small oil-engine. But, if good light be wanted, and use can be found for motors of fractional horse power in dairy or house, a private electric plant may be worth consideration. The dynamo is generally driven by a water turbine or oil-engine, but the use of windmills seems now becoming possible. (*See* also FARM MACHINERY and TRACTORS.)

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PRACTICAL WORK ON THE ALL-ELECTRIC FARM

The following account of practical operations is derived from the experience gained on a British farm in Sussex.

Electric Light.—The use of electric light is a great aid to the safety and convenience of work in the barns, byres, stables, etc., where there is always inflammable material lying about. The farm worker in the electrically lighted building is able to do far more work than he would in the building where the only form of illuminant is the old-fashioned hurricane oil lamp. It has been shown by careful test that cattle can be fed with a saving of over a third of the usual time. During the winter months a great deal of work has to be done in the buildings after dusk or before dawn and the preparation of foodstuffs or the cleaning of byres by the aid of a poor light is not an easy task. Some time ago on the farm here described, the amount of milk produced was carefully checked; it was found that after the introduction of electric light into the cow byres much less milk was lost through spillage; the value of the milk thus saved was nearly sufficient to pay for the cost of electric light. It is the general experience on the continent of Europe, that as soon as electricity is available, the first thing done by the farmer is to light the byres and stables; his house comes last. The next step is usually the lighting of the poultry houses in winter to obtain an increased egg supply. Careful investigation shows that while the hens do not lay more eggs per annum through electric lighting, it is possible to alter the distribution of the laying period with the result that from 10 to 30 per cent. more eggs are obtained at a time when eggs are at their highest prices.

Normally, the supply of eggs is considerably reduced in winter because a good deal more than half of the day is spent by the hens on their perches. In the first four hours of this time the hen has digested almost the whole of the food contained in her crop and is afterwards drawing on the stored fats in her body which should be utilized for egg production. The electrically lighted house, however, reduces the number of hours sleep to the ample amount of ten a day; thus the birds are kept active for about 14 hours and are given a longer period for obtaining exercise and consuming food. The hours at which the lights are introduced vary according to the opinion of the poultry-man; the management described favours the morning and evening lighting system. Lamps of 40 candle-power are used and these are placed in scientific reflectors for distributing the light evenly over the feeding and scratching space in the house. As the switching on and off of the lights regularly at definite times would of necessity prove very inconvenient to the poultry-man (and electric lighting is apt to bring on a moult) automatic time switches are installed. These switches not only turn the light on and off but also dim the lights for a period of 15 minutes before switching on and off. This dimming arrangement is really essential when lights are switched off after dark, as its gives the birds an artificial dusk and yet provides sufficient light to enable them to return to their perches. The clock is fitted with a self-winding device and also an astronomical attachment. The latter automatically switches on and off a few minutes earlier or later each day, according to the earlier or later rising or setting of the sun. Careful records have been kept and it has been found that the total cost of electric light for the whole period during which lights are required amounts to about the average price of one egg per hen, in return for which 15% more eggs are laid at times of top prices.

Machines in Farm Buildings.—One of the outstanding advantages of electricity on a farm is that it can be used to drive nearly every type of farm machine.

When a farmer begins employing an electric drive he generally purchases two portable electric motors, one small one of 2 to 5 horse power for use with various machines, and a larger one, of 15 to 30 horse power, to operate a thrashing machine. Often a motor of 10 to 15 horse power is employed to drive a counter-shaft in place of an oil engine. In the course of five or seven years, it will be found that he is gradually adopting individual driving of his machines—in spite of economists' and engineers' calculations that this is not a good financial method—and often increases to as many as 15 electric motors. Though this practice may not seem sound, it is so, for after all labourers' wages have to be taken into account. The machine that is ready at a turn of the switch, is far more economical than one where the portable motor required to drive it has to be dragged into position and lined up. Again, the losses in driving a counter-shaft (often as much as 3 horse power out of a main drive of 8) are eliminated.

Milking Machines.—The electric milking machine was at one time not considered an economic proposition on a small farm where the dairy herd did not exceed ten. This, however, is not now the case, for small portable machines are available. These machines are driven by a one-sixth horse power motor and their current consumption is very low; they do not require any installation and are in fact just as reliable as the larger machines. Milking machines are often condemned because of the high bacterial count in the milk thus produced. This, however, is not the fault of the machine, but of want of cleanliness and care.

Thrashing Machines.—The thrashing machine on the farm in question is self-propelled and self-contained. It consists of a petrol-electric ex-omnibus chassis on which has been mounted a six-foot drum, ball bearing, thrashing machine. An electric motor has been erected on an angle iron framework on the front of the thrasher. This motor is directly connected to the thrashing drum through a flexible coupling. As is usual in this type of petrol-electric vehicle, the petrol engine on the chassis drives an electric dynamo. The current from this dynamo can be utilised either for propelling the vehicle or driving the motor connected to the thrasher. When the machine is used for thrashing, the electric motor is connected to the farm power lines; if however the machine is sent to a neighbouring farm where an electric supply is not available, the electric motor is operated from the dynamo on the machine. This equipment can proceed along the roads at a speed of 12 miles per hour. An electrically driven thrashing

machine has the advantage that about five per cent. more grain is thrashed out, owing to the steady speed of the motor.

Electric Ploughing.—The large electric plough has now become a usual sight on many large continental farms; over 200 are now in use in Europe. Its usefulness is, of course, restricted to large scale operation. Many seem to imagine that a farm equipped for electric ploughing must necessarily be one mass of overhead lines. This, however, is not the case, since the electric plough operates anywhere within a quarter of a mile from the source of supply, and farms are generally long in comparison with their width. Hence one line along the major axis of the arable portion of the farm will usually suffice. For the individual farmer a smaller type of plough is essential. On the Sussex farm described here, the management has for 5 years used the only working electric plough in England. The equipment consists of a two-wheeled carriage upon which is mounted a 12 horse-power motor with a speed reduction gear. There are also mounted on the carriage two cable drums, either of which can be driven by means of the motor. The equipment is anchored in a convenient position on the field, and adjacent to the overhead lines. The set operates on the old round-about haulage system. A double furrow anti-balance plough is used and this is drawn to and fro across the field by the steel rope attached to the drums mounted on the carriage. The speed of ploughing is from one-third to one acre per hour, varying with the nature of the soil and depth of furrow ploughed, five acres per day being the average. The great advantage of the small electric plough is that the ploughing can commence by merely pressing a switch. The objectionable hard "pan" made by the tractor is avoided, as only the plough passes over the ground. The consumption of electricity with this type is remarkably low; an acre of heavy arable land can be ploughed to a depth of six inches with a current consumption of 15 units; 25 units is sufficient to plough the same class of land to a depth of ten inches. The large electric ploughs, as used on the continent of Europe, plough up to 30 acres per day.

FURTHER APPLICATIONS OF ELECTRICITY

Ultra Violet Rays.—The present day electric farm is incomplete without its ultra violet ray equipment. Experiments have been made on cattle, pigs and poultry with these rays. It has been found that chickens so treated develop into strong vigorous birds in a much shorter time than under normal conditions. The treatment is only given during December, January, February and March, for about ten minutes morning and evening. Laying hens have been found to lay better during the winter months when treated with the rays.

Experiments have shown that the danger of rickets in young pigs, owing to their very rapid growth, can be considerably minimised by treating them with ultra violet rays. This is especially true during the winter. A farmer really has no business to rear young livestock in the winter-time when adequate health-giving sunshine is not available. However, the profits are greater, and the use of ultra violet rays combined with small doses of cod-liver oil, enable him to overcome adverse conditions.

Haymaking.—Adverse weather conditions constitute one of the greatest risks facing the farmer, for only too often excellent crops are ruined through rain at harvest time. Some years ago the manager of the Sussex farm, as a result of a number of laboratory and field experiments, decided to eliminate this risk, with the result that the hay and corn can now be cut when in the best condition, carted almost immediately, and stacked and cured with the aid of a small fan and an electric motor. This is not a drying but rather a bacteriological process. Stacks of from 15 to 100 tons have been cured without the aid of any pre-heated air. The method of procedure is as follows. On the place where the ricks are to be built, covered channels are prepared, provided with openings at about every ten feet of their length. High sided extensions are provided at the openings to give the air a lead into the cavities that are to be formed in the rick above. Over these cavities a drum or former is fixed. These drums are about 3 feet high and $2\frac{1}{2}$ feet in diameter. The rick is then built in the ordinary way. When the crop reaches the level of the top of the drums, the latter are drawn upwards to provide a ventilating shaft. When

Saving Effected per Annum
by
Equipping a Medium Sized Farm with Electricity
(Cost of electricity 4d per unit)

Before electrification	£	s.	d.	After electrification	£	s.	d.
Light							
50 gal. of oil @ 1/- per gallon	2	10	0	15–20 electric light points, consuming 300 units per annum	5	0	0
150 hours of labour cleaning and trimming lamps @ 6d per hour	3	15	0				
	6	5	0		5	0	0
Direct gross saving					1	5	0
Indirect saving							
Additional milk output due to saving in spillage, 45 gals. @ 1/- per gal.					2	5	0
Time saved in the feeding of livestock by good lighting 182 hours per annum @ 6d per hour					4	11	0
Gross saving					£8	1	0
Milking							
Time for hand milking, $3\frac{1}{2}$ hr. per day @ 6d per hour	31	18	0	Time when electric milkers are used, $1\frac{3}{4}$ hr. per day @ 6d per hour	15	19	0
				Electric power, 250 units @ 4d per unit	4	3	4
	31	18	0		20	2	4
Gross saving					£11	15	8
Cream Separating 7,500 gallons per annum							
Time for man to operate separator, 320 hours @ 6d per hour	8	0	0	Time for man to attend to electrical separator 40 hr. @ 6d per hour	1	0	0
				Electric power, 72 units @ 4d per unit	1	4	0
	8	0	0		2	4	0
Gross saving					£5	16	0
Pumping Water							
300 hours hand labour @ 6d per hour	7	10	0	Power for operating pump, 65 units @ 4d per unit	1	1	8
	7	10	0		1	1	8
Gross saving					£6	8	4
Chaff Cutting							
100 hours per annum to operate machine @ 6d per hour	2	10	0	25 hours attending electrical machine @ 6d per hour	12	6	0
				Cost of power, 18 units @ 4d per unit	6	0	0
	2	10	0		18	6	0
Gross saving					£1	11	6
Total gross saving on:					£	s.	d.
Electric light					8	1	0
Electric milking					11	15	8
Electric separating					5	16	0
Electric pumping					6	8	4
Electric chaff cutting					1	11	6
					33	12	6
Cost of electrical installation:					£	s.	d.
Electric wiring in buildings					34	0	0
Belts, etc.					6	0	0
Electric motors, one of 2 horse power and one of 5 horse power					36	0	0
					76	0	0

this shaft has reached about two-thirds of the finished height of the stack, the drum is removed and pieces of trellis are placed over the cavities to prevent fresh material from falling down. The stack is then finished in the ordinary way.

The main ducts in the ground are led to a portable fan which is driven by an electric motor. The time when blowing commences on the stack depends upon the state of the grass. If the grass has been carried in a very wet condition, blowing commences immediately and is continued for ten to fifteen hours, thus ensuring the removal of the surface moisture.

The fan is afterwards operated for half an hour every twenty-four hours for the ten following days. The object of blowing is to keep the stack within certain temperature limits and thereby control the bacterial action. To this end temperature readings are taken at least twice a day. The thermometers are enclosed in steel cases and pushed into the rick about half way up for a distance of about 3½ feet. The size of fan used absorbs the full power of a 5 horse power electric motor. While the process was originally designed for curing hay, it has also been used successfully on cereals, thus saving the necessity of stooking and the consequent loss due to birds and vermin; incidentally also permitting of earlier ploughing.

The whole process is of course dependent upon bacteriological principles, coupled with a knowledge of the art of the ventilating engineer.

In the Garden.—The electric farmer also uses electricity for heating the soil in garden frames, dispensing with the erratic warmth of a horse-manure hot-bed. This is ideal for early spring crops. Excellent water melons have been grown in this way in succession to early lettuces. Around Stockholm where this system has been most extensively employed, 5,000 kilowatts of energy are now used during the nights for this particular application alone. Very intensive illumination of plants in bud quickly brings them into bloom; seedlings thus treated will not wilt.

COMPARATIVE FIGURES

Cost of Equipment and Saving Effected.—There is an increase of about 25 per cent. in the capital expenditure of the electrified farm, but this can be recovered in a comparatively short time, usually about 3 years, whereas, in a factory, 10 years is the usual time allowed for the recovery of capital sunk in the enterprise.

The saving effected on a medium sized farm, when a few general machines are electrically driven has been carefully compiled, and the table on p. 163 shows how appreciable this is.

Now, 15% interest and depreciation on £76 equals £11 8s. od. Deducting this from the gross saving of £33 12s. 6d. shows a net profit to the electrical installation of £21 4s. 6d., so that, even if there had been no profit, the convenience and other indirect gains would have been well worth while. (R. B. M.)

UNITED STATES

In the United States the utilization of electricity in agriculture has advanced rapidly during the past decade and will surely increase even more rapidly in the near future. The greatest obstacle to the electrification of American farms is the great distance between them and the consequent cost of installation. The relatively small initial demand for electric power of a few scattered farms is generally not sufficient to cover the cost of bringing the power to the farms. For the economical generation of electricity large plants must be built as near as feasible to the centre of the load of the district which they serve. From the central generating plant the power is sent out at high voltage. Where power is to be transmitted long distances it is necessary to employ high voltage in order to reduce the size of wire and hence the cost of the transmission line. Should low voltages be employed, the size of wire required to carry the power with a reasonable loss would become so great that the cost would be prohibitive.

Cost of Electrification.—It has been found that the cost of serving the average farm with electricity is about five times the average cost of serving the average city customer. It is, therefore, necessary for the farmer to use about five times the quantity of electricity as used by the city customer in order for the cost per unit of electricity, kilowatt hour, to be the same. The problem of farm electrification, in its broadest sense, is one of finding uses for electricity on the farm which will insure the utilization of sufficient power to justify the service at a price the farmer can pay and the power company is willing to accept. To this end the National Committee on the Relation of Electricity to Agriculture was formed. This committee is composed of the following organizations: American Farm Bureau Federation; American Home Economics Association; American Society of Agricultural Engineers; General Federation of Women's Clubs; Individual Plant Manufacturers; National Association of Farm Equipment Manufacturers; National Electric Light Association; National Grange; National Electrical Manufacturers' Association; U.S. Department of Agriculture; U.S. Department of Commerce; U.S. Department of the Interior.

In 1928 associations in 24 States were studying the same problems, largely through the agricultural colleges and experiment stations. Their investigations have shown that many farms can find practical and economical use for the amount of electricity provided at the minimum charge. Some 200 separate and distinct uses of electricity on the farm are now listed. Many of these uses necessitated the design and development of special apparatus and devices, and as the service for the farm differs materially from other classes of the electric light and power business, it became necessary to draft special rates and regulations.

The price of electricity depends upon the relation between the expense of carrying the power to the point of use and the amount of power supplied. The rate forms generally provide for the financing of the line construction by the power company, thus making the farmer's capital available for the purchase of electrical equipment. While many forms of rural rates are in use throughout the country, there appears to be a general tendency towards standardization in two general types: (1) Monthly service charge plus a relatively low energy rate, usually in two steps. (2) a guaranteed minimum yearly revenue with various energy rates. A survey by the rural electric service committee shows that on Jan. 1, 1927, there were 227,442 farms in 27 States having service from high tension lines, which is an increase of 86% for the same 27 States over Jan. 1, 1924. On this basis, between 300,000 and 350,000 farms were receiving electric service on Jan. 1, 1927, and it is believed that the number of farms having their own electric plants is as great. This gives between 600,000 and 700,000 farms in the United States using electric power, or about 10% of the total number.

Use in the Household.—The first consideration of the farmer when installing electric supply lines to his farm is lighting and household equipment, consequently this line of apparatus has been developed and employed to a greater extent than that of power. The proper economical lighting of the farmhouse, outbuildings and grounds is very important and the principles of lighting must be observed if satisfactory and economical illumination is to be obtained. Furthermore, the special requirements of each room must be considered. Yard lighting is also very important on the farm. The intensity of the lighting need not be great but it should be such as to enable one to find one's way around easily. The fixtures and fittings should be weather-proof, and the bulbs should be protected from rain by a glass covering. In addition to lighting there are more than 40 electrical household devices. On account of the labour which it saves, the washing machine (*q.v.*) is generally one of the first pieces of electric household equipment purchased. The importance of having running water in the bathroom and kitchen, and fresh water for cattle, horses and other stock is generally recognized by the farmer; the pneumatic system is most frequently employed on the farm as it is cheaper to install, more sanitary, better adapted to automatic control and can be easily housed, either in the basement of the house, or in a cheaply constructed building in the farm yard. Elevated tank systems in which the water is distributed by gravity are employed to some extent, but the tanks and tank towers are expensive to construct, and deteriorate rapidly; the water freezes in the winter, and the system does not lend itself readily to automatic control.

The electrically-operated household refrigerator (*see* REFRIGERATORS, HOUSEHOLD) is rapidly being installed in the farm home. The need of refrigeration on the farm is generally greater than in the city, as larger quantities of perishable foods must be kept for longer periods. The electric range is a most convenient method of cooking food, but its intelligent operation is one of the most important factors. If meals are planned so as to use for the most part the insulated oven and boiler, the energy consumption can be greatly reduced below that required where the open grids are used. For satisfactory cooking with electricity, using automatic control, it is essential that the voltage applied be that for which the heating elements are designed, as the temperature of the elements drops rapidly with a decrease in voltage.

An electric water heater should be used in conjunction with an electric range. The heater should not be larger than is absolutely necessary to provide the quantity of hot water needed, as losses by radiation are considerable. A well-insulated heater of about 3 gal. capacity hand operated, is usually employed for providing hot water in the kitchen, principally for dish washing. Electricity also finds large use on the farm in connection with radio. In April 1927, the number of radio sets on farms was 1,251,186. This number is about 25% of the total number of farms in the country. In Sept. 1928 it was estimated that the total number of sets on farms was 1,500,000, or about 30% of the total number of farms. The number of farms reporting telephones in 1920 was 2,498,493. The number in 1928 was perhaps 3,000,000, or about 50% of the entire number of farms in the country.

Dairying.—Many dairy farms have electric service. Electric lights are particularly useful in the dairy barns and milk house in order to provide illumination for the early morning and evening milkings and for feeding the cows, cleaning buildings, etc. The silo should be properly lighted not only for convenience and freedom of movement, but for safety as well. Electricity is largely responsible for the rapid development of the milking machine. The electric motor, owing to its light weight, simplicity of construction, cleanliness and constant speed, furnishes an ideal drive for the milking machine. Two types of these machines are in use, the pipe line machine and the portable machine. The pipe line machine, as the name implies, consists of a number of pipes installed in the barn with a vacuum pump located in a separate room. The portable type has the motor and vacuum pump mounted directly on the cover of the milk receptacle. This gives a direct suction to the machine and eliminates considerable leakage which occurs in the pipe line. The portable machine is usually arranged as a double milking unit; that is, one machine will serve two cows. The capacity of the electric motors for these double units is standardized at $\frac{1}{6}$ horsepower. The power required to operate the pipe line type varies with the type and efficiency of the particular machine and usually ranges from $\frac{1}{8}$ to $\frac{1}{4}$ horsepower per cow milked at one time. The time saved by the milking machine over hand milking is considerable. Tests show that with a herd of 15 cows, the saving in time amounts to 37½ minutes at each milking, or an hour and a quarter a day. The time saving per cow increases with the size of the herd. There are two serious problems encountered in the operation of milking machines: viz., low voltage and sanitation. Low voltage produces unsatisfactory operating conditions, but can be remedied by proper electrical installations.

The refrigeration of milk embodies two distinct problems; viz., the initial cooling for removing the animal heat, and the storage at a temperature sufficiently low to greatly retard the growth of bacteria. The initial cooling is accomplished by running the warm milk over some form of surface cooler, while refrigerated water or brine is pumped through the interior of the cooler. Usually the cooler coils are divided into two sections. Cool well or spring water is pumped through the upper section and refrigerated brine through the lower section. Such an arrangement economizes in mechanically produced refrigeration, as approximately half the cooling is accomplished through the use of the cold well or spring water. The morning's milk is generally cooled to about 45° F, placed in insulated cans and taken immediately to the milk plant or railway station. The night's milk comes from the surface cooler at about 50° or 55° F, and is placed in cans and stored overnight, either in an insulated tank of refrigerated water or in an insulated cold storage room, where the temperature of the milk is further lowered throughout the night to around 45° F. Refrigeration is stored in the tank of water and also in the tank of brine which is located in the top of the cold storage room. Storing up refrigeration makes possible the use of a much smaller refrigerating plant, as the plant can be operated a longer time, thus storing up refrigeration which is available for quick action when needed.

The pasteurizing of milk by electricity is little employed. The usual method is to pass the milk between electrodes, the milk itself forming a part of the electric circuit. The resistance to the flow of electricity offered by the stream of milk serves to heat the milk to a temperature sufficiently high to destroy the bacteria. Alternating current is employed, generally at a voltage of 220. The regenerative or heat exchange method is used to reduce the quantity of electric energy required to a minimum.

Owing to the large amount of hot water required in the dairy for washing purposes, it is impracticable to employ electric energy as the heating medium except when a very low rate per kilowatt hour is available. Many States require the sterilization of utensils employed in dairying, and electricity is being used to a considerable extent for this purpose. The type of sterilizer generally employed consists of a well insulated box containing the heating elements. The heating elements are placed at the bottom of the box and covered with a small quantity of water, while the utensils to be sterilized are placed on a false bottom just above the heating elements. The temperature is automatically held at about 210° F. It should be noted that the operation of the cream separator at exactly the proper speed is very important for efficient separation. The practically constant speed of the electric motor, especially of the alternating current type, makes it an ideal drive for this class of work. Consequently, on the dairy farm where electricity is available, the cream separator is one of the first pieces of equipment to be electrically equipped. The average size of farm separator is provided with a motor ranging in capacity from $\frac{1}{6}$ to $\frac{1}{4}$ horsepower. The $\frac{1}{6}$ h.p. machine will handle up to 1,000 lb. per hour, while the $\frac{1}{4}$ h.p. will handle up to 1,400 pounds.

The heating of the drinking water for the dairy cow, and constant maintenance of a supply at the proper temperature, has served to increase the yearly average of milk production from 5 to 15%, the increase being greater in colder climates than in warmer. The milk tester is a valuable piece of apparatus for the dairy as it enables the dairyman to make more accurate selections in the building up of his herd on a butter fat basis. The energy consumption when operated electrically is very small and the speed of rotation is practically constant.

Bottle washers for the average dairy require about $\frac{1}{18}$ h.p. motor and operate at about 1,800 r.p.m. They are convenient and economical in the use of electric energy. The animal groomer is largely employed. It thoroughly removes the loose hair and dirt from the udder and flanks of the cow without permitting them to escape into the stable air and eventually into the milk. The control of flies by means of the electric fan is also largely employed. The usual method is to install vertical ceiling fans just inside the doors, the draft from the fans preventing the flies from entering. Electrocution screens have been used with some success in destroying flies and other insects around the dairy. Some trouble, however, has been experienced due to the short-circuiting of the wires by the dead flies.

Ensilage is one of the best feeds for dairy cattle, and practically all dairy farms are equipped for providing this food. Due largely to the different methods of operating the ensilage cutter, the energy consumption per ton of material ensiled is extremely variable. The size of machine, sharpeners of knives, speed of fan, length of cut, method of feeding machine and kind of material being ensiled all affect the energy consumption per ton. Dull knives will increase the energy consumption approximately 50%. The speed of the fan should be just sufficient to elevate the material into the silo. The motor load fluctuates over a wide range, depending upon the care and uniformity of feeding the cutting machine. Owing to this wide fluctuation of load it is very important that the wires connecting the motor to the transformer be

exceptionally large, especially if the motor is at a considerable distance from the transformer. In other words, the wiring should be so proportioned that there will be not over 10% drop in voltage at the motor terminals under extreme conditions.

Owing to the short time required for cutting ensilage for a single farm, and to the comparatively large size of motor necessary for driving the machine, a community-owned outfit is sometimes employed. The outfit, in addition to the motor and ensilage machine, consists of a portable substation embodying the necessary transformers. This substation is mounted on a truck and transported from farm to farm to handle the ensilage cutting, threshing, etc. The portable substation eliminates the necessity of a bank of large transformers to supply the power for these jobs which are performed for only a short period of each year, and in this way lowers the cost of transformer installation for each of the individual subscribers. Such an outfit will provide ample power for any of the heavier farm operations where rotating machinery is used.

Poultry.—Electricity seems to be especially adapted to the needs of poultry farming. It has been known for years that artificial illumination so timed as to lengthen the day during the autumn and winter season serves to increase egg production during this period. The artificial lengthening of the day does not increase the total yearly egg production, but it does increase the output at the time of highest prices. The decrease of egg production during the winter months is obviously due to the fact that hens go to roost at twilight and consequently in winter they have less exercise, consume less food and lay fewer eggs. Artificial lighting of the poultry house in winter lengthens the hen's day; she therefore scratches more, consumes more food, lays more eggs during this season and thus more evenly distributes her year's production.

The average working day for the hens is from 12 to 13 hours from November to March. In the case of late maturing pullets it has often proved practicable to use the lights even earlier. To avoid sudden changes in the habits of the flock, the artificial day should be lengthened gradually in autumn and reduced gradually in the spring. The usual practice is to light from 5 A.M. until daylight and from dusk until 7.30 or 8.00 P.M. There is need for gentle brightening and dimming of the lights. If these are turned off suddenly and the flock is plunged into darkness they become demoralized and many roost on the floor. An arrangement is provided that will extinguish the lights gradually, to simulate the effect of the natural approach of twilight. A satisfactory method of doing this is to dim the lights down to at least half voltage for a period of from 10 to 15 minutes before turning them off entirely. When the lamps are dimmed, the hens instinctively go to roost in their accustomed manner.

The lights for the poultry house are placed about 6 ft. from the floor and 10 ft. apart. They should be fitted with cone-shaped reflectors 16 in. in diameter and 4 in. deep. The reflecting surface should be covered with three coats of aluminium bronze paint. With the above mentioned spacing 40-watt lamps will properly light 200 sq.ft. of floor space; therefore, to find the number of lights required, divide the square feet of floor space by 200. The nearest whole number will be the number of lighting units required. Should the poultry house be divided into pens, figure each pen separately. The energy consumption for lighting is from 3 to 5 kw. hours per month for each 100 hens. Warming the drinking water for poultry is necessary for maximum egg production. When the temperature is below freezing, hens consume about 25% more warm water than cold, and about 5% more when the temperature is above freezing. The result of drinking more water is better appetites and more eggs. Electrically operated dropping boards are employed to some extent, and have practically eliminated the manual labour required for cleaning the boards.

Electricity is the ideal heating medium for the incubation of eggs, because of the reliability and ease of automatic temperature control. Automatic thermostats are the heart of the incubator, consequently they should be sensitive, reliable, durable and maintain their setting. They should be capable of controlling the temperature inside the incubator to within plus or minus ½° F from the thermostat setting. The incubator should be well insulated in order to conserve heat, thus making it possible to control the temperature more accurately and to maintain the temperature for a long period in case the power should be cut off. It is the usual practice in designing incubators to provide in the heating element ½ watt per egg.

Chilling and over-heating are to be guarded against in the brooder. Electricity furnishes the most reliable source of heat for this purpose. The brooder should be equipped with a no-voltage or temperature alarm to notify the poultryman when the power fails so that he can take the necessary steps to keep the chicks warm, such as placing a blanket over the brooder. A temperature alarm is further valuable in that it gives warning when the thermostat points fail to function. The temperature regulator need not be so sensitive as in the case of the incubator, as a temperature range between plus or minus 3° F from the thermostat setting is satisfactory. The area per chick under the brooder is one of the important factors in determining the energy consumption. The construction of the brooder and the temperature of the brooder house are other factors affecting the quantity of heat required. The area per chick allowed under the brooder varies from 3½ to 7½ sq.in. and an energy consumption of from 1 to 3 watts per chick. The maximum of 3 watts is required when the outside temperature is around 0° F.

The electric brooder, due to the even and dependable heat, has proved successful in the raising of turkeys. During cold damp weather the mortality rate among newly hatched birds is usually very high. This has largely been overcome by the employment of the electric brooder. Time and labour are saved the poultryman by the employment of electrically driven green feed cutters and bone grinders, which operate with a small energy consumption. The electrically heated oat sprouter provides an easy and satisfactory means of providing green feed requirements. A large, well insulated sprouter, when placed in a warm protected location, uses about 75 kw. hours per month for sufficient oats for 1,000 birds. A smaller type sprouter consumes about 15 kw. hours per month to furnish green feed for about 200 birds.

Extensive experiments have been conducted on the treatment of poultry with ultra-violet rays. The lack of vitamin D in the ration of growing chicks which are confined indoors, causes leg weakness or rickets. Vitamin D controls the utilization of minerals in the ration, and the use of this vitamin is greatly increased through the application of ultra-violet rays. These rays are present in sunlight, and poultry that are exposed to sunlight for the greater part of the day do not require treatment with artificially produced ultra-violet rays. Ordinary window glass, which is commonly used in the front of poultry houses, prevents the passage of these rays in sunlight, and it therefore becomes necessary to supply them artificially. The energy consumption of the ultra-violet lamp is small. About 7½ kw. hours is required per month per 1,000 chicks treated, one month of treatment generally being sufficient. In the case of hens about 100 kw. hours are required per month for each 1,000 birds treated. The ultra-violet lamp offers the poultryman a convenient method of maintaining the vigour of his flock or the vitamin content of the eggs during cold sunless days of winter when the birds must be kept in the house.

General Farming.—There are a large number of uses to which electricity has been successfully applied on the general farm. Among these are corn shelling, corn husking and shredding, hay hoisting, hay baling, grain cleaning and grading, grain elevating, fertilizer grading and mixing, feed grinding and mixing, wood sawing and the driving of equipment in the farm shop. The general-purpose motor employed for driving various machines that are used only for a short period, such as concrete mixers, threshers, ensilage cutters, etc., are quite generally employed. The motor together with its controller and a special flexible cable are mounted on a truck or a sled which can be drawn to the location desired.

Irrigation.—Electricity is used extensively for irrigation at the present time and its use for this purpose is increasing rapidly. The lower initial cost of the plant together with the simplicity and ease of operation serves to increase its popularity for this class of service. While in arid or semi-arid regions irrigation is necessary

for successful farming, it is also receiving attention in connection with lands that are subject to possible temporary drought, especially when such crops are grown that require considerable moisture and that suffer severely even from a short drought.

Drainage.—Drainage plants are usually of large capacity and hence a large amount of power is consumed in their operation. While a large percentage of these plants are driven by Diesel, semi-Diesel or steam engines, many are driven by electric motors, and the number of electrically-driven plants is rapidly increasing. The low initial cost of the motors compared with that of the engines, the smaller installation cost due largely to the avoidance of massive foundations, the simplicity of the motor and the ease and convenience of operation are factors in favour of the electrically-driven plant and are largely responsible for the rapidly increasing use of electricity for this class of work.

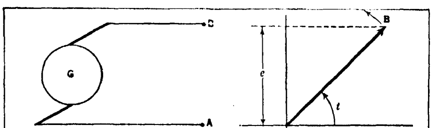
Orchards.—The apparatus for washing poisonous sprays from fruits, the grading of fruits, stationary spray plants, etc., are successfully operated by electric motors. The electrically-operated refrigerating plants are largely employed for the cold storage of fruits, berries and vegetables on the farms, due primarily to the ease with which the temperatures can be controlled. The dehydration of fruits, vegetables, hops, nuts, etc., by means of electricity is being extensively employed because of its reliability, ease of operation and automatic temperature control. A novel use for electricity for orchard and truck farms is that of trapping insects, by means of an electric lamp suspended over a pan partly filled with oil. (J. T. B.)

ELECTRICAL POWER TRANSMISSION. The transmission of electrical energy has now been so developed as to supply inexpensive and reliable power over distances as great as several hundred miles. Its service in making cheap water power available is obvious. A great share of all power is steam generated, and the function of transmission is equally essential here. This is not because it may permit locating generating stations at the coal mines, a plan that is frequently discovered to be uneconomical, but because steam power generation may be economically concentrated in large central stations if that power can be transmitted to the user. Such stations can be located where adequate supplies of cold water are available for condensing steam —an operation necessary to high efficiency. Larger generating units (inherently more efficient) can be used and greater refinements adopted to increase the efficiency of generation. (*See* ELECTRIC POWER GENERATION.) The number of attendants in a large station is about the same as in a small one, but one large station replaces many small ones with a consequent saving in wages. Further, the equipment necessary for a given generating capacity can be furnished more cheaply in large units than in small. This is true not only for prime movers and generators but for boilers, auxiliary apparatus and even buildings. Actually, however, more expensive apparatus is used in large stations in order to obtain very high efficiency. The second fundamental reason for the economies available through power transmission is as follows: When small isolated stations are used, each station must be large enough to supply the maximum demand for power in its area. The total generating capacity required in the whole district is equal to the sum of the maximum demands. These demands, however, do not all occur at once. There is a certain diversity, as it is called. If one large station supplies the district, its capacity need only be as great as the maximum simultaneous demands, or total load from all the areas. With the maximum demands from the areas occurring at different times the load is maintained longer on the large station and the output for the whole day is larger in relation to the generating capacity, thus making the load factor higher. It is for this reason that the efficiency of a large station is so important. A third advantage that transmission offers is that of increased reliability. This applies chiefly where several generating stations are concerned, because when trouble occurs in one station, power may be transmitted from others to replace the output of the affected station. Further economies also are possible through such interconnection of stations and will be explained later.

A transmission system as actually developed to take advantage of all these possibilities may include several generating stations, both steam and hydro-electric. There will be transmission or "tie-lines" between stations for feeding power back and forth as desired, and also transmission lines connecting generating stations to sub-stations. Each sub-station may be fed by lines from several generating stations. From the sub-stations low voltage lines and feeders bring the power to the consumers. Transformers are used to step the voltage up and down, switches are used to connect and disconnect different lines. The actual transmission lines may be either underground or overhead. When overhead, the conductors are usually strung on poles or towers to which they are secured through insulators supported on cross-arms. The insulating support and the air are relied on for insulation though at the lower voltages fabric and rubber insulation is also used. The underground lines are cables, that is, a conducting core surrounded usually by wrappings of oil-impregnated paper, the whole being protected by a lead sheath.

Development.—The desirability of transmission was obvious from the first, but there were intricate problems to be solved. The loss of energy in the conductors, which varies with the square of the current, limited the amount of power and the distance to which it could be sent. True, this loss could be reduced by increasing the size of the conductors, but that was expensive. Lord Kelvin early showed that the best combination is that in which the annual cost of the energy loss equals the interest on the investment in the transmission line. There is a loss of voltage, also, that increases with the current. Since the luminosity of electric lights varies practically with the fourth power of the voltage, such a voltage drop is very objectionable. The power sent over a transmission line equals the product of voltage and current. If the voltage can be increased the current can be decreased accordingly without decreasing the power. Thus the energy loss and the voltage drop may be cut down. Unfortunately, the voltage for domestic service is limited to 110 or 220 volts, for reasons of safety and convenience. Edison found a way to double the transmission voltage of a direct current by the use of a three wire system which made it possible to serve 110 V. lights from a 220 V. system, but further extensions of this scheme were impracticable.

At one time hope centred around the scheme of connecting the lights in series, allowing the same current to flow from one light into the next, the total voltage being the sum of the voltages used across all the lights. Thus small current and high voltage might be obtained; but though the voltage across each light would be small, the potential of the circuit would be unsafe, and the connection very inflexible because it was necessary that all lights should be burning at once. The problem thus took form as one of transmitting at high voltage but distributing at low voltage with lights, motors, and heating devices connected in parallel and operating independently. Up to this time only direct-current systems had been used. In such a system the current flows continuously in one direction around the circuit, and one generator terminal remains positive in voltage, the other negative. The fruitlessness of early efforts to develop a satisfactory transmission system with direct current turned the attention of investigators to alternating current.



e = ACTUAL VALUE OF VOLTAGE AB AT INSTANT t FIG. 1

In an alternating-current circuit the direction both of current around the circuit and of voltage between the generator terminals reverses periodically and smoothly so that if their values are plotted against time a sine wave results. A complete change from positive to negative and back again is called a cycle. Alternating-current power is ordinarily generated at 25, 50 or 60 cycles per second. It is customary to represent alternating voltages diagrammatically by means of rotating arrows

or vectors. Thus in fig. 1, A and B are the terminals of a generator. The voltage between A and B is represented by the vector AB, rotating counter-clockwise about A. The voltage from A to B is positive while the rotating arrow points upward, and negative while it points downward. The distance of the arrow head above the horizontal line gives the actual positive or negative value of the voltage. All problems in alternating current design may be solved by means of such a vector diagram.

Following the shift of interest to alternating current, the transformer was developed by such pioneers as Stanley, in America, and Zipernowski, Deri and Blathy, in Hungary, in 1886. The transformer consists of an iron core surrounded by two coils. One coil—the primary—is connected to a source of alternating voltage which tends to force current through the coil, first in one direction, then in the other. This change of current sets up a magnetic flux in the iron linking the two coils; the flux induces a voltage in each coil which has the same value per turn in both coils. Enough current flows to induce in the primary coil a voltage opposite and almost equal to the impressed voltage. Since the voltage in each turn is the same, the voltage induced in each coil is proportional to the number of turns; but the voltage induced in the primary is nearly equal to the impressed voltage. Therefore the voltage induced in the secondary bears practically the same ratio to the impressed voltage as the number of secondary turns does to the primary. The voltage available across the secondary can be made whatever desired by winding the proper number of turns into the coil. Thus the problem of a high transmission and a low distribution voltage is solved. When a voltage higher than the generator voltage is desired a transformer can be used to step up the voltage; at the other end of the transmission line transformers can step the voltage down again. Alternating current is necessary because the electro-magnetic induction in the transformer is caused only by a change of magnetic flux, which in turn depends on the increase and decrease of current. Mechanical motion can produce the same effect, but one of the great advantages of the transformer is that there are no moving parts, a fact which makes it most efficient.

The alternating current, however, introduces certain minor difficulties, the chief of them being this very induction that is essential in the transformer. That characteristic of the circuit which produces induction, the inductance, acts upon the current like inertia. Due to the inductance the current does not change direction or arrive at its positive and negative maxima as soon as the voltage. Engineers say the current lags behind the voltage, and represent the relations with vectors. Thus in fig. 2, the vector *E*, rotating counter-clockwise, represents the voltage. It may be imagined as "caught" by a camera in the position shown at a certain instant. The vector I, representing the current flowing from A to B was also caught at the same instant as it follows along behind the voltage vector. It will be seen that the current, measured by the distance of the head of the arrow from the horizontal line (fig. 2) changes from one direction to the other and reaches its positive and negative maxima after the voltage. The amount of lag depends on the inductance, though the current never lags the voltage by more than a quarter of a cycle or 90° difference in vector position. When the current lags, it is impossible to supply the maximum power over a given system. The power at any instant equals the product of instantaneous voltage and current. If the voltage is a maximum when the current is zero and vice versa, that is, if the angle of lag is 90°, the power flows out and then back in equal amounts so that the net power delivered is zero. The more nearly the lag approaches 90° the less is the net power transmitted to the load by a given current and voltage. But, independently of whether the lag is zero and the power delivered a maximum for a given current and voltage, or whether the lag is 90° and the power a minimum, the maximum voltage and current are limited by the capacity of the generating and transmitting apparatus because excess voltage would result in insulation failure and excess current would cause a high temperature and extreme electro-mechanical forces, either of which might cause an interruption to service. The net power delivered, which of course is the only fraction of the power that does useful work, is equal to the product of the current and voltage multiplied by the power factor, a factor equal to the cosine of the angle between the voltage and current vectors. The net power delivered is measured in kilowatts or active kilovolt amperes.

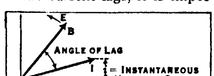


FIG. 2

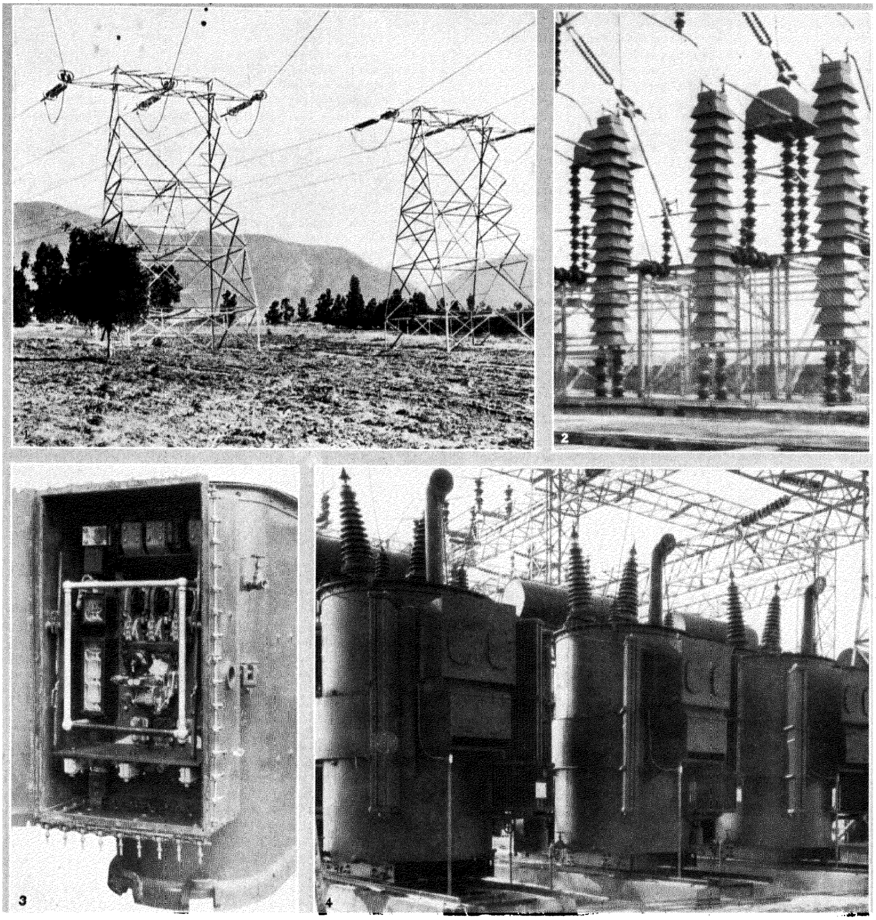
As said before, the maximum power which the generating and transmitting system can deliver is reduced when the power factor is low, that is to say—when the angle of lag is large. The excess generating capacity represented by this reduction in maximum net power delivered serves merely to pump energy into the system during part of the cycle and to receive it back during another part. This energy is called the reactive power and is found by multiplying the product of volts and amperes by the reactive factor. Thus there are active and reactive kilovolt amperes to be supplied. There are, however, two types of reactive power; that due to a lag of current behind the voltage, already described, and that when the current leads the voltage. The latter tends to neutralize the former so that with equal amounts of leading and lagging reactive power there would be left only the true active power. Such an ideal situation rarely exists, however.

The leading current arises from capacitance, the ability of parts of the circuit to store electrical energy in a static condition (condenser effect), just as the lagging power factor is caused by inductance, the ability of the circuit to store electrical energy in a magnetic condition. Electric lights cause no lag of current, but most motors and other apparatus, in which there are magnetic or capacity effects, draw a lagging current, so that usually the power to be sent over a transmission line is at lagging power factor, thus giving rise to a certain inefficiency which cannot be avoided, but can only be reduced to a minimum by proper design. The transmission line itself possesses both inductance and capacitance, factors which create several transmission problems. In the first place the line inductance of itself causes a further lag of current and requires more lagging kilovolt-amperes from the generating source. Furthermore, the inductance is related to the resistance of the line. In absorbing reactive power it causes a drop of voltage similar to the drop of voltage caused by the resistance in absorbing active power, except that the reactive voltage drop is a maximum when the current is a minimum, producing the effect of a lag of reactive voltage drop of 90° behind the current. As a result, if the current is in phase with the impressed voltage the reactive drop is a maximum when the impressed voltage is zero, or the reactive drop lags 90° behind the impressed voltage. The effect is to delay the time when the voltage arrives at the far end of the line. If the current is just a quarter cycle behind the impressed voltage the reactive drop subtracts directly from the impressed voltage. Conversely, if the current leads the impressed voltage by a quarter of a cycle the reactive drop adds to the impressed voltage producing a higher voltage at the end of the line than if this drop did not occur.

There are two principal effects of line capacitance. One effect is that it requires a so-called line charging current at leading power factor. When there is no lagging current required by the load the generator must supply the charging current in addition; when the load does require lagging current, the line charging current partially neutralizes it so that the generator must supply only the net reactive power. The second effect has already been alluded to; when the generator must supply a net leading current to charge the line, some of this current flows out to the farther part of the line, causing a rise of voltage.

The values of the line capacitance and inductance depend chiefly on the size of wire and the distance between wires. Capacitance increases with the diameter of the wire and the closeness of the spacing. Inductance decreases with these factors.

Following the invention of the transformer came another contribution of great importance to the alternating current system. This was the development of the three-phase system by Tesla and others about 1890. The original single-phase system consisted of only two wires through which the current flowed. The three-phase system combined three phases into one system, so arranged



BY COURTESY OF (1) THE LOCKE INSULATOR CO., (2, 3, 4) THE GENERAL ELECTRIC COMPANY

EQUIPMENT FOR HIGH TENSION ELECTRIC POWER TRANSMISSION

1. Steel towers carrying two three-phrase high tension circuits in southern California. Rectangular shape of towers and looping of line beneath insulators relieve strain at bend in power transmission line
2. Group of oxide film lightning arresters used to protect 220,000 volt transmission line. Multiple hood insulators divert possible discharge from passing thunderclouds, thus ensuring continuous power service
3. Small power transformer for subway service on alternating current network system. The device in cabinet automatically protects network and is widely used in traction systems throughout the United States
4. Outdoor substation showing bank of transformers and steel superstructure supporting conductors overhead. High tension voltage from main line is here transformed for distribution over local feed lines

that if the voltage of one phase should be at say a positive maximum at a certain time, that of another would be at a positive maximum a third of a cycle later, and the third voltage two thirds of a cycle later than the first; this would institute a complete cycle and would be followed in turn by a second positive maximum of the voltage in the first phase. All three phases could be sent over only three wires. Mathematical analysis showed that almost twice the power could be transmitted over 1·5 times the copper, as with the single-phase system with a resultant important saving. Any two of the wires could be used independently to form one phase.

Since the advent of the three-phase system there has been growth in size, power and voltage of transmission systems but no radically new developments (in fact there are some few systems in Europe, known as Thury systems, where direct current is still used).

Design of a Transmission Line.—With this preparation the problems that enter into the construction of a transmission line may be considered. Surveys must be made to estimate future power requirements, various possible sites for a steam generating station or a water power station must be studied. With these factors established the best route for the transmission line must be found. To determine this route a preliminary airplane reconnaisance may be made, followed by a careful survey; then come the acquirement of right-of-way and the work of clearing it out, erecting poles and towers, and stringing the conductors on the insulators.

Before the latter stages of this work are begun the transmission voltage must be decided on. Although this is usually about 1,000 volts per mile, the actual value depends on the amount of power to be transmitted and various other factors as well as the distance. Against the cost of the conductor, decreasing as the voltage is increased, must be balanced the increased cost of insulation, spacing, and towers throughout the line. Of equal importance are the means to maintain service in case of a failure on the system.

Corona.—Among the factors that affect the choice of the conductor, aside from the current to be carried, is the phenomenon known as corona. As the voltage on a conductor is increased beyond a certain point a hissing sound will be audible and in the dark a glow can be seen around the conductor (Plate II., fig. 3). The voltage at which this phenomenon occurs depends upon the diameter of the conductor, its surface, the distance between conductors, and the atmospheric conditions. Corona is due to a partial breakdown or ionization of the air around the conductor. Its importance arises from the loss which it causes, a loss which varies as the square of the excess voltage above the starting potential. At high voltages a small percentage variation in voltage means a considerable absolute change and considerable loss will result unless the conductor is of such a diameter that the starting voltage for corona is above the operating voltage, at least under normal atmospheric conditions. This means, with a voltage of 220,000 volts, a conductor at least 0·95 in. in diameter and usually more. A solid copper conductor of this size would often contain more copper than necessary to carry the power, so conductors of aluminium, or copper with a steel core, or even hollow copper conductors are sometimes used for high voltage transmission.

Since corona does not begin until a certain voltage is reached the current flowing to supply the corona loss flows only while the voltage is near its maximum value in the cycle. A current flowing in this way is the equivalent of a triple frequency current. Corona is not the only phenomenon affecting the conductor. As the size of the conductor increases the current tends to concentrate near the surface, thus in effect reducing the cross-section of the conductor. This is called the "skin effect." To reduce the skin effect the conductor is made of strands twisted together.

Transmission Line Insulation.—The problems of insulation are much more complicated than those which concern the size of conductor, and equally important, for if transmission is to increase the reliability of electric power, the interruptions of service which the transmission system itself causes must be reduced to a minimum. Obviously the lines must not fall, or cross or swing against towers. Yet the system may comprise hundreds of miles of line exposed to wind, storm and lightning.

The mechanical stresses are relatively simple and may be mentioned first. Normally there is the weight of conductors to be supported. At certain points there must be tension sufficient to keep the conductors from sagging too far. The wind often exerts heavy side pressures on conductors and towers. However, the worst stress occurs when sleet freezes around the conductor, creating a cylindrical mass 3 or 4 in. in diameter. The dead weight is very much increased and the increased area augments wind stresses. In localities where storms are frequent and severe, copper conductors with steel cores are sometimes used to give a high tensile strength.

The electrical stresses are most acute on the insulators holding the conductors at each support and in the apparatus connected to the line. The thousands of insulators used all along the line must have sufficient dielectric strength to resist the continuously applied voltages. Dirt may collect on them, rain may wet them, but still they must continue to insulate. In the early days this was a hard requirement to meet. The type of insulator chiefly used on high voltage lines is shown in Plate II., fig. 2. Formerly the chief cause of failure, aside from poor materials or design, was that the voltage stress did not divide evenly over the insulator string. The disc nearest the line was subject to excess stress. To eliminate the concentration of stress, grading shields were introduced (shown at ends of the arc, Plate II., fig. 2). This device divides the stress evenly over the string. The shield has the further advantage that if an arc does occur it strikes through air instead of cascading along the surface of the insulators and weakening them.

Lightning Protection.—The most severe stresses are caused by transient voltages arising from switching operations and, particularly, lightning storms. Since the stresses due to switching are less severe than, and of a character similar to, lightning, only lightning phenomena will be discussed. When lightning actually hits a transmission line, the destruction of insulators or apparatus may follow if protective measures are not provided. The lightning voltage and energy will be drained off at the points where failure occurs.

Lightning, however, need only strike in the vicinity of a transmission line to cause abnormal voltages. When a cloud bearing an electric charge passes over a transmission line, the charge on the cloud induces a charge on the transmission line, the charge on the line being of opposite sign to that on the cloud. So long as the charge remains on the cloud the line charge is held in place by attraction and is known as a bound charge. The line voltage also is held to low values. However, when the lightning strikes to ground or to another cloud, the cloud charge is drained off in a few millionths of a second. The charge on the line is suddenly released and its voltage increased. It starts travelling out in both directions along the line putting increased stress on all the insulation. Lightning voltages have been studied on transmission lines and in the laboratory, by means of a generator which produces sudden voltages of the same sort as lightning. Voltages as high as 5,000,000 volts have been employed for such tests by the General Electric company in its laboratory at Pittsfield. Plate II., fig. 2 shows a discharge produced by this "lightning generator." Miniature towns, transmission lines, and clouds have been built to scale—likewise devices called surge recorders have been used on transmission lines to measure the voltage set up by lightning.

From these investigations a considerable amount of data has been collected, and as a result apparatus highly resistant to lightning has been built and protective measures for life and property have been devised. It appears from measurements of the induced voltage on transmission lines, and of the length of lightning strokes, that the voltage is of the order of 100,000,000 volts. This voltage exists between clouds or between cloud and earth until the moment of discharge, then it is drained off in a few micro-seconds. The maximum current may be perhaps

100,000 amperes and the total energy of the discharge 4 kilowatt-hours. The voltage appearing on the line will vary as the height of the line. It frequently attains a value of 50,000 volts per foot height of line, but may approach 100,000 volts per foot of height. Such voltages are far in excess of normal operating voltages and may cause arcs to strike across the line insulators. Such an arc may constitute either a short-circuit or an arcing ground and is very undesirable in either case. The lightning voltage stresses the apparatus even more than the line.

The voltage may be reduced in several ways. In the first place the high voltage causes corona which drains the energy of the surge and the high current flowing through the line resistance drains more energy. The loss in energy is accompanied by a decrease in voltage. The voltages can also be reduced to approximately one half by stringing a wire, called a ground wire, along the tops of the line supports and connecting it solidly to ground.

Devices known as lightning arresters are usually connected between each line wire and ground, close to the transformers at each end of the line. Plate I., fig. 2 shows a group of lightning arresters. Their function is to drain off the energy represented by the freed lightning charge. At ordinary operating voltages they do not allow line currents to pass, but where lightning surges traverse the line, the arresters become conducting and thus discharge the high potential charges harmlessly to ground. Their characteristics are such that they do not permit line current to follow the lightning currents, but immediately restore their high resistance by automatic action. This action is, unfortunately, not characteristic of line insulator breakdowns, and consequently disastrous sustained power arcs may follow lightning disturbances if the insulators are not large enough.

But the danger of the lightning voltage is much greater than indicated by its mere magnitude. This increased danger lies in its rapid rate of increase or impulse character. Ordinary 60-cycle voltage rises from zero to a maximum in a quarter of a cycle or $\frac{1}{240}$ of a second, but a lightning impulse rises to maximum value in perhaps one millionth of a second, and may be all over when a 60 cycle voltage is just beginning to rise. When the voltage is of this type, much higher values are required to break down the line insulators and apparatus because it lasts so short a time and is not repeated. On the other hand the effect of such impulses is to concentrate all of the voltage across the first few turns of a transformer. For this reason these turns are specially insulated and shields have been developed to distribute the stress evenly over the whole winding. Such care is taken in building the transformer because, however undesirable it may be for a line insulator to break down, a transformer breakdown causes a greater damage. A short-circuit or ground results in either case but a breakdown of the transformer places it out of service for some time and incurs heavy expense. Also an insulator flashover or breakdown can often be taken care of by removing the voltage from the transmission line.

This problem demands careful co-ordination of transformer and line insulation. If the transformer insulation is weaker than the line insulation the transformer fails; if the line insulation is weak the excess voltage flashes over a line insulator and the arc may remain to form a short-circuit. The best solution seems to be offered by using a transformer insulation which is stronger than the line insulators in its immediate vicinity. Suitable protective devices are also generally desirable. Another problem is whether to operate with a certain point in the system, called the "neutral," connected to ground. If such a connection is not made, an accidental grounding of one line, or an insulator flashover, will produce a very high transient voltage and probably a short-circuit will result; if the system is grounded an accidental line ground causes a short-circuit directly, but there are no extreme voltages to injure the insulation permanently. Heavy third harmonic or triple-frequency currents are more likely to result when the system is grounded.

Oil Switches.—However imperative it is to maintain service, there may be mentioned short circuits and grounds. Under such conditions it is necessary to disconnect the transmission line from the generator. As will be explained later, special circuit arrangements make continuous service possible even when there is a short-circuit, if the affected portion of the line can be removed from the system. Although there are other reasons for desiring switches, it is the problem of short circuits that has developed a particular form of switches known as oil circuit breakers. The problem lies in the fact that under short-circuit conditions the heavy current makes it difficult to break the circuit. The increasing voltages, too, have had their effect in increasing the difficulty of making proper circuit breakers. A switch group is shown in Plate II., fig. 5. The switch itself, immersed in a special oil possessing very high insulating properties, is made so that the contacts will open as quickly as possible, making it difficult for the arc to follow. Also, the space for the arc is restricted so that the gas pressure evolved by the arc forces the contacts apart and blows out the arc itself.

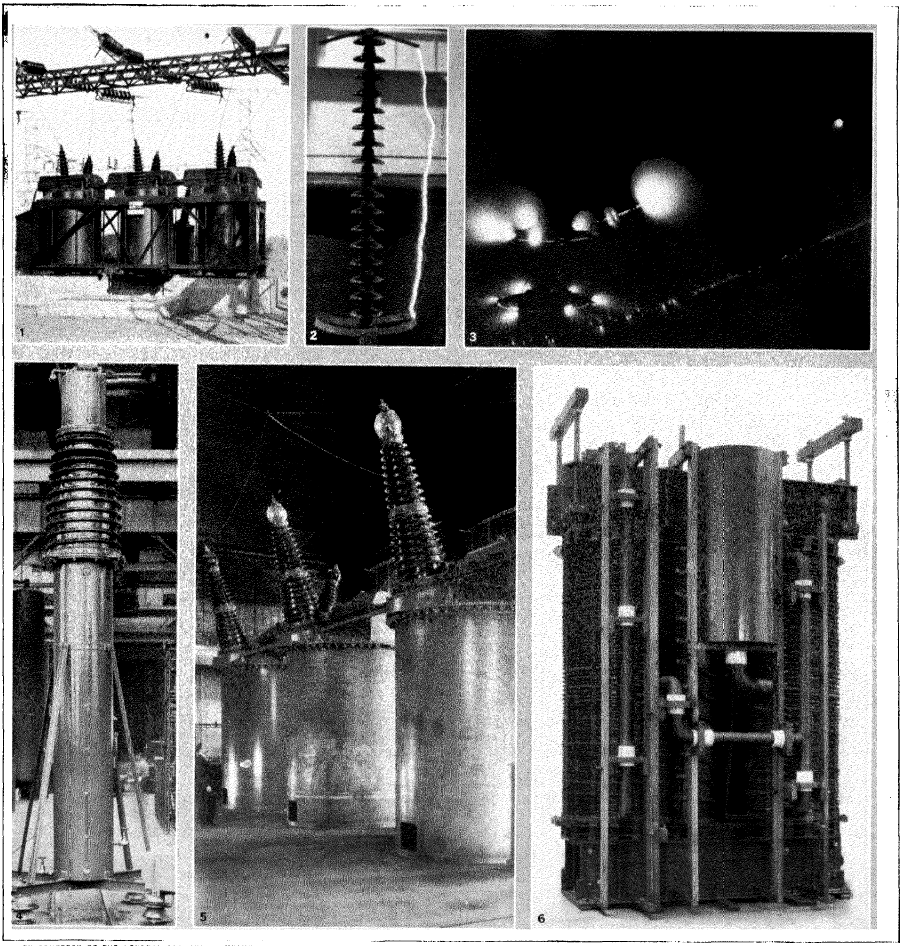
Transmission and Distribution Systems.—There are several types of transmission systems. A generating station may deliver power over one circuit to a distant point. As a rule, however, two circuits at least will be used so that if one fails the other may be kept in service. Such an arrangement would be typical of a water power station feeding a distant centre. At the generating station there would be the oil circuit breakers, transformers and lightning arresters. At the receiving end, besides the step down transformers, switches and arresters, there might be a synchronous condenser. This is a rotating machine similar to a generator which supplies reactive power at either leading or lagging power factor as required. Sometimes when the load power factor is low, capacitors are used which take a leading current in the same manner as the line capacity and raise the power factor.

The station at the receiving end is commonly called a substation. There the power is transformed to a lower voltage. Out from the substation, supply lines or "feeders" radiate at reduced voltage, ordinarily 2,300, 4,000, 6,900, 11,000 or even up to 25,000 volts. The loads are supplied from the secondary windings of transformers whose primaries are connected across the feeders, located near the buildings supplied. The early scheme was to run the wires from a particular transformer secondary, to the building or buildings supplied. Thus a group of buildings receives its power from a certain definite transformer.

In recent years another plan has been adopted for cities where the load in a given area is heavy. The secondaries of all the transformers are connected together, making a secondary network. Several transformers may feed to a concentrated load and if one transformer fails the service is not interrupted. One development of this scheme employs several feeders covering approximately the same area. When the load is light one or more of the feeders is switched off at the substation, whereupon switches on the secondaries of the transformers associated with the disconnected feeders are opened, removing the transformers from the system and saving the losses which they occasion even when supplying no load. The secondary switches referred to, and other automatic devices necessary to control the flow of power in case of a failure, constitute the most serious difficulty presented by this arrangement.

The substation as an intermediate step between the transmission and distribution systems may seem an unnecessary complication, but in fact, it is economical. A small transformer designed for direct connection to a high voltage system would cost several times as much as one for connection to a relatively low voltage feeder. Since the higher voltage does not make so much difference in a large transformer it is cheaper to step down the voltage from the transmission voltage in a few large units, and to use lower voltage feeders in which the power is divided and the current small and to which the cheaper distribution transformers can be connected.

After this brief description of distribution systems the more complicated transmission systems may be considered. There is, first, the radial system where a central generating station must supply several substations surrounding it. Such a system is



BY COURTESY OF THE GENERAL ELECTRIC COMPANY

METHODS OF CONTROLLING HIGH POWER ELECTRIC TRANSMISSION

1. Solenoid operated, 73,000 volt oil circuit breaker, used to disconnect three phase transmission line in case of short circuit, thereby ensuring automatic protection to power station
2. Impulse voltage arcing over a string of insulators. The rings at top and bottom are called grading shields, serving double purpose of distributing the electric field evenly over the string and holding the arc, when it does strike, away from the string of insulators
3. Appearance of corona on conductors at super voltages, due to partial ionization of the air around conductors. Bright glow in centre indicates the approach of arcing voltage across a nine foot gap. Photograph was made by means of a quartz lens camera
4. Capacitor used to couple a carrier current telephone set, or "wired wireless," to high tension transmission lines. This device enables sound waves to be carried over the main power system for communication with distant stations along the high tension transmission system
5. Group of oil circuit breakers, 400 amp. capacity, used on 220,000 volt high tension transmission lines. Unit control enables these oil breakers to operate simultaneously, ensuring protection to the station
6. Interior or structural view of a large power transformer in 220,000 volt power system, showing circular disc coil construction of the windings. This is one of the highest voltage transformers in use on any transmission line

similar to that previously described except that several lines radiate from one station. The more developed system is of the ring type, in which two lines start from the generating station and after being tapped at several substations, meet again. The advantage is that power can flow to any station in either of two directions.

Finally, there are transmission networks which are made by a combination of the radial and ring systems and offer several paths for power flow to each station. The gain from having more than one path is twofold. Power can be fed over the most economical paths and in case of trouble on one line, others can be used to supply power.

A final stage is the interconnection of generating systems, so that each system can be fed by several stations. The advantages are manifold. When there is trouble anywhere, there are many directions for feeding the desired power and many sources that may be used. With so many generating sources, the amount of spare capacity is reduced as compared to that which an isolated station would have to have to maintain service in case of a generator failure. The area covered is larger and the diversity greater, so that the total capacity required is less.

The interconnection of water-power and steam power stations is very advantageous. Ordinarily in a water-power plant the investment cost is higher, the operating cost low; in a steam plant the ratio reverses. By interconnecting, the water-power station can be operated at nearly full capacity all the time. For such operation the total cost is only a little more than if operation were only at, say, 10% capacity. Only when the peak or maximum load comes on is the power taken from the steam station. Thus steam power, with its high operating cost, is used as little as possible, while hydro-electric power, with its high fixed investment charges, is used as much as possible.

Such interconnection involves many problems, however. Before operation can be effected at all, all of the apparatus on the system must be held to exactly the same frequency of alternation and to definite phase relations. When one station speeds up a little it takes more power and the others less. This tends to slow down the faster station, but the force may often be too small, and if the generators once pull out of step large amounts of power surge back and forth and there is a probability that the whole system will be stalled. Even when the stations do not pull out of step the directions in which the power is forced to flow may be undesirable for economic reasons.

Aside from mere mechanical excellence of the speed regulating devices a supervisory control of the whole system must be exercised to control the exchange of power both active and reactive. This is done by the chief load dispatcher, who has in front of him a plan of the whole system dotted with indicating devices to show the position of switches, generators and other apparatus. (*See* ELECTRIC POWER GENERATION.)

The load dispatcher must receive information from all points on the system. This is often carried out by means of carrier current telephony—that is, telephony making use of radio frequency which is sent over the transmission lines themselves. The telephone circuits at both ends of the transmission line are coupled to the line electrically by means of capacitance, or, less frequently, inductance. Plate II., fig. 4 shows a capacitor used for this purpose.

However, the control which the dispatcher can exercise over the flow of power is limited by the circuit constants and the voltages that must be held at certain points. In general the flow of active power depends on the lag of voltages with respect to each other; the flow of reactive power on voltage magnitudes. The supply of reactive power costs little in steam and may best be supplied from relatively inefficient stations of earlier design. This leaves the supply of active power to the most efficient stations; *i.e.*, modern steam stations or hydro-electric stations where "fuel" is cheap per kilowatt-hour generated.

Ordinarily the transformer does not allow any change in the ratio of voltage during operation, but such a change may be desirable to control the flow of reactive power. It is obtained by a special transformer arrangement known as load ratio control, which allows the changing of the number of active turns in the windings and hence of the voltage during operation.

Other very complicated aspects of transmission should be mentioned. Oil switches are necessary, but useless unless properly controlled. If when trouble occurs it were necessary to locate it by tests and to open switches by hand, the system would be out of operation or burned up long before anything could be done. Schemes dependent on devices called relays, have been developed which automatically locate all sorts of trouble and then open just those switches which disconnect the affected part and leave the rest of the system in operation. These relays may be operated by temperatures, under- or over-voltage, overcurrent, over-power, reverse-power, unbalance of currents, etc. They may have various sorts of time delay. They may even be actuated by carrier current.

Telephone Interference.—A problem, which in a way is extraneous, is that of acoustic interference with telephone circuits. Telephone lines are conveniently placed parallel to power lines. So placed, they are exposed to induction from the power line, that is, the heavy current in the power lines sets up a magnetic flux which links the telephone wires, thus inducing a voltage in them. This voltage acts on the telephone receivers and confuses the sound of the voices. If the power current is very heavy the noise may be so great as to give a listener a severe acoustic shock.

If the three power conductors could be so arranged that they were equidistant from both telephone wires there would be no interference, because in a three-phase system the relations of the currents are such that one is always the equal and opposite of the other two. The voltage induced by any one power line would be nullified by the other two. As it is impractical to arrange the conductors with the desired symmetry at any point, an approach is made to this by transposition, that is by rearranging the conductors on the poles regularly after a certain distance has been traversed.

Transposition cannot always be made completely effective, particularly when it is triple frequency (third harmonic) currents rather than those of fundamental (operating) frequency which cause the interference. Triple frequency currents occur with certain transformer connections and flow out along all three conductors, returning through the ground. Transposition between ground and lines is impossible, so the telephone wires offer the only opportunity for transposition, but one that it is difficult to make effective. Circuits made of inductances and capacitances and called "filters" are frequently used to filter out these undesired voltages from the telephone circuits.

The Trend of Transmission Development.—Some of the limitations to the further development of transmission may be interesting. In general there is no purely technical obstacle to prevent the use of transmission voltages higher than the present maximum of about 220,000. Research has been carried out with values far in excess of present voltages, and if economic factors should require higher voltage transmission it could be accomplished. In general, economical transmission at high voltage requires large amounts of power available for transmission to considerable distance. Approximately 100,000 kilowatts is usually required per transmission line for economical 220 kilovolt transmission.

Large amounts of power per line introduce a problem which must always be considered. The greater the flow of current over a given transmission line with a given amount of inductance, the greater is the lag of the receiver voltage behind the generator voltage. Therefore, when it is attempted to increase the power transmitted over a line by increasing the current flowing, the lag of the receiver voltage behind the generator voltage becomes greater. But the maximum power that can be transmitted over any given line under present circumstances is obtained when the receiver voltage lags the generator voltage by about 90°. Longer transmission lines mean more inductance, and hence more lag. Beyond the 90° point, therefore, the maximum power decreases, or, in other words, the longer the line the less power can be transmitted.

Another factor, namely the increase of charging current with added length of line, also tends to cut down the maximum power carrying capacity of the line. This line charging current, being 90° in the lead of the generator voltage, and reacting within the generator operates to raise the generator voltage. In order to keep the voltage down to normal, the magnetic field supplied to the machine by the exciter (*see* ELECTRIC POWER GENERATION) must be cut down. Therefore, the larger the charging current required of the machine, the less the field that can be carried. But it is only the current produced by the action of this field on the generator windings that gives useful power. So, to keep down the voltage, the power output of the machine must be sacrificed. To allow the voltage to rise would ultimately result in destruction of the insulation of the system.

This whole situation is termed "stability," and is one of the limiting factors in long distance power transmission. Methods of increasing the stability limits of a system have been devised, and the problem constitutes one of the principal fields of study for transmission engineers to-day.

The stability problem on long lines is accompanied by other serious conditions brought about during short circuits. The principal factors here are the increased line voltage drop due to the exceedingly heavy currents flowing, and the inability of the generators and other synchronous machines to adjust themselves promptly to the short-circuit condition. The machines are no longer held to the same speed because the reactions which occur are not strong enough to hold the system stable. Increasing the speed of response of the electrical machine, however, overcomes these difficulties in considerable measure. All of these problems are called problems of stability.

As a whole, the requirement that a system be stable tends to limit both the distance of transmission and the amount of power at present voltages, but the problem is being solved through the use of specially designed apparatus. Higher voltages involve an increase of cost as compared to present voltages, unless the amount of power and the distance of transmission are very much increased.

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(F. W. P.; D. D. C.)

ELECTRIC CHARGE. An electrified body is said to have acquired an electric charge (*see* ELECTRICITY). The unit of electrical quantity is the *unit charge* (*see* UNITS, PHYSICAL, and ELECTRON).

ELECTRIC EEL (*Electrophorus* [*Gymnotus*] *electricus*), a South American fish which, in spite of its external similarity, has nothing to do with the eels (*Anguilla*), but belongs to the order Ostariophysi, which includes the carps or *Cyprinidae* and the catfishes or *Siluridae*. The dorsal and caudal fins are rudimentary or absent, and the anal long, extending from the anus, which is under the throat, to the end of the body.

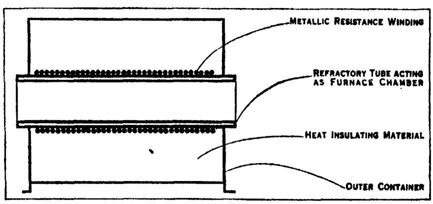
Electrophorus is the only genus of the family which possesses electric organs. These extend the whole length of the tail, which is four-fifths of the body. They are modifications of the lateral muscles and are supplied with numerous branches of the spinal nerves. They consist of longitudinal columns, each composed of an immense number of "electric plates." The posterior end of the organ is positive, the anterior negative, and the current passes from the tail to the head. The maximum shock is given when the head and tail are in contact with different points on the surface of some other animal. *E. electricus* attains a length of 3ft. and the thickness of a man's thigh, and frequents the marshes of Brazil and the Guianas. When this natural battery is discharged in a favourable position, it is sufficiently powerful to stun the largest animal. These fish are eaten by the Indians, who are said by Humboldt first to exhaust their electrical power by driving horses into the ponds. The strength of the shock varies with the size and condition of the fish. Several other fish possess the power of discharging electricity but to a lesser degree. The African genus *Malapterurus* of cat-fish of which the best known is the raash (*M. electricus*) of the Nile and other large tropical rivers; in habit it is sluggish and the flesh is edible. The shock passes from head to tail.

Less developed than in either of the above, some 15 species of electric rays or torpedoes also have the faculty of electrical discharge; the most famous of these is *Torpedo marmoratus* of southern Europe. The discharge passes from below upwards.

Electrical power has been independently acquired in each of these groups.

ELECTRIC FURNACES. All electric furnaces depend for their operation on the fact that when electricity passes along any path a certain proportion of the electrical energy is converted into heat energy. The amount so converted is directly proportional to the resistance offered by the path traversed by the electrical energy.

One of the simplest forms of electric furnace is the resistance type furnace in which heat is generated by the passage of electricity through a conductor of a resistance designed so as to ensure the conversion to heat of the required amount of energy. Furnaces of this type may depend upon either metallic conductors or non-metallic conductors. Of metallic conductors the most widely used are nickel-chromium alloys; platinum, molybdenum and tungsten, are used to a lesser extent, the choice of conductor depending on the temperature at which is required to operate the furnace. For temperatures up to 1,000° C, nickel-chromium is used, but for higher temperatures the other metals mentioned above must be employed. If molybdenum or tungsten be used it is necessary that these should be operated in an atmosphere from which oxygen is excluded, the normal method of employing these materials being to use them in a furnace through which a constant stream of hydrogen is passed. Using wire-wound furnaces of this type, temperatures of at least 1,600° C may be attained. In cases where it is not possible to exclude oxygen, platinum may be used for temperatures up to about 1,400° C, the disadvantage of platinum being its high cost. For laboratory type furnaces the conductor is usually arranged in the form of a wire or tape winding on a tube of refractory material, the whole being enclosed in an outer case filled with some heat-insulating material. Care has to be taken that the refractory and heat-insulating materials in contact with the winding are also electrical insulators. Industrial furnaces of this type usually comprise a furnace chamber built of fire-brick, strengthened on the outside by metal framework and fitted on the inside with insulating supports, upon which



BY COURTESY OF METROPOLITAN-VICKERS CO. LIMITED

FIG. 1.—DIAGRAM OF WIRE-WOUND RESISTANCE TYPE TUBULAR ELECTRIC FURNACE

the wire or tape is wound. Furnaces of this type are used for the heat treatment of steel and general industrial purposes. Up to the present, the only metallic winding used for furnaces exposed to the atmosphere has been a nickel-chromium alloy. Where higher temperatures have been desired and the use of hydrogen, nitrogen, steam and various other atmospheres has been possible, iron tape resistances have been used. Inasmuch as with a furnace of the resistance type the whole of the electrical energy used is converted to heat, it is essential in order to obtain a high overall efficiency, that good thermal insulation should be employed.

Still higher temperatures may be obtained by using a high melting point metal in the form of sheet. The reason for this is the difficulty experienced in obtaining refractory materials which are insulators at temperatures of 1,600° C or over, and which do not at this temperature react with the metal through which current is passing. By using metal sheet it is possible to avoid the use of any insulating material, although it necessitates a radical alteration in the design of the furnace. An example of a furnace of this

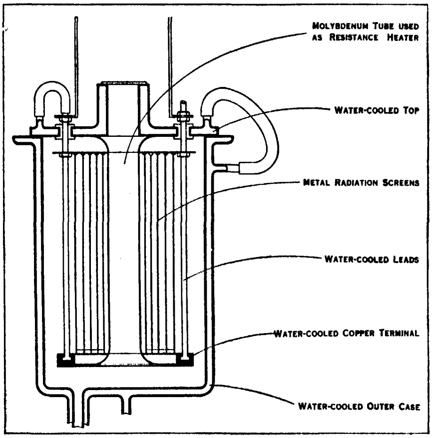


FIG. 2.—DIAGRAM OF MOLYBDENUM SHEET TUBULAR RESISTANCE FURNACE

type is one in which a tube of molybdenum sheet functions as the heating element and as the wall of the furnace chamber. It is surrounded by concentric tubes of gradually increasing diameter, the whole being enclosed in a water-cooled copper jacket, the furnace having water-cooled leads and top. It is necessary to exhaust the furnace to an X-ray vacuum before raising its temperature, for two reasons. The first is the necessity for having present no gas which can react with the metal, and the second is due to the fact that no conduction of heat either directly or by convection, may occur through a gaseous medium. The outer concentric tubes then act as radiation shields. The disadvantage is that the resistance of the inner tube which functions as the heating element is very low, so that a very low voltage and a very large current must be used, necessitating the use of a special transformer in order to operate the furnace. Its advantage is that by using molybdenum, temperatures of the order of 2,000° C may be attained quickly, owing to the small heat capacity of the furnace.

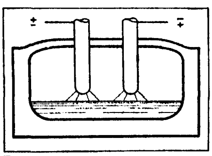


FIG. 3.—ELECTRIC ARC FURNACE
The current passes from one electrode to the other through the metal

The earliest types of resistance furnace employing non-metallic resistances normally consisted of two concentric tubes of electrical insulating refractory material; the space between them was filled with carbon granules or powder, through which a low voltage heavy current was passed. They had the disadvantage that their resistance was very uncertain. Another type of furnace employed a carbon resistor in the form of a helix machined from a graphite tube, but these had to be operated under special conditions, as for example, a vacuum or a non-oxidising atmosphere, in order that the carbon might not be oxidised.

Of recent years, various non-metallic resistors in the shape of rods have been developed and utilised. These chiefly consist of a mixture of carborundum and some suitable binding material. Furnaces have been constructed and operated utilizing these as resistance elements fixed on insulating supports attached to the inner walls. Such furnaces are used mostly for temperatures between 800° C and 1,200° C. The chief disadvantage of elements of this type is the gradual change in resistance which occurs as the life of the element increases, this increase of resistance in some cases being of the order of 100 per cent. The latest type of non-metallic resistor to appear by 1928 was in the form of a flat bar consisting of some carbonaceous material, together with a binder, which has been fired at a high temperature and then glazed with an inert refractory. The main industrial application of these up till then had been for the ceramic industry. The furnaces developed in this connection have been regenerative tunnel kilns in which the heating elements are placed in the centre of a long tunnel, the ware being passed through continuously at a speed appropriate to the temperatures which it is desired to attain. Two such kilns are placed in close juxtaposition, the ware being passed in opposite directions in the two kilns so that the hot ware leaving each kiln gives up a large portion of its heat to the cold ware entering the other.

One specialised form of electric resistance furnace is the Wild Barfield furnace for the heat treatment of steels. The temperature to which certain steels have to be heated for treatment coincides with the temperature at which they become non-magnetic. This fact is utilised to make the furnace automatic.

Arc Furnaces.—The first electrical furnaces were arc furnaces in which attempts were made to use the high local heat generated by the arc. Rapid progress was made with these furnaces which are now soundly established in industry. Although in detail they vary greatly, in principle they conform to three main types. In the first type electrodes are inserted through either the walls or the roof, the arc or arcs being formed between the electrodes. The whole is above the metal contained in the furnace hearth, the heat transfer being effected almost entirely by radiation. As this is not direct heating, the thermal efficiency of this type of furnace is not as high as is desirable. In some types an attempt to increase this thermal efficiency is made by directing an arc electromagnetically down against the contents of the furnace. This type of furnace has, however, been almost entirely superseded by other types in which the electrodes are inserted through the roof of the furnace and current passed from them to the metal. In some cases the current passes from one electrode to the metal, through the metal and then to the other electrode or electrodes, depending upon whether one, two or three phase supply is being used. In other furnaces an electrode is inserted in the bottom of the furnace, this electrode carrying part of the current from the metal. The advantages claimed for this latter type of furnace are that short arcs may be used, giving a higher thermal efficiency, inasmuch as the arc is brought into closer contact with the metal. On the other hand a disadvantage is the high local temperature attained at the surface of the metal, where the arc strikes it. This high local temperature is very objectionable when volatile metals are being melted. Furnaces have been constructed up to 40-tons capacity and can be used either for melting cold scrap or for the refining of the molten steel. They are used chiefly for the production of high grade steels. Carbon electrodes are used, these being gradually consumed, much of the carbon passing into the molten metal, a disadvantage when alloys with a low carbon content are required. The furnaces are almost invariably made to tilt.

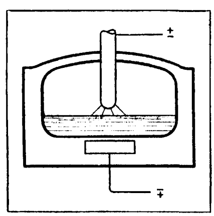


FIG. 4.—ELECTRIC ARC FURNACE
In this design, the current passes from a top electrode through the metal and conducting hearth to a bottom electrode

Another type of arc furnace is one in which the electrodes dip into a bath of a molten salt, the current operating in two ways. The passage of the current from one electrode through the molten salt to the other electrode gives a resistance heating effect keep-

ing the bath molten, whilst the electrolytic action of the current decomposes the salt giving a deposit of metal on one electrode. This is the process used in the production of aluminium from bauxite.

Induction Furnaces.—Furnaces of the induction type depend essentially for their operation upon resistance heating. Although there is no direct electrical connection between the electrical supply and the metal in the bath in a furnace of the induction type, there is an indirect connection by electrical induction. They may be broadly classed into two groups, the cored induction furnace and the coreless induction furnace. The cored induction furnace for steel consists of an annular, ring-shaped bath which acts as the secondary winding of a transformer. The transformer core is a closed iron circuit, the ring-shaped bath and the primary winding being round one leg of this. The furnaces so constructed are normally arranged to tilt, and from the purely electrical standpoint are very efficient.

For brass melting, a furnace of this type, but so arranged as to have a reservoir of metal above the ring, is known as the Ajax-Wyatt type. These furnaces have the disadvantage that a continuous ring of metal is necessary in the trough. They must be started by pouring in molten metal and this reduces the flexibility of the furnace from the standpoint of melting alloys of different compositions. Furthermore, there is always a danger of the metal cracking the lining if it is allowed to solidify in the ring part of the furnace.

The ring type furnace for steel making has been somewhat superseded by other types, but for brass melting the core type furnace with a metal reservoir is both efficient and satisfactory. Should continuous operation not be maintained the efficiency of the furnace is seriously impaired. Owing to the action of the electromagnetic field, forces are brought into play which tend to contract the cross section of the metal to such an extent that if the current be large enough the column of liquid metal in the trough may be broken. This effect, of course, varies with the specific gravity of the metal and is much more serious for the light than for the heavy metals.

Many difficulties are eliminated by the introduction of the coreless induction furnace, known as the Ajax Northrup High Frequency Furnace, as this permits the use of a standard crucible and removes the necessity for a ring type bath and continuously molten charge. In this furnace the metal to be melted is contained in a crucible, which in turn is surrounded by a water-cooled coil through which the supply current is passed. It has been known for some time that if a very high frequency current be passed round a coil such as described, the metal in the bath would have eddy currents induced in it, which, provided conditions were right, would generate sufficient heat to melt the charge. It has recently been discovered that for a melt of given resistivity, the minimum frequency which is necessary in order to melt a charge in such a furnace is dependent on the diameter of the charge to be

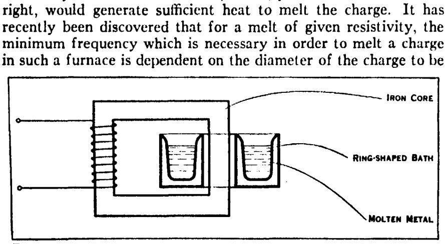


FIG. 5.—DIAGRAMMATIC SECTION OF RING TYPE INDUCTION FURNACE

melted. For example, with a crucible 15″ in diameter, it is possible to melt steel using a 500-cycle supply, whereas in the same crucible it is possible to melt brass using a supply with a periodicity of 50 alternations per second. As these periodicities can easily be obtained by the use of rotating machinery, furnaces operating on this principle are of commercial utility.

The induction furnace has the advantage that the melting time can be reduced to a very short period. Very thorough mixing of the charge is obtained and it can be kept free from any contamination from outside sources. This property is one which is of especial value when it is required to produce carbon-free alloys. Accurate control of the temperature is simple and there is no necessity for keeping a minimum of metal in the bath continuously molten. The furnace can easily be adapted to take any type of charge, whilst the fact that the heat is generated in the charge itself means a low metal loss due to evaporation.

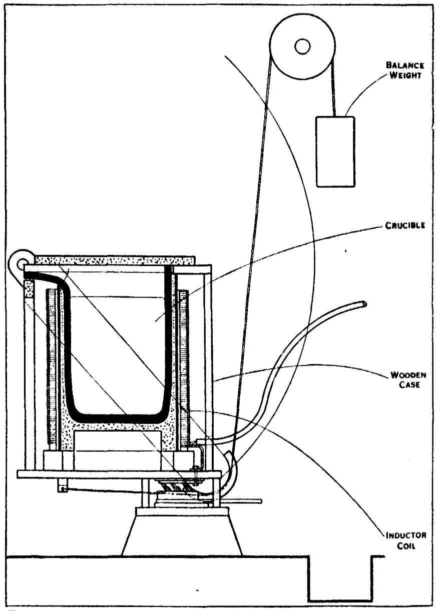


FIG. 6.—DIAGRAM SHOWING CONSTRUCTION OF AN INDUCTION FURNACE

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ELECTRIC GENERATOR, a machine that converts mechanical into electric power, as the result of the continuous motion of a system of electrical conductors across a magnetic field. The term "dynamo," formerly used widely to designate an electric generator or motor, is now obsolescent. In general, a generator consists of a *field,* comprising a series of alternate north and south magnetic poles spaced around a circular periphery, and of a concentric *armature* built of laminated steel and carrying a system of electrical conductors at its surface, together with a mechanical structure that permits the field to be revolved with respect to the armature by external means, either armature or field being held stationary in particular cases. The armature conductors are so connected that the voltages induced by their passage across the magnetic flux from the field poles are additive. The field poles are magnetized by electric currents passing through one or more encircling coils, called the field winding.

History.—Faraday, in 1831, rotated a copper disc edgewise between the poles of a horseshoe magnet and collected a continuous current from it by closing a circuit through two rubbing

contacts, one on the periphery and the other on the shaft of the disc. This first electric generator was a homopolar machine with radial current paths. Since its field was provided by a permanent magnet, the magnetic density was extremely low, and since the current paths were not definitely controlled, it was extremely inefficient. The next year, H. Pixii developed and constructed the first heteropolar machine, and provided it with a wire armature winding. The voltage produced was alternating, so to secure a continuous voltage he constructed the first commutator, reversing the current every half cycle. In 1845 another real advance was made when Wheatstone replaced the permanent magnet fields with electro-magnets, which he made self-exciting in 1857. The introduction of the "ring-winding" of Paccinotti (1860) and Gramme (1870) solved the problem of connecting in series any number of the conductors of a multipolar dynamo, thus adding their induced voltages, while yet affording mechanical means of holding them in place on the surface of the revolving armature. It was used extensively in various forms during the next 20 years, but was finally replaced by the "barrel" or "drum" type winding of Alteneck (1871), which was a development from the earlier "shuttle" winding of Werner von Siemens (1856). The greatest defect of the ring winding is that the currents existing in the return conductors on the inside of the armature core produce large magnetic fluxes which greatly impair the generator characteristics. The barrel winding overcame the difficulty, and greatly reduced the amount of copper required, by joining the ends of conductors under opposite poles by connections across the ends of the armature. When it was found how much the magnetic densities could be increased by decreasing the air gap length between field and armature, the slotted armature was generally adopted. This consummated a great advance, as embedding the armature winding in slots (first proposed by Paccinotti in 1860) not only reduced the air gap length, but also reduced eddy current losses in the copper by removing it from the intense magnetic field; and made the mechanical design immensely more rugged. In order to avoid ruinous eddy current losses, due to the cyclic alternation of the magnetic flux, it was early realized that the armature iron must be laminated. Edward Weston and Edison were the first to appreciate all these factors, however, and the latter's bipolar dynamo at once raised the standard of generator efficiency from about 50 to the then unheard of figure of 90%. This machine had a much greater ratio of iron to copper weight than earlier generators, and had the first mica insulated commutator. Hopkinson's paper on dynamo-electric machinery (1886) gave the first rational method of calculating generator performance, and so put designing on a solid foundation. Edison's inventions of his bipolor dynamo in 1878, of the incandescent lamp in 1879, and the "Edison system" of central station power production in 1882, gave the first real commercial impetus to electric generator and power development, and thereafter it progressed rapidly. In 1881 C. F. Brush made the first "compound wound" generator, by adding an auxiliary field winding in series with the armature, and thus solved the problem of automatic voltage regulation of direct current generators. The invention of the carbon brush by Van Depoele in 1888 revolutionized direct current generator design by improving commutation and reducing commutator wear immensely. In the early '90s, parallel operation by means of external equalizer connections was discovered, and in 1896 Lamme invented the internal equalizer connections, which ensure an equal division of the current between parallel armature current paths, and which made really large generators practical. Thereafter larger and larger multipolar generators, directly connected to reciprocating steam engines, came into use, reaching a peak of development about 1900. Since then, the invention of the "commutating pole" and many refinements of design have greatly improved direct current generator performance, but fundamental design features have not changed markedly. The use of direct current is now restricted to the congested sections of large cities, and to special purposes, as for the drive of variable speed machinery, for electrolytic work, and for electric railways. Most of this power is first generated as alternating current and then transformed to direct current by means of rotary converters, mercury arc rectifiers, or motor generator sets.

The invention of the first alternating current system of power production and distribution by Zipernowski and Deri, Gaulard and Gibbo in Europe, and by William Stanley in the United States (1885), and of the induction motor by Nikola Tesla (1888), initiated a new trend in generator development. Stanley's most successful alternator commercially was of the inductor type, having one central field coil carrying direct current from a separate "exciter." The magnetic flux did not alternate, but simply pulsated, so that the voltage induced in each armature conductor comprised both an alternating and a continuous component, the continuous voltages being cancelled by the series connection of conductors one-half pole pitch apart in the reverse direction. When the alternating current frequencies were reduced to 25 and 60 cycles from their early high values, the double weight of core this construction entails led to its abandonment, and it was replaced by the synchronous alternator with "chain" windings.

In the early types revolving armatures were used, following the design of direct current generators, but the disadvantages of making a rotary high voltage armature with slip rings and brushes soon led to the adoption of the rotating field design. By 1902, the average size of central station generators in the United States had increased to 100 kw., and over 60% of all were alternators. The development of the steam turbine (*q.v.*) by Parsons, Curtis and Emmet, and the very rapid increase in size of central station then led to a new stage of development, in which the turbine replaced the reciprocating engine. The first large steam turbine driven alternator in the United States was built by the American General Electric company and installed in Chicago in 1903. It was rated 5,000 kw., and was of the vertical shaft type. Its immediate success led to the almost universal adoption of steam turbine driven polyphase alternators for large central stations, a practice which has since continued. After a few years, turbine alternators were designed, almost entirely, with horizontal shafts and revolving fields. Refinements in design have resulted in larger and larger machines, till now ratings of 50,000 kw. at 13,200 volts and 1,800 revolutions per minute (r.p.m.) in a single unit are common in the United States, and much larger ones are available, while voltages up to 22,000 are used. Accompanying the growth of large central stations in the cities, hydro-electric plants using waterwheel driven alternating current generators have grown proportionately. The three phase 100 kw. Lauffen generators designed by C. E. L. Brown (1891) and the two phase 5,000 kw. Niagara generators built by the Westinghouse Company (1894), both vertical shaft machines with external revolving fields, are notable examples of early progress. W. M. Mordey, H. F. Parshall, Elihu Thomson, B. G. Lamme, G. Kapp, Ganz and many others contributed much to the rapidly growing art, but since 1900 developments have been carried on by co-operative enterprise of the engineers of large corporations, rather than by individuals. In the United States, waterwheel generators are almost universally of the laminated salient pole revolving field type, with barrel armature windings consisting of machine wound coils in open slots. In Europe, the field poles are generally made solid, or with the tips only laminated; and chain type armature windings, consisting of hand wound coils, or bars, in closed slots are often used. Kilowatt ratings up to 30,000 at 514 r.p.m. and 65,000 at 107 r.p.m. have been built, and there is no obvious limit to the possible size at the lower speeds.

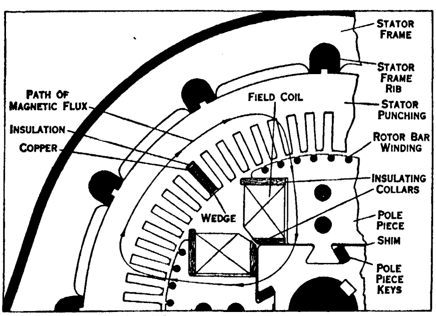
In the late '90s, when polyphase alternating current (a.c.) was superseding direct current (d.c.) supply, and before the steam turbine was adopted, steam reciprocating-engine-driven alternators were built, with ratings up to several thousand kilowatts and speeds well below 100 r.p.m. Since the advent of the internal combustion engine, many power plants have been built with oil engine driven generators, and the high efficiency and economy of the Diesel engine has brought it under consideration for large projects. Alternating current generators for this service are similar in construction to waterwheel generators, except that the former must be provided with damper or *amortisseur* windings and often with extra flywheels to limit the electric oscillations set up by

the pulsating torque of the engine. Increasing specialization and refinement of design have marked recent generator development. Improved insulating and ventilating methods have so increased reliability that base power generation is being concentrated in relatively few units of very large size. In the early days, alternator voltage regulation was a difficult problem. A solution was attempted by the use of self-excited alternators, but automatic voltage regulators have since been highly developed, and are now relied upon almost universally. The construction of the first hydrogen-cooled machine by the American General Electric company in 1928 typifies the constant improvements in efficiency and the reduction in size of machines per power developed.

Types of Generators.—A generator merely converts mechanical power into electric power. The highest object to be attained in generator design is, therefore, to make a machine that will (1) receive mechanical power in the form most conveniently produced from the available source of energy; (2) deliver electric power in the form most easily utilized for the purposes desired; and, (3) function with the least energy loss in the conversion, with the greatest reliability of operation, and at the least cost.

Generators are logically classified in accordance with the way in which these three objectives are met. Arranged in accordance with the type of mechanical drive, and in order of their importance, there are: (*a*) Steam turbine-driven generators, (*b*) water-wheel-driven generators, (*c*) engine-driven generators, (*d*) electric motor-driven generators. In accordance with the type of electric power they deliver, and their electrical design, they are divided into: (*e*) Synchronous generators (a.c.), (*f*) generators with commutators (normally d.c.), (*g*) induction generators (a.c.), (*h*) inductor generators (a.c.), (*i*) homopolar generators (alternating d.c.).

In mechanical construction, any generator can be made with a horizontal or a vertical shaft, with radial (disc type) or axial conductor arrangement, and with the field inside or outside of the armature. The most usual construction has a horizontal shaft, with axial conductors, and outside armature. Exceptions are type *f* machines, which have the armature inside, and type *b* machines, which are now commonly made with vertical shafts. Of the various types, the engine-driven continuous current generator (*c, f*) was by far the most important during the early years of electric development, due to the pre-eminence of the reciprocating steam engine as a source of primary power, and the preference for direct current, but it was little used in 1928. The development of the electric transformer and the



BY COURTESY OF THE GENERAL ELECTRIC CO.

FIG. 1.—QUARTER SECTION OF SMALL 4-POLE SYNCHRONOUS MOTOR

steam turbine brought type *a, e* into the lead about 1905, and improvements in power transmission have made type *b, e* of great importance also. The advent of efficient gas and oil engines, notably the Diesel engine, have in recent years brought type *c, e* into prominence too. The advantages inherent in alternating current power generation and transmission have made it common to produce direct current power, when required, by conversion from alternating current power, so that direct current generators are now most frequently of type *d, f*. Other types of generator are of minor importance in the production of primary electric power, though they are useful in special applications, as *d, h* for the production of high frequency alternating currents. Any generator can be used as an electric motor (*q.v.*), but in practice only types *e, f* and *g* are so used. An intermediate variety of machines that is much used is the synchronous condenser, which is really an electrically driven synchronous generator of reactive power, or a generator of type *d, e*, in which the driving motor and the generator are combined into a single machine. Such a machine draws from a system a very small energy current and returns to it a large magnetizing current. Another important intermediate variety of machine is the "synchronous converter," which is really the combination of a generator of type *d, f* with a synchronous driving motor. By building a synchronous motor as shown in fig. 1, with revolving armature and a direct current generator with common windings, the incoming and outgoing armature currents can be made largely to cancel each other, so that a greatly increased output can be secured from a given amount of material. A large proportion of all the direct current power now generated is produced by such converters.

Theory of Generator Design.—All electric generators operate by virtue of the principle discovered by Faraday (*see* ELECTROMAGNET), that the passage of magnetic flux across a conductor forming part of a closed circuit produces a current in the circuit. The current always flows in such a direction as to create a force opposing the relative motion of flux and conductor, by virtue of the reaction between the new magnetic flux created by the current and the original flux. The instantaneous voltage generated in the closed circuit is given by the equation

$$(1) \qquad e = BLV\ 10^{-8}\ \text{volts}$$

where B is the average magnetic flux density at the conductor in gausses, L the length of conductor in cm. in the magnetic field at right angles to the direction of rotation, and V the velocity of motion in cm. per second. A general type construction, which has been found to be satisfactory for the usual medium speed synchronous generator has been developed. The field poles are magnetized by the "exciting current" carried by the field winding. The magnetic flux flows in planes perpendicular to the shaft, and crosses the air gap twice to complete its circuit. Consequently, the voltage induced in each armature conductor reverses its direction each time a pole passes by, or the voltage "alternates." For many reasons, it is desirable to make the time variation of voltage sinusoidal, and so the magnetic flux distribution around the periphery is also made approximately sinusoidal. Except in homopolar and inductor machines, therefore, the voltage induced in the armature by the magnetic flux alternates in time at a frequency:

$$(2) \qquad f = \frac{NP}{120}\ \text{cycles per second}$$

where N is the speed of the flux in revolutions per minute, and P is the number of poles. When a continuous current is desired, it is necessary to rectify the induced voltage by means of a commutator. The operation of an electric generator also depends on a second law of electromagnetism (*q.v.*), that was discovered by H. C. Oersted, and which states that a current of i amperes flowing in a conductor of length L cm. at right angles to a magnetic field of density B gausses, produces a force at right angles to the conductor equal to:

$$(3) \qquad F = BLi\,10^{-1}\ \text{dynes.}$$

As the total current that can be carried in the armature conductors without excessive power losses is roughly proportional to its diameter, D cm., and as the power input is proportional to force times speed, the power rating of a generator, from (3), is approximately proportional to:

$$(4) \qquad \text{Power} = (BL)\,(D\Delta)\,(V) = (kB\Delta)\,(D^2LN)$$

where Δ is the "current loading," or number of ampere conductors per cm. of periphery, and k is an "experience constant." Equation (4) shows that for given densities of magnetic and electric

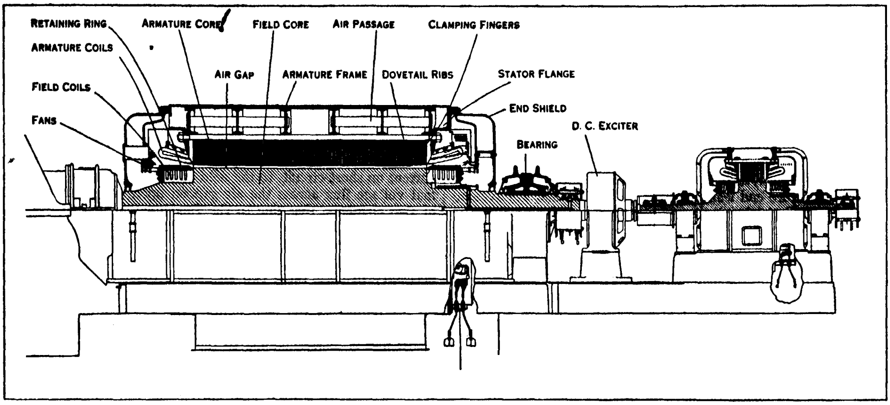


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FIG. 2.—GENERATOR SHOWING FANS AND DOUBLE FLOW SYSTEM OF VENTILATION

loading, the power output of a machine is approximately proportional to its cubic contents (D^2L) times its speed of rotation N. Actually, B can be increased slightly, and Δ considerably, as the diameter is made larger. Also, the fixed losses in the end windings become a smaller proportion of the whole as the length is increased. The output of very small machines (less than 5 kw. output), therefore, varies nearly as the $\frac{4}{3}$ power of D^2L, and even for very large machines the output rises slightly faster than D^2L. The magnetic saturation density of steel (*see* ELECTROMAGNETISM) provides a fairly definite upper limit to the value of B, which in practice is usually about 4,500 gausses, averaged over the entire air gap area. The current loading, Δ, varies over a wider range, from less than 500 amperes per inch of periphery for small machines to over 2,000 amperes per inch for very large generators. The armature winding is so laid out that the currents flowing in it will make, as nearly as may be, a steadily rotating flux wave that will keep in step with the field flux. To this end, three phase windings are most often employed, the armature conductors under each pole being grouped in three similar "phase belts," which carry alternating currents that are equal in magnitude, but displaced in time by $\frac{1}{3}$ of a cycle. A single phase machine necessarily has a pulsating armature magnetomotive force, and so requires a damping winding on the field to prevent pulsations of the field flux.

The general procedure in generator design may then be summarized thus: (*a*) The cubic volume of the machine is determined by equation (4), the values of k, B and Δ being fixed by experience. (*b*) The number of poles, P, is found by equation (2) from the given speed of the drive and the desired electrical frequency. (*c*) The ratio of D to L is usually selected so as to make L between one and three times the circumferential pole pitch, depending chiefly on ventilation and mechanical stress limitations. (*d*) The armature and field windings and the magnetic circuit details are then laid out in such a way as to secure evenly balanced magnetic and electric densities throughout, while providing adequate space for insulation and a practical mechanical construction. Copper (rarely aluminium) is used for the conductors, varnished cloth, treated paper, or built up mica for the insulation, laminated silicon steel for the armature, and commercially pure iron or steel (generally laminated) for the field, as these materials give the least power losses consistent with economical manufacture.

Steam Turbine Driven Alternators.—In fig. 2, the general construction of a large steam turbine driven generator is shown. High turbine efficiency requires high speed, the high speed causes centrifugal stresses which limit the rotor diameter (to about 60 in. at 1,800 r.p.m.), and the large output desired from a single unit requires a great rotor length. The great length and small diameter make the critical speed so low that an extremely rigid rotor construction is necessary for satisfactory operation. Hence, large rotors are made from solid steel forgings, or are built up from thick steel plates held together by heavy end forgings and alloy steel bolts. In European practice, the rotor body only is sometimes made from a forging, and the separate, laminated, teeth are subsequently inserted in dovetailed slots cut in this central core. The field windings consist of concentric coils of strip copper, insulated with mica, and laid in deep radial slots cut in the solid rotor. The coil ends are usually held in place against centrifugal forces by shrunk on "retaining rings" of forged alloy steel. In order to dispose of the heat from the field copper loss and the eddy losses in the rotor surface, it is necessary to provide means of cooling the rotor. This is usually done by fans attached to the ends of the rotor which blow air along the air gap surface and out through radial ducts in the stator. Also small channels under the rotor slots are frequently provided, through which air is drawn, escaping through holes or ducts in the rotor teeth. In the latest practice, the rotor surface is grooved with a screw thread, thus greatly increasing the peripheral area exposed to the cooling air. This thread also decreases the rotor surface losses due to the stator tooth flux pulsations, by increasing the axial length of (surface) path along which the eddy currents flow. As the rotor heating is normally the limiting feature of the machine, much study has been given to methods of cooling it. Water cooling has been experimented with, the water being fed into the hollow shaft at one end and taken out at the other, passing on the way through channels in the rotor body, but the scheme has not found favour. A more promising method, which is coming into prominence, is to use hydrogen as a cooling medium. The hydrogen is circulated inside the gas-tight frame, passing over water cooling coils which carry away the heat. The excellent cooling properties and the lightness of hydrogen enable a large increase in output, and a great reduction of windage loss, to be secured. The scheme involves many difficulties, among which the problems of making a gas-tight seal around the revolving shaft and of preventing explosions due to admixture of air and hydrogen, are the most serious. The stationary armature is built of segmental punchings of 2 to 4% silicon steel, 0.019 in. or less in thickness, and insulated from each other by thin paper or enamel. The iron losses in the stator, due to the cyclic alternation of the magnetic flux, are a large factor in the total losses and the heating, so every effort is made to reduce them. Due to the great lengths of core, the armature windings are almost always made of half coils, or bars, which are

soldered together at both ends after insertion in the slots. To avoid excessive eddy current losses in the copper, the conductors must be made of numerous insulated strands, and these must be transposed so that they occupy the same average positions in the slots, each manufacturer using his own methods of accomplishing these ends. The armature slots are very deep in proportion to their width, to secure large cooling surfaces and to increase the armature leakage reactance. In European practice, single layer windings with involute end connections and partially closed slots are generally employed. This construction leads to high power losses (and heating), in the ends, due to eddy currents induced by the large armature end leakage fluxes, difficulties that are avoided in American practice by the use of two-layer barrel type armature windings, which produce only about half as much end leakage flux. As high leakage reactance is desirable in a turbine generator, to reduce the instantaneous short circuit currents, European engineers prefer to retain the high end leakage fluxes and endeavour to reduce the losses they cause by use of non-magnetic flanges, magnetic shunts, and so forth, while American designers prefer to reduce these fluxes and obtain additional reactance, where necessary, by other means. Another important detail of design is the provision of a true sine wave of voltage at all loads, to avoid wasteful circulating currents of high frequency, which cause power losses, lower the power factor, and produce induction, etc. As large numbers of slots per pole on both field and armature are desirable from a heating point of view, and as a barrel type winding is economically made with fractional pitch, it is not difficult to secure excellent voltage wave form. Large generators are almost always wound for 3 phase and Y connection, and often have the neutral point grounded. In the latter case, special care in design must be taken to avoid triple harmonic circulating currents that interfere with telephone circuits. The stator frame which supports the armature punchings is generally built up of steel plates and ribs welded together in American practice, and of cast iron sections in European practice. The larger machines are frequently made with split frames, or with separate inner and outer frames, to facilitate shipment. The outside of the frame is covered with steel sheeting, and the interior space is utilized for ventilating air passages. For short machines, the air from the fans enters the air gap at both ends, and flows outwards through ducts in the stator core over its entire length. On very long machines, however, the area of the air gap is insufficient for this, and so two or more separate fans are used on each end, the air from the second set being led through pipes along the back of the core, then fed radially inwards through a section of the stator, and allowed to flow outwards again in adjoining sections, thus giving "multiple radial flow" ventilation.

The insulation of the armature winding is practically always made of mica flakes, cemented to paper tape or sheets. The bonding material used to cement the mica is very important, since, if it has too low a boiling point, it will volatilize at operating temperatures, puffing the insulation and decreasing its dielectric strength, besides increasing its thermal resistivity. Shellac is widely used, but this and all the ordinary yellow-coloured varnishes are likely to puff when first heated, and to become brittle with age. The black (asphalt base) varnishes are preferable, as they can be cured at high temperatures and they remain flexible for a long period. Corona protection, consisting of asbestos tape or some other semi-conducting armour, is often used on the exterior of high voltage armature coils, in order to avoid the destructive effects of the corona discharge that otherwise occurs at the conductor ends.

The theory of operation of such a "round rotor" synchronous generator may be simply explained by aid of the vector diagrams. Vector E, the upper part of fig. 3, represents the voltage that would be produced in the armature by the synchronously rotating field magnetomotive force (m.m.f) acting alone (armature current, zero). I is the armature current actually flowing, which creates a drop in voltage equal to I times the synchronous impedence. Subtracting this drop vectorially from E, there is obtained the terminal voltage, V. The angle θ, between V and I, is the load power factor angle, which is indicated in the diagram to be lagging, corresponding to a reactive, or induction motor, load. If the load consisted largely of static condensers, I would be leading, and the impedence drop would make V greater than E. Thus, as a reactive load is put on, with a fixed field current, the terminal voltage fails, falling faster the more the load current lags the terminal voltage. To hold constant voltage, independent of load, it is necessary to adjust the field current, which is usually done by cutting in and out resistance in the exciter field circuit. The synchronous reactance, X_s, expressed as a decimal, is equal to the ratio of the field current required to produce normal armature current on short circuit, to the field current required to force normal voltage flux across the air gap on open circuit. It consists of two elements, that due to the fundamental air gap flux produced by the armature current, or "armature reaction reactance," and that due to the armature leakage flux, or "armature leakage reactance." When saturation of the magnetic circuit occurs, it is necessary to treat these two elements separately, since only the latter produces a real addition to the flux under load. In Figure 3b, I_f represents the field m.m.f., and I_a the armature m.m.f. The vector sum, I_ϕ, represents the net m.m.f. which produces the actual flux ϕ, corresponding to the "internal" voltage, E_i. Evidently the larger X_s is, the greater the change in voltage due to change in load, and hence the greater the necessity for voltage regulation. With a fixed field current, as the armature current rises and the voltage falls, their product, which is the generator output, reaches a maximum and then decreases, so that beyond a certain load the generator will suddenly "break down" and drop its motor load, unless the field current is raised. These considerations impose an upper limit on the value of X_s, which in Europe

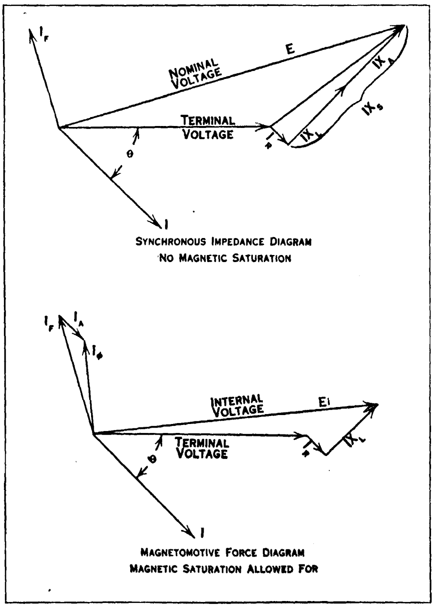

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FIG. 3.—VECTOR DIAGRAMS OF NON-SALIENT POLE SYNCHRONOUS MACHINE

is generally put at about 1·8, and in the United States about 1·2. The continued trend to large units will depend considerably on how the problem of short circuit protection will be taken care of. Roth has suggested the use of high internal generator reactance

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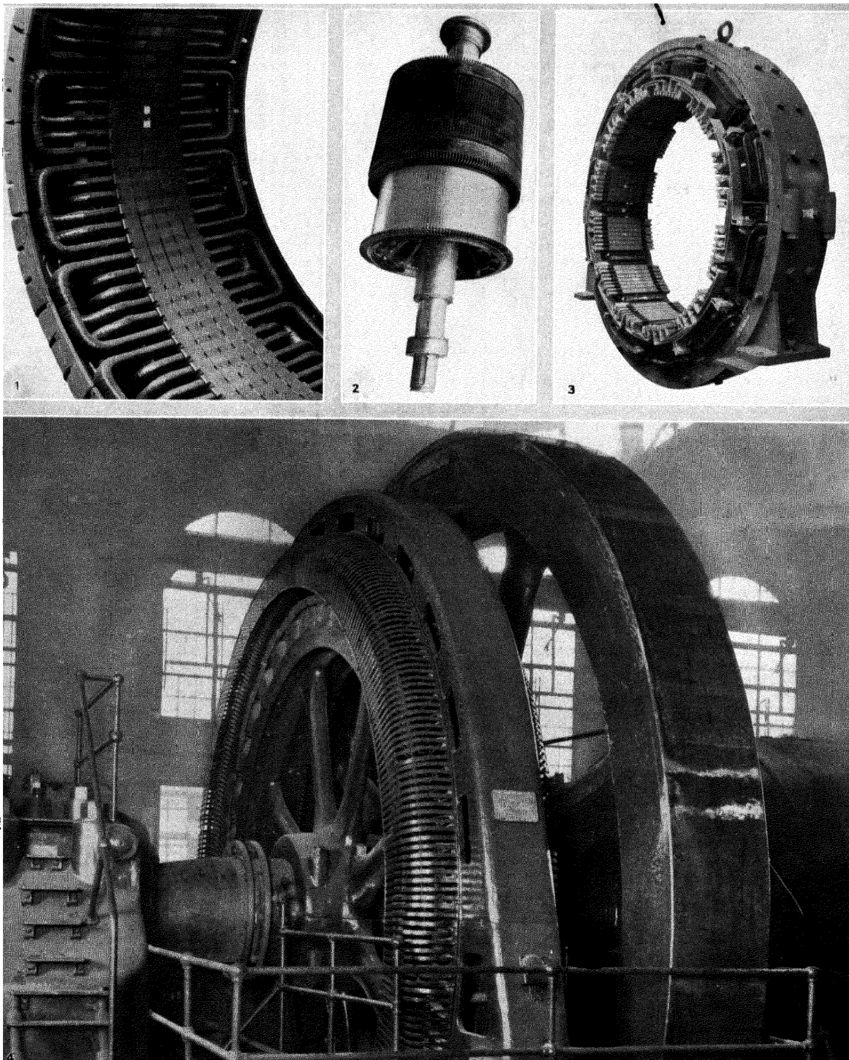
STATIONARY PART OF A LARGE ELECTRIC GENERATOR

End view of stator winding and connections, with supports assembled on the inside frame. This section of the generator, known as the *armature*, consists of a series of electro-magnetic circuits forming a hollow cylinder. Within this cylinder the *field*, a steel laminated drum, carrying another electric circuit, revolves, to generate electric power in the armature



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CONSTRUCTION OF LARGE ELECTRIC GENERATORS

1. Chain wound stator for synchronous alternating current generator. **2.** Armature for direct current generator, shaft in vertical position. Dark portion or upper half is armature winding, light portion or lower half is the commutator, built of hardened copper segments, each being attached to end of armature winding, forming connection when turning. **3.** Field structure of 200 kilowatt direct current generator. The armature (*see* fig. 4) revolves at slow speed in this type of generator. **4.** Generator and flywheel of direct current set driven by gas engine. Left to right: main bearing with steps for oiling and inspection; generator, acting as auxiliary flywheel: heavy flywheel at right

secured by deep "leakage slots," but the latest developments point to the use of double winding generators as a better solution. A 160,000 kw., 25 cycle, single shaft generator, built by the General Electric company for the New York Edison company has two similar independent windings disposed in alternate slots, which are connected separately to different loads. With this scheme, the transformer action between the two windings serves to transfer power from one to the other load when needed, but the reactance for this transfer is the sum of the slot leakage reactances of the two windings, so that the flow of current on short circuit is limited. At the same time, the two loads being fed from the same field, they can not fall out of step, and so the extra reactance does not impair the system stability. By such means, short circuit currents and the corresponding protection costs can be greatly reduced without detriment to operating characteristics. The future trend will probably continue toward larger and larger machines, and 50,000 kw. at 3,000 r.p.m., 150,000 kw. at 1,800 r.p.m., and 200,000 kw. at 1,500 r.p.m. may soon be realities. Hydrogen cooling, double windings, high synchronous reactances, high speed regulating equipment, voltages of 22,000, and efficiencies about 98·5% will probably be familiar features of the larger turbine generators of the next decade.

Waterwheel Driven Alternators.—A cross section of a typical large waterwheel driven alternator is shown in fig. 4. Such

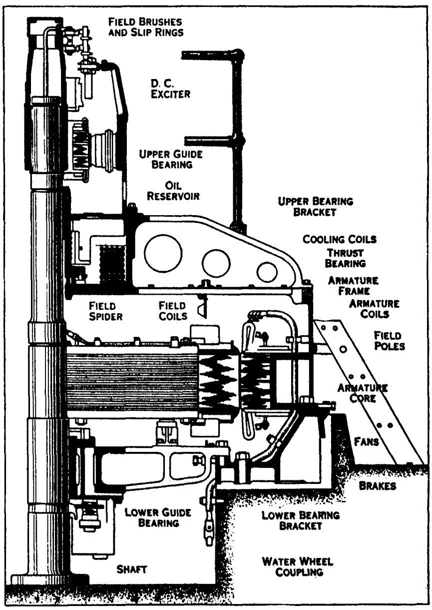

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FIG. 4.—ASSEMBLY OF VERTICAL WATERWHEEL DRIVEN GENERATOR

machines have been built with horizontal shafts, and for very high head plants they are still made, but vertical shafts are employed in almost all recent installations, thus securing better utilization of the full head of water. The weight of the rotor and downward thrust of the water are usually carried by a thrust bearing at the upper end of the shaft, while guide bearings above and below hold the rotor in a central position. Such thrust bearings carry loads of about 400 pounds per square inch, and are cooled by immersion in oil. The field normally revolves, inside the stationary armature. The armature frame was formerly made of cast iron, but since 1925 there has been a marked trend toward built-up frames of welded steel plates. The weight of the thrust bearing is supported by upper bearing brackets resting on the outer rim of the stator frame. The central rotor structure, or "spider," has generally been made from steel castings, but present tendencies are toward the use of built-up structures of steel plate. The rim frequently "floats" on the spider arms, the arms merely taking the weight and the torque, leaving the rim free to expand radially under thermal and centrifugal stresses. Such a separation of the functions of rim and arms enables each to be designed to withstand definite stresses, whereas when arms and rim are integral, the division of stress is indeterminate, and larger factors of safety are required. The rim is then generally made of segmental overlapping punchings held together by through pins and attached to the spider arms by rectangular keys. The "salient" field poles are held on dovetails fitting into slots in the rim, or, in low speed machines, by radial bolts passing through the rim. As most waterwheels will attain nearly double normal speed if full load is dropped, and the water is not shut off at once, the generator rotor must meet severe overspeed tests, and so its mechanical design is of the greatest importance. The field winding is most economically made with one coil per pole. On large machines, the field coils are made of edgewise wound copper strip, insulated by varnished paper between turns; but wire windings are employed on small machines. Generally the field current is supplied by a direct current "exciter" mounted on the same shaft. As some water may leak through the closed turbine gates, it is necessary to supply brakes to stop and hold the generator rotor at rest, when it is taken out of service. These are mounted below the rotor, and a separate "braking ring" should be provided on the lower end of the rotor spider, which can withstand the extreme heat that may be generated. Ventilation is provided by air drawn in between the poles from the ends and blown out through radial air ducts in the stator. Fins are often provided on the field coils, to increase the heat dissipating surface, and sometimes air channels are provided between the coils and the pole iron for increasing ventilation.

Hydrogen cooling is less practical for these generators than for the steam turbine type, due to their much greater volume, and since reduction of the windage loss is here unimportant. The armature is made of silicon steel laminations as for turbine generators. The number of slots per pole must be small, to preserve a satisfactory ratio of copper to insulation space, and so the flux pulsations due to the teeth are important. In American practice, open slots and machine-wound coils are used, and good voltage wave shape is preserved by fractional pitch, fractional slots per pole windings, while the pole face losses are held down by the use of $\frac{1}{16}$ in. or thinner pole piece laminations. Eddy current losses in the armature copper are avoided by using several turns per coil and employing transpositions in the end windings or coil connections. In European practice, partially closed armature slots and single-layer chain windings are most often employed; good wave form being obtained by building the pole tips in staggered sections, displaced one armature slot pitch. Solid cast steel poles, but often with laminated tips, are used. Eddy current losses in the armature copper are then controlled by transpositions in the slots, just as for turbine generators. In Europe, and to an increasing extent in the United States, "*amortisseur* windings" are used on waterwheel-driven generators. These consist of copper bars passing through slots in the pole faces, and solidly connected together by short circuiting rings at both ends. As such windings enclose the air gap flux, opposing eddy currents are induced in them by any change of the flux, and so they are often called "damper" windings. They facilitate synchronizing, damp out speed oscillations, or "hunting," and greatly reduce the peak voltages occurring across the open armature phase during a single phase short circuit. When such a short circuit occurs, the air gap flux is forced into the leakage paths when the pole is opposite the shorted phase, but it returns to its normal path with extreme rapidity as the pole comes opposite the open phase, and so induces a very high peak voltage in the latter. Finally, an *amortisseur* winding reduces the duty of circuit breakers, as its effect in increasing the initial short

circuit current dies away before the breaker can open, while it materially delays the restoration of voltage across the opening breaker contacts. On large turbine generators, the massive rotor iron serves the same purposes effectively. The theory of the electrical operation of a salient pole generator is more complicated than for a round rotor, due to the variable permeance of the air gap. As the permeance may be represented by the sum of a constant term and a sinusoidally varying term completing one cycle in each pole pitch (two cycles per electrical cycle), the vector diagrams of fig. 3 must be changed to that of fig. 5 for accurate work. The round rotor theory can be used fairly well for calculating normal operating characteristics, however, except for the torque angle relations. The relation between torque and angle of displacement, between the field axis and the flux axis is given by the expression:

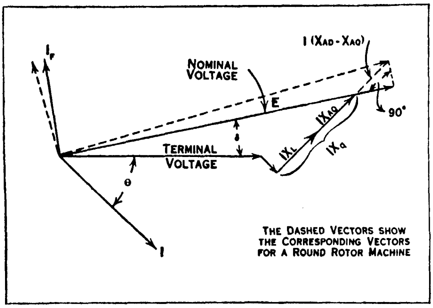

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FIG. 5.—SYNCHRONOUS IMPEDANCE DIAGRAM OF SALIENT POLE SYNCHRONOUS GENERATOR

$$T = \frac{E_d V}{X_d} \sin \delta + \frac{V^2(X_d - X_q)}{2 X_d X_q} \sin 2\delta$$

where V and E_d are the terminal and nominal voltage, and δ is the angle between them, as indicated in fig. 5. X_d and X_q are the synchronous reactances in the direct and quadrature field axes, respectively. If all values are expressed as ratios to full load values, T will be the ratio of actual to full load synchronous torque. The second term of the formula accounts for the ability of a salient pole machine to synchronize and carry an appreciable load without field excitation. It becomes zero for a round rotor, when $X_d = X_q$. The entire steady state operation of a salient pole synchronous machine may be foretold from a knowledge of its two synchronous reactances, X_d and X_q, and its power losses, while its transient operating characteristics can be foretold if the corresponding transient reactances, X'_d and X'_q, and the zero phase sequence reactance, X_0, are also known. A complete theory of synchronous machines, including both transient and steady state phenomena, is given in a series of four papers by R. E. Doherty and C. A. Nickle. The calculation of the reactive coefficients required is described in two other papers by Park and Robertson and by Alger.

The diagram (fig. 6) shows curves enabling the approximate dimensions of a waterwheel generator for any given speed and output to be determined. The several points marked on the curves indicate the ratings of some large machines built up to 1928. The efficiencies of modern generators of this type are very high, all except very small ones being above 95% and some reaching 98%. The general design features of these machines are now well standardized, though changes from cast to built-up mechanical construction, and improvements in ventilation and in efficiency are being made. The use of oil to insulate and cool the armature has been considered, as offering the possibility of securing higher voltages, but there are many difficulties to be overcome before this can be made practical.

Engine Driven Alternators.—The construction of a machine of this type is very similar to that of a waterwheel generator. The two main differences are that the engine-driven alternators have horizontal shafts, and practically all have *amortisseur* windings. Most of them operate at very low speeds, and so have cast iron spiders and bolted poles. Some are made with the revolving field outside the stationary armature, with the object of securing greater flywheel effect. The principal problem in connection with the design and operation of engine-driven generators is that of controlling their "hunting," or oscillations in speed, due to the variable engine torque. When an alternator operates alone, this trouble is not serious, though it may cause flickering of the connected lights, but, when two or more machines are operated in parallel, they will not stay in step unless the hunting is controlled.

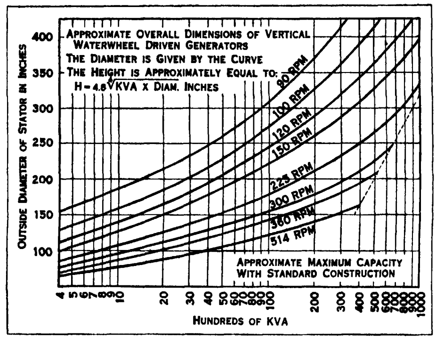

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FIG. 6.—GRAPH SHOWING THE RELATION BETWEEN THE CAPACITY AND THE DIAMETER OF A VERTICAL WATERWHEEL DRIVEN GENERATOR

This is made possible by calculating the "natural frequency" of the alternator, from the familiar pendulum formula which becomes in electrical terms:

$$F = \frac{266{,}500}{\text{r.p.m.}} \sqrt{\frac{fPs}{WR^2}} \text{ cycles per minute;}$$

where f = cycles per second of alternator voltage; P = synchronizing power of alternator in kilowatts per electrical degree; WR^2 = moment of inertia of revolving parts in pound feet squared; r.p.m. = revolutions per minute. Knowing F, and the magnitudes of the principal harmonics in the torque of the engine, the maximum electrical angle of hunting can be calculated, and thence the variations in voltage and current. When two or more alternators and engines of different types are involved, the problem becomes complicated, but methods for its solution have been thoroughly worked out by Stevenson. If the calculated hunting angle is too great in any case, it is usually best to simply add to the flywheel effect of the alternator rotor, thus lowering its natural frequency. These alternators are used in sizes up to several thousand kilowatts, chiefly for small isolated power plants in rural communities and in certain specialized applications.

Direct Current Generators.—In typical constructions of this type the armature consists of a shaft on which are mounted two cast spiders, one to support the armature core and the other the commutator. The armature core is built-up of thin iron laminations, insulated from each other to prevent internal losses and held together by end flanges. In the slots in the outer periphery of the core are placed copper conductors which are insulated from the core with treated fabric or paper materials, or pasted mica flakes, and held in the slots by means of strong insulating wedges. These conductors extend beyond the slots at each end where they are connected in series, and are held down on the end flanges by strong binding wire. The commutator is made of a number of copper segments insulated from each other and from the spider and clamping flanges by means of pasted mica flakes. Copper strips form connections between the armature winding and the commu-

tator segments. The field structure is composed of an iron or steel ring to the inside of which are bolted the main and commutating poles. The main poles are built-up of steel laminations. The lower portion of the pole is broadened to form a pole shoe in order to more effectively spread the magnetic flux over the armature surface. Above the pole shoe and around the pole body are placed the field coils. The shunt field coils are made of a large number of turns of insulated wire encircling the poles. These coils are usually connected in series with a rheostat across the armature terminals. The series, or compound field coils, consisting of a few turns of heavy section copper, are usually wound and supported with the shunt coils. In order to prevent distortion of the main pole flux by armature reaction, a compensating winding, placed in slots in the pole faces is often used. This winding has an axis coinciding with that of the armature reaction and also with that of the commutating poles. The series, compensating and commutating windings are connected so that the main load current passes through them. In order to collect the current from the commutator, graphitized carbon brushes are usually provided, which normally carry about 40 amperes per square inch of area. These brushes are arranged in axial rows, one row for each main pole, equally spaced around the commutator periphery. The brushes are held in position against the commutator by metal brush holders and suitable springs, the brush holders being bolted to brackets which are supported by a brush yoke. The direct current generator is the only machine that is self-exciting, all alternators requiring a separately generated magnetizing current to be supplied before any voltage is generated. When a direct current generator is started, the residual magnetization of the field poles creates a small voltage across the armature brushes, and this voltage in turn creates a small current through the connected field winding. This current further magnetizes the poles, the voltage is thereby increased, etc., until the increasing saturation of the magnetic circuit halts the process. The limiting features in the design of d.c. generators are usually encountered in the armature. The armature laminations, armature winding and commutator segments compose a structure which can not easily be designed to withstand high centrifugal forces, so that the peripheral speeds of the armature and commutator are limited to about 10,000 and 6,000 ft. per minute, respectively. Another limitation is encountered in the design of the armature slots. If the slots are made too deep the

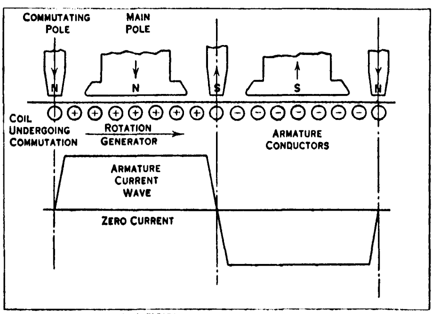

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FIG. 7.—CURRENT WAVE FORM OF D.C. GENERATOR

reactance voltage of commutation becomes too great and commutation is impaired. In addition, the roots of the armature teeth become saturated, and the excitation is greatly increased. The terminal voltage is limited by two factors; the commutator segment width, and the permissible voltage between segments. Mechanical construction limits the minimum width of segment to about 0·1 inches. The average voltage between segments is ordinarily limited to about 20 volts by the sensitivity of the commutator to arcing between brushes at times of sudden load changes. These limitations have made it impracticable to exceed about 2,000 volts on one commutator with a normal design, though by using distributed field and compensating windings and other precautions, the voltage between segments may be increased to nearly 100. Where higher voltages are desired, two or more commutators are connected in series. The current in the armature conductors is essentially trapezoidal in wave shape, as shown in fig. 7. It remains substantially constant during the greater portion of the pole pitch and then reverses rapidly during the commutation period. In order to accomplish this sudden reversal of current, accu-

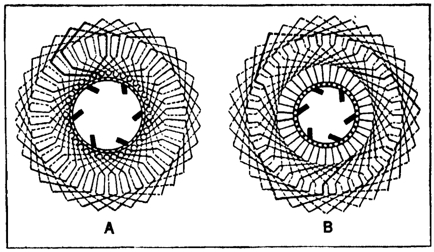

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FIG. 8A.—SIMPLE LAP WINDING. FIG. 8B.—SIMPLE WAVE WINDING

rate adjustments of the commutating field strength and brush positions are essential. Two types of armature windings are in general use. The most used is the simple lap winding shown in fig. 8*a* the other is the simple wave winding shown in fig. 8*b*. In the lap winding the number of circuits or paths is equal to the number of poles, and the conductors of each path come under the influence of only two poles. In order to balance the currents in these paths before the current passes to the brushes, it is necessary to provide equalizer connections which connect together similar points of the various paths. In the simple wave winding, there are only two armature paths regardless of the number of poles, and since the conductors of each path come under the influence of all poles no equalizer connections are necessary. It is also possible to use only two rows of brushes, one for each polarity, in place of as many rows of brushes as poles, as in the case of the lap winding. Where it is desirable to supply power at two voltages, as for example 250 volts and 125 volts, the armature winding, or commutator, is provided with diametrical taps which are brought out to slip-rings. Across the slip-rings is connected a transformer, the midpoint of the secondary of which provides a neutral terminal which is midway in potential between that of the machine terminals. This external transformer, or compensator as it is called, is sometimes constructed at one end of the armature spider, in which case it is only necessary to have one slipring connected to the centre of the compensator. This type of generator is called a three-wire generator and is used for combination power and lighting service. In generators that must operate occasionally on short circuit, such as those operating on Edison systems, the series field winding is made differential, so that as the machine becomes overloaded the terminal voltage will fall off to practically zero before dangerous overloads are reached. A slight amount of separate excitation is also provided, so as to obtain stable operation at low values of terminal voltage. Their many fields of application have led to the development of generators of capacities up to 300 kw. at 12 volts for electro-plating, 3,500 kw. at 600 volts and 180 r.p.m. for industrial power, 1,500 kw. at 1,500 volts and 400 r.p.m. for railways, and 100 kw. at 15,000 volts for radio broadcasting work. The desire to obtain generators of better operating characteristics, higher efficiency and lower cost is gradually introducing new methods of construction, different materials and higher speeds. Efficiencies as high as 94% have been obtained on large high voltage generators. Welded steel parts are replacing castings, as they are more reliable and less expensive. Alloy steel is replacing ordinary sheet steel for armature punchings, because of its lower core loss. Machines are better ventilated and are often enclosed to reduce noise and to control the air circulation.

Special Types of Generator.—The homopolar or acyclic generator has been much experimented with, as it is the only machine that can produce direct current without a commutator. There are various forms of the homopolar generator, Faraday's dynamo being an early type, but all are characterized by the magnetic flux crossing a single air gap in only one direction. The rotating armature conductors, therefore, always cut the flux in the same direction and must be connected to slip-rings at both ends. A fundamental property of such a machine is that only the voltage of a single conductor can be generated between slip-rings; hence only very low voltages can be produced without an excessive number of rings. Another interesting property is that the core loss is extremely small, since the flux is always in the same direction in each part of the magnetic circuit. Machines up to 2,000 kw. capacity have been built, but the mechanical difficulties and power losses due to the large number of brushes and slip-rings render them inferior to commutator-type machines for ordinary purposes, and they are very rarely used.

The inductor alternator (Plate II., fig. 4) basically consists of a homopolar generator with a toothed field structure, so that, while the flux always crosses a single air gap in the same direction, it pulsates in the armature teeth from a low to a high value at the field tooth frequency. The armature conductors are so connected as to add the alternating voltages due to these pulsations, and to cancel the continuous voltages due to the average flux. Since the single conductor can be generated between slip-rings; hence only half the possible working range of flux variation is utilized, and so the magnetic structure is approximately twice as heavy as for an equivalent alternator. This handicap in size prevents its use for ordinary purposes, but the inductor alternator is useful for the generations of high-frequency power. The frequency generated is fixed by the number of teeth on the revolving field, and the speed. Since the field can be made of a solid forging, without electrical conductors, it can be run at a very high speed. Alexanderson has built large 100,000 cycle generators of this type for radio telegraphy, and, in general, the inductor alternator construction affords the best means of generating considerable amounts of electric power at frequencies above 2,000 cycles per second. The induction generator is simply an induction motor that is driven above its synchronous speed. The armature consists of a laminated cylindrical rotor with a short circuited winding. The field is usually stationary, and is similar to the armature of a normal synchronous generator. It is not self-exciting, but receives its magnetizing currents from the power system to which it is connected. Hence, an induction generator must draw a reactive current from the system before it can deliver any power, and it can only apply any given amount of power at a fixed leading power factor. To reduce the magnetizing current required, a small air gap is used, and this in turn requires a larger number of slots and thinner laminations than a synchronous alternator has. The inability of the induction generator to deliver a lagging current, or to operate without a synchronous machine to supply its excitation, limits its usefulness to very few applications.

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ELECTRICITY. The study of electricity to-day comprehends a vast range of phenomena, in all of which we are brought back ultimately to the fundamental conceptions of electric charge and of electric and magnetic fields. These conceptions are at present ultimates, not explained in terms of others. In the past there have been various attempts to explain them in terms of electric fluids and aethers having the properties of material bodies known to us by the study of mechanics. To-day, however, we find that the phenomena of electricity cannot be so explained, and the tendency is to explain all other phenomena in terms of electricity, taken as a fundamental thing. The question "What is electricity?" is therefore essentially unanswerable, if by it is sought an explanation of the nature of electricity in terms of material bodies. Electricity is a name which we give the assumed source of to certain manifestations of force and energy. What is the nature of these manifestations, what are the properties of electricity, will be described in the present article. Only in this sense can we say what electricity is.

HISTORICAL INTRODUCTION

The phenomena of static electricity produced by friction were known to the ancients, who were acquainted also with the shock-giving properties of the torpedo fish. The discoveries of the electric effects of heat and of chemical action, current electricity and electro-magnetism, however, were not made until after the 17th century A.D., and the study of ionization is a development of the 19th and 20th centuries.

STATIC ELECTRICITY

The fact that amber, jet and perhaps a few other bodies have the power, after being rubbed, of attracting light objects, such as bits of straw or feathers, is said to have been known to Thales of Miletus (600 B.C.), and was mentioned by Theophrastus (321 B.C.) and by Pliny (A.D. 70). These attractions were studied by William Gilbert (1544–1603), queen Elizabeth's physician, who found that many substances possess the power in question, and he called such attractions electric after ἤλεκτρον the Greek word meaning amber. As he wrote in Latin, the actual phrase which he used for the attraction was *vis electrica;* the word *electricity* was first used by Walter Charleton in his *Ternary of Paradoxes*, 1650. Bodies having this power of attracting light objects are said to be electrified or to be charged with electricity. A striking way of illustrating such attractions is to place a very light celluloid ball on the top of a smooth table. If a piece of hard rubber (ebonite) rod which has been rubbed on woollen cloth is brought near the ball, the latter will roll towards the rod. Instead of a ball a circular cylinder of smooth paper may be used. Glass, rubbed with silk or sheet rubber, will also attract light objects, and many other pairs of bodies have the same property.

In 1729 Stephen Gray discovered that the attracting power may be transferred by contact from one body to another and is transmitted from one part of some bodies to all other parts. Such bodies through which the power is freely transmitted were called conductors by Desaguliers in 1736. Bodies through which the power is not transmitted are called insulators. Amber, sealing wax, hard rubber, paraffin wax, silk and dry glass are good insulators. All metals are good conductors. A conducting body supported on an insulating stand, *e.g.*, a metal can supported on a hard rubber rod, can be given the power of attracting light objects by touching it with a hard rubber rod which has been rubbed on woollen cloth. The conductor is then said to be electrified or to have been given a charge of electricity. If the charged conductor is allowed to touch another insulated but uncharged conductor the second conductor also becomes electrified. The charge is shared by the two conductors. If the charged conductor is connected to the earth through any conductor the charge immediately disappears. For example if the conductor is touched for a moment with the finger the charge disappears since the human body is a fairly good conductor.

About 1733 du Fay, superintendent of gardens to the king of France, discovered that there are two kinds of electricity and that unlike kinds attract each other but like kinds repel each other. If two bodies are electrified by contact with the same electrified body then they repel each other. For example if a light pith ball

coated with aluminium or gold leaf is suspended by an insulating silk thread and touched with a glass rod, which has been electrified by rubbing with silk, it will then be repelled by the glass rod. If two such pith balls are suspended by silk threads from the same point, so that they hang touching each other, then if they are touched by an electrified body they will repel each other and so hang at some distance apart.

If a rod of hard rubber, sealing wax or bakelite is rubbed with woollen cloth and then brought near the pith ball which was electrified by means of the glass rod it is found to attract the ball. Thus the ball is attracted by the electrified hard rubber but repelled by the electrified glass. In the same way if the ball is electrified by touching the rubber rod it will be attracted by the glass and repelled by the rubber. The electricity on glass rubbed with silk was called vitreous and that on resin rubbed with wool or fur resinous electricity by du Fay. Vitreous electricity is now usually called positive electricity and resinous negative. It is found that two different solid substances, if mounted on insulating handles and then rubbed together or merely allowed to touch, both become electrified, one with vitreous and the other with resinous electricity, so that they attract each other. Suppose we have two such pairs of the same substances A and B. Then it is found that after rubbing together the A's attract the B's but the A's repel each other as do the B's. Two positively electrified bodies or two negatively electrified bodies repel each other but a positively electrified body and a negatively electrified body attract each other. If insulating handles are not used conductors immediately lose their electricity and so do not appear to be electrified by rubbing with other bodies. All pairs of different bodies are not equally electrified by contact; in many cases the effect is very slight.

Frictional electrical machines, by means of which more powerful electrical effects could be obtained, were invented about 1700. The first attempt was made by Guericke, who, in his book *De Vacuo Spatio,* published in 1672, describes experiments carried out with a large sphere of sulphur, which was mounted on an iron shaft and rubbed with the hand. He demonstrated the electrical attraction, and subsequent repulsion, of light bodies with it, but did little more. A much more finished and efficient frictional machine, consisting of a glass globe which could be set in rapid rotation, was constructed by Hauksbee and described by him in 1709. This was the first machine with which electric sparks were obtained. The operator turned the handle with one hand and held the other hand against the revolving sphere. Improved machines on these lines were soon made, in which electricity could be collected, from the side of the sphere remote from the hand, by means of a chain or similar device connected to an insulated conductor. In this way insulated conductors could be strongly charged, and it was seen that, when a conductor connected to the earth, *e.g.,* a man's finger, is brought near enough to a charged conductor, a spark passes between the two conductors accompanied by a sharp crackle and the emission of light. The spark appears to be a bright narrow streak lasting for only a fraction of a second.

In 1745 an important discovery was made independently by von Kleist at Kummin, and by Musschenbrock at Leyden. Musschenbrock was trying to charge water contained in a glass bottle. A wire attached to an insulated conductor kept charged by an electrical machine was allowed to dip into the water. A friend, Cunaeus, held the bottle in one hand and then touched the charged conductor with the other whereat he received a violent electric shock which he felt in his arms and chest. It was soon found that a dry bottle with the lower part of the inside and outside surfaces coated with tin-foil is better than a bottle of water and such an apparatus was called a Leyden jar. William Watson who lived in London repeated this experiment and it suggested to him that when the jar is discharged something is transferred from the jar to the insulated conductor through the arms and chest of the experimenter. In a paper published in 1746 he suggested a theory of electrical actions which was a distinct advance on previous ideas. Watson supposed that all bodies contain electricity which is a kind of elastic fluid. Uncharged bodies contain the normal or equilibrium amount which produces no observable effects. The process of charging conductors, Watson supposed, consists in taking some of the electricity from one body and giving it to another, so that electricity is not generated or created but is merely transferred. Thus a vitreously electrified body might be a body with more than its normal amount of electricity, and a resinously electrified body one with less, or vice versa.

Benjamin Franklin.—A similar view was developed by Benjamin Franklin (1706–1790), who made a series of electrical experiments which, with his discussion of them, formed an important advance in scientific knowledge. In one of his first experiments two men stood on cakes of wax so that they were insulated from the ground. One of them rubbed a glass tube and then the other passed his hand along it so that he received a charge of vitreous electricity. It was then found that both men were about equally electrified for the sparks obtained when either touched an uninsulated conductor were of equal intensity. If before touching an insulated conductor the two men touched each other then it was found that they were completely discharged. It thus appeared that the charge on one man was just sufficient to neutralize the charge on the other man. Franklin explained this result by supposing that uncharged bodies contain a fluid, which is electricity, which when present in the normal amount produces no observable effects. If some of this fluid is transferred from one insulated conductor to another then one becomes vitreously and the other resinously electrified. If then the two conductors are allowed to touch, the fluid flows back again and all signs of electrification disappear. Franklin supposed that a vitreously electrified body contains an excess of the fluid above the normal amount and a resinously electrified body less than its normal amount. He therefore called vitreous electricity positive and resinous electricity negative but he pointed out that it was not really known which kind of electricity corresponded to an excess of the fluid. Franklin supposed that the particles of the fluid repelled each other but attracted the particles of ordinary matter. He supposed therefore that two vitreously electrified bodies would repel each other and that a vitreously electrified body would attract a resinously electrified body but he did not expect two resinously electrified bodies to repel each other and did not then know that in fact they do. He observed that a vitreously electrified jet of water is broken up into small drops which repel each other and so spread out but he did not try electrifying a similar jet resinously, probably because the electrical machines available only gave a supply of vitreous electricity.

When two bodies are rubbed together and then separated the vitreous charge on one is just enough to neutralize the resinous charge on the other. This may be shown by means of a disk of hard rubber mounted on an insulated handle and an equal wooden disk covered with woollen cloth and also mounted on an insulating handle. If the two disks are rubbed together and then separated they are both found to be electrified, the rubber resinously and the wool vitreously, and either will attract a suspended pith ball. But if they are put one against the other in contact all signs of electrification disappear, showing that the electricity on one disk is just enough to neutralize the effects due to that on the other one. Facts like this are easily explained by Watson and Franklin's theory which came to be known as the one fluid theory of electricity. According to this theory electricity is neither created nor destroyed so that the total amount of it remains constant. Franklin studied the Leyden jar and showed how its action could be explained on his theory. He showed that, when a Leyden jar is charged, one coating receives a vitreous charge and the other an equal resinous charge, and, when the two coatings are connected, the two charges just neutralize each other and disappear. He explained this by supposing that the jar could be charged by taking the electric fluid from one coating and giving it to the other. Also, if the inner coating was vitreously electrified while the outer coating was not insulated, the electricity on the inner coating repelled that in the outer coating, so driving some of it away into the earth and leaving the outer coating resinously or negatively electrified. He supposed that the electric fluid cannot pass through insulators like glass, so that, although the excess of fluid on one

coating was attracted by the matter with a defect of the fluid in the other, it could not flow through the glass. He observed that a positively and a negatively charged conductor attract each other when a sheet of glass is put between them. Since the fluid itself could not pass through glass while the action of attraction could, it was clear that the fluid itself did not extend into the space around a charged conductor where the attraction occurred. Franklin therefore gave up the view, held by his predecessors, that the attractions and repulsions were due to the presence of electric effluvia in the space around charged bodies. He supposed the fluid confined to the body and that the forces it exerted on other charged bodies were actions at a distance. Franklin's views were soon adopted by other physicists and the one fluid action at a distance theory was generally adopted.

It is probable that very few physicists really supposed that this action at a distance meant action with no medium of communication in between. What was meant was that one body acted on another across the intervening space by means of some unknown process, and that, since the phenomena could be described adequately in terms of the bodies themselves without reference to the unknown process, it was not necessary to discuss it. The position was similar to that taken with regard to gravitational attraction. Newton had shown that the motion of the planets and their satellites could be explained by supposing that they attracted each other with forces proportional to their masses and inversely proportional to the squares of their distances from each other. This was a theory of the observed motions and the force between the bodies was assumed to exist and was not explained by the theory. In the same way in electricity it was found that electrical phenomena, for example the distribution of charges on conductors, could be explained by assuming that particles of electricity exerted forces on each other across the intervening space. This was a theory of the electrical phenomena and the assumed forces were not explained any more than Newton's gravitational forces were explained. That lightning and the electric spark are identical had been suggested by several scientists before Franklin's time, but he showed that electricity could be drawn from the clouds during a thunderstorm and that it had all the properties of ordinary electricity. This celebrated experiment was made in 1752. Franklin flew a kite during a thunderstorm, insulated the twine leading up to the kite with a silk ribbon, and attached a key to the end of the twine. When a thunderstorm passed over the kite he was able to get electric sparks from the key and to charge Leyden jars from it. Thus the identity of atmospheric electricity and ordinary electricity was established.

Aepinus.—Following Franklin, Aepinus (1724–1802) made important contributions to electrical science. Aepinus showed that two parallel metal plates separated only by a layer of air acted just like a Leyden jar. If one plate was connected to the ground and the other insulated and charged by means of an electric machine, an electric shock and a bright spark could be obtained by touching the uninsulated plate with one hand and then the other plate with the other hand. When the insulated plate was charged positively the other plate became negatively charged, just as in the case of a Leyden jar, and, when the plates were connected, the electric fluid passed from the positively charged plate to the other one, and both charges disappeared. Aepinus concluded that the electric fluid cannot pass through any insulator including air, unless a spark occurs, and he denied the existence of electric effluvia around charged bodies. He supposed that electric attractions and repulsions are actions at a distance; *i.e.*, the charges on conductors produced actions at points outside the conductors without occupying the intervening space. Aepinus agreed with Franklin that the particles of the electric fluid repel each other but attract matter, and he showed that, in order to explain the repulsion between resinous or negative charges, it was also necessary to suppose that the particles of matter repel each other. Thus according to Aepinus an uncharged body contains matter and the electric fluid in such proportions that the opposite actions of the two just balance each other. The fluid repels a particle of the fluid outside the body but the matter attracts it equally. Also the fluid attracts a particle of matter outside the body but the matter in the body repels it equally. A body containing more than the normal amount of electric fluid repels particles of the fluid and attracts particles of matter. Consequently it repels a positively charged body and attracts a negatively charged body. Aepinus also suggested that the attractive forces between two uncharged bodies might be very slightly greater than the repulsive forces and that this difference might be the cause of the force of gravitation.

It had been observed by several physicists that when a charged conductor is brought near to an uncharged insulated conductor then the insulated conductor acquires charges which disappear when the charged conductor is removed. The parts of the insulated conductor nearest to the charged conductor acquire a charge of the opposite sign to that on the charged conductor and the remoter parts a charge of the same sign. The fact that the charges disappear when the charged conductor is removed or discharged shows that the two charges are equal but of opposite sign. This effect was carefully studied by Canton (1753) and by Wilcke (1757) and is called electrification by induction. The charges on the insulated conductor are called induced charges.

The effect may be illustrated by means of the apparatus shown in fig. 1. *A* is a metal sphere supported by a hard rubber rod, and *BC* is an elongated conductor supported in the same way. If the sphere *A* is charged positively by means of an electric machine and then brought near one end *B* of the conductor *BC*, it is found that *BC* is negatively charged near *B* but positively charged near *C*, as indicated in the figure by the plus and minus signs. This can be shown to be the case by means of a small metal plate *P* mounted on an insulating handle. If the plate is put in contact with the conductor near *B* and removed, it is found to be negatively charged. It will attract a suspended pith ball which has been charged by contact with a rubbed glass rod. If the plate is put on the conductor near *C*, it acquires a positive charge and will repel the pith ball. About half way between *B* and *C*, it acquires no charge. If the conductor *A* is removed or discharged the induced charges on *BC* immediately disappear.

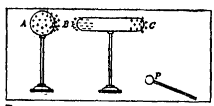


FIG. 1.—ELECTRIC CHARGES INDUCED ON AN INSULATED METAL CYLINDER BY MEANS OF AN INSULATED CHARGED METAL SPHERE

Aepinus showed how to explain electrification by induction on the one fluid action at a distance theory. The electric fluid on *A* repels that in *BC* so that, since the fluid can move freely in conductors, the fluid in *BC* moves towards *C* leaving the end *B* negatively charged. This goes on until the repulsion on the fluid inside *BC* due to the fluid on *A* is balanced by the attraction of the matter near *B* left with less than the normal amount of the fluid and the repulsion of the excess fluid around *C*. The originally uniform distribution of the fluid in the conductor *BC* is changed by the presence of the charged conductor *A* in such a way that every particle of the fluid in *BC* remains at rest in *BC* under the action of the repulsion of the charge on *A* and the attractions and repulsions of the charges induced on *BC*.

If a charged conductor is brought near to a conductor which is not insulated, a charge of opposite sign is induced on the insulated conductor; *e.g.*, if the conductor *BC* in fig. 1 is connected to the earth by touching it, some of the electric fluid in *BC* flows into the earth because of the repulsion of the charge at *A* and the conductor *BC* is left with only negative charge on it near *B*. When the conductor *BC* is connected to the earth, it and the earth form one large conductor, and the charge on *A* induces on *BC* a negative charge on the part nearest to *A* and a positive charge on the parts remote from *A*, *i.e.*, on the earth. If the connection of *BC* to the earth is broken before *A* is discharged or removed, we have a negative charge on *BC*, and we can remove *BC* from the vicinity of *A* and use the charge for any purpose. In this way a conductor can be charged by induction with a charge of opposite sign to the inducing charge. The inducing charge is not used up in this process so that the conductor *BC* can be charged an indefinite number of times by induction by means of the original charge on *A*. An example of this is afforded by the charging of the outer uninsulated coating of a Leyden jar when the inner

coating is charged. A positive charge given to the inner coating induces a negative charge on the outer coating by repelling some of the fluid in it away into the earth.

Law of Force Between Charges.—Aepinus supposed that the electric forces between particles diminished as the distance between them increased but he did not determine how the force varied with the distance. The law according to which the force varies with the distance was first demonstrated by Joseph Priestley (1733–1804), the discoverer of oxygen, by means of an experiment of Franklin's which Franklin asked him to repeat. Franklin found that a strongly electrified metal cup which attracted and repelled small balls of cork had no action on these balls when they were dropped into the cup. Priestley repeated this experiment in the year 1766, and found that, when a hollow metal vessel was electrified, there was no charge on its inner surface, except very near the opening, and no force on small light objects inside it. Priestley argued that there would therefore be no electric force on bodies inside a hollow charged metal sphere on which, by symmetry, the charge would be uniformly spread over the surface. But it was well known that, according to Newton's theory, there is no gravitational force inside a uniform hollow spherical shell of matter, and therefore Priestley concluded that the force between electric charges must vary inversely as the square of the distance between them, as in the case of gravitational attraction between two particles of matter.

That there is no force on a particle inside a uniform hollow spherical shell, the particles of which exert a force on a particle inside varying inversely as the square of the distance, may be shown easily, as follows:—In fig. 2, the circle represents the hollow spherical shell. Let the particle inside it be at any point P. Take any very small area α at A on the surface of the shell, and let a line drawn from the boundary of this area to P be produced so as to cut the shell near B. Let this line move round the boundary of α so tracing out a double cone with vertices at P and cutting off a small area β on the surface of the shell at B. Consider the forces on the particle at P due to the areas α and β of the shell. The areas α and β are equally inclined to the axis of the double cone, so that these areas are proportional to the squares of their distances from P. Hence $\alpha/(PA)^2=\beta/(PB)^2$. But the force on the particle at P due to the area α of the shell will be proportional to $\alpha/(PA)^2$, and that due to the area B to $\beta/(PB)^2$; so that we see that these two forces on the particle at P are equal but in opposite directions, and so give no resultant force on the particle. The whole surface of the shell may be divided up into pairs of areas like α and β, so that it follows that the force on the particle at P due to the whole shell is zero.

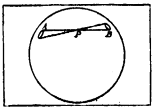


FIG. 2. PROOF OF THE INVERSE SQUARE LAW

Henry Cavendish.—The one fluid, action at a distance, theory of electrical phenomena was developed by Cavendish (1731–1810) along the lines initiated by Aepinus. He supposed the law of force to be as some inverse power of the distance less than three. Cavendish introduced the idea of an electrical state of a conductor which he called the overcharged or undercharged state which was not determined by the electrification of or the charge on the conductor. The name he adopted for this state was badly chosen, because one would naturally suppose a body in an overcharged state to be positively charged, and indeed Cavendish himself seems to have been confused in this way. Two conductors connected together were in the same overcharged or undercharged state, and if, when two insulated conductors A and B were connected electricity flowed from A to B, then A was said to be overcharged relatively to B. This idea is analogous to that of potential which many years afterwards became of fundamental importance in electrical theory.

Cavendish discussed electrical phenomena very clearly and showed how they could be explained on the one fluid theory. It is now known that he also carried out a series of electrical researches which he did not publish, in which he anticipated many important discoveries made later by other physicists. His laboratory notes were edited by Clerk Maxwell and published in 1879, more than a century after they were written. Cavendish's papers on gravitation, chemistry, electricity and other subjects established his reputation as one of the greatest experimental and theoretical scientists of all time, and the presumption is that the researches which he did not publish were not, in his opinion, sufficiently worked out to be suitable for publication according to the extraordinarily high standard which he set for himself.

One of Cavendish's experiments, which he did not publish, may be conveniently considered here. He made a pasteboard sphere 12in. in diameter, which was coated with tin-foil and mounted on a glass rod along a diameter of the sphere. Another similar sphere 13in. in diameter was made in two halves which were supported by glass rods on a folding frame, so that they could be put round the 12in. sphere enclosing it completely and could be quickly taken away without touching it. A wire attached to a silk thread could be put through a small hole in the larger sphere so as to connect the two spheres together. The larger sphere was put round the smaller one and the wire inserted so that the two spheres were connected together. The spheres were then strongly charged with electricity from a Leyden jar. The wire was then pulled out by means of the silk thread. Next the outer sphere was removed without letting it touch the inner one. The inner sphere was then found to be uncharged, when tested with two cork balls hung by threads attached to the end of a glass rod, so that the threads could be put in contact with the sphere without discharging it. Cavendish estimated that the charge remaining on the inner sphere could not be more than $\frac{1}{60}$ part of that originally given to the spheres when they were connected together by the wire.

This experiment shows that the charge on a conducting sphere is all on its outer surface. There can be no force on the electricity in conductors inside, for if there were it would cause a motion of the electricity and a redistribution which would go on until there was no force. We may therefore conclude that a uniform spherical shell of electricity exerts no force on charges inside it and so that the force between charges varies inversely as the square of the distance between them. Cavendish showed that his experiment required the inverse power of the distance to be between 2·02 and 1·98. This experiment was repeated by Clerk Maxwell in 1878 using a sensitive electrometer with which to test the inner sphere. He showed that the inverse power of the distance did not differ from two by more than one part in twenty thousand.

The Electrophorus.—A useful electrical device was invented by Alessandro Volta (1745–1827) in 1775, which is called the *electrophorus*. The form usually employed consists of a circular plate of some good insulator, such as hard rubber, about 8in. in diameter, which is laid on a metal plate, of the same size, which is not insulated from the ground. The upper surface of the hard rubber plate is rubbed with a piece of catskin or dry woollen cloth, and so becomes negatively electrified. The negative charge induces a positive charge on the metal plate through the hard rubber, and the two charges attract each other so that a much larger charge can be produced than would be possible if the metal plate were not used. A second circular metal plate about 6in. in diameter and provided with an insulating handle is now placed on the top of the charged plate of hard rubber and is then touched with the finger, so connecting it to the earth. The negative charge on the surface of the hard rubber induces a positive charge on the underside and a negative charge on the top of this plate, and the negative charge escapes to the earth when the plate is touched. If the plate is now removed by means of its insulating handle it is found to be strongly charged with positive electricity. The negative charge on the hard rubber remains on it so that the moveable plate can be positively charged a great many times merely by putting it on the rubber plate, touching it and then removing it. The moveable plate does not remove the negative charge on the hard rubber, because it only actually touches it at a few points since the surfaces are not truly plane. Work has to be done in removing the moveable plate against the attraction between it and the negative charge, and this work is the source of the electrical energy obtained. The electrophorus is merely a convenient arrangement for charging a conductor by induction.

Coulomb's Investigations.—The law of force between charges was investigated by Coulomb (1736–1806), a French physicist, who made many important researches on electricity. Coulomb measured the force between two small charged spheres by means of a torsion balance, a type of apparatus first used by Mitchell and Cavendish to measure the force of gravitation between small bodies. Coulomb's apparatus is shown diagrammatically in fig. 3. A small conducting sphere A attached to one end of a rod of shellac AB is suspended by a fine wire CD from a support which can be rotated about the wire as axis. A graduated circle on the support enables the angle through which it is turned to be measured. A second conducting sphere G is supported by a rod of shellac attached to a plate which covers a hole in the case of the apparatus as shown. The sphere G can be lifted out and given a charge. It is then put back in position and allowed to touch the suspended sphere with which it shares the charge. The two spheres then repel each other and separate until the repulsion is balanced by the torsion of the wire. By turning the support at the top, the angle through which the wire is twisted can be varied and so the distance between the spheres altered. The distance between the spheres can be read off on a scale on the case. Coulomb showed that the angle through which the wire was twisted was nearly inversely proportional to the square of the distance between the centres of the two spheres, and so gave a direct proof of the law of inverse squares. He also showed that the force was proportional to the product of the two charges. For example, if when both spheres were charged the fixed one was removed and allowed to touch an equal uncharged sphere so as to give up half its charge to it, then on putting the sphere back in the apparatus the repulsion was found to be halved.

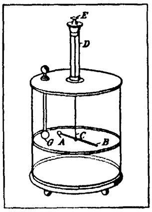


FIG. 3. COULOMB'S APPARATUS FOR VERIFYING LAW OF FORCE BETWEEN CHARGES

Coulomb advocated a two fluid theory of electricity. He supposed that there were two kinds of electric fluid which may be called positive and negative electricity, and that two particles of the same kind repelled while two unlike particles attracted each other. Uncharged bodies he supposed contained both fluids in such proportions that their actions on charges were equal and opposite. Both fluids could move freely in conductors but not in insulators. It is easy to see that the electrical phenomena so far considered can be explained as well on this two fluid theory as on the one fluid theory of Franklin and Aepinus. On the two fluid theory a conductor with a positive charge may have been charged either by adding positive-electricity to it or by removing negative from it or by both processes. On this theory it ought to be possible to go on removing equal amounts of positive and negative electricity from a conductor until it is left without either kind and so should not then conduct, but nothing of this sort has ever been observed. The conducting power of a metal like copper is always the same at the same temperature and pressure, and so the copper must always contain the same amount of electricity. We might suppose that both kinds of electric fluid always move equally but in opposite directions in conductors, so that when a conductor receives any amount of positive electricity then it also loses an equal amount of negative. Since the facts could be explained by the one fluid theory the introduction of two fluids was unnecessary and the modern view as we shall see later agrees closely with the one fluid theory.

Coulomb made a series of experiments on the distribution of the charge on charged conductors. He showed that the charge is confined to the surface of the conductor, and that the force on a small charged body when close to the surface of a charged conductor is proportional to the charge per unit area on the conductor near to the small charged body. Coulomb investigated the distribution of the charge between two or more conductors when in contact, *e.g.*, two or more spheres of different sizes, and could measure the relative charges by means of his torsion balance. He examined the distribution of the charge over the surface of conductors of different shapes by means of a proof plane. The proof plane is a small thin metal plate supported by an insulating handle which can be put on the surface of a conductor so as to form part of the surface. When removed it carries away the charge on the part of the surface which it covered. The charge on the proof plane was measured with the torsion balance. In this way Coulomb showed that the surface density on a conductor is greater where the surface is more convex and less where it is concave. The fact that there is a great density of charge on a sharp point was well known to Franklin.

The Development of the Mathematical Theory of Electrostatics.—The law of force between electric charges having been established, the time was ripe for the development of a mathematical theory of *electrostatics*, which is the name now given to that branch of electrical science which deals with the properties of electricity when at rest or in equilibrium. In 1812 Siméon Denis Poisson (1781–1840) published a paper on the mathematical theory of electrostatics which forms the basis of the modern theory of this branch of electricity. He pointed out that the equilibrium distribution of the charges on conductors must be such that the force on any particle of electricity in the interior of a conductor is zero, since in a conductor electricity can move freely and the existence of a force on the particles will cause a flow of the electricity.

Poisson showed that many of the methods and results of the mathematical theory of gravitation could be made use of in the theory of electrostatics. For example, it had been proved that a hollow shell of gravitating matter, bounded by two similar and similarly situated ellipsoids, exerts no force on a particle in its interior. Poisson showed that the distribution of the electricity on a charged conducting ellipsoid therefore must be such that the charge is on the surface of the ellipsoid, and that the surface density, or charge per unit area, is proportional to the distance from the surface to a similar and similarly situated ellipsoidal surface drawn very close to it. This makes the surface density greater where the surface is more convex as was known to be the case.

Lagrange had used a function of position V, in the theory of gravitation, the value of which at any point was obtained by adding together the mass of each particle of gravitating matter divided by its distance from the point. He had shown that the force on any particle is equal to the space rate of decrease of this function and that it satisfies the differential equation, $\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0$, where x, y, z are the co-ordinates of the point. Poisson pointed out that, since the law of force due to electric charges was the same as that of gravitation, the same function V could be used in the solution of electrostatic problems and that, since inside a conductor the forces are zero when the electricity is equilibrium, it follows that $\partial V/\partial x$, $\partial V/\partial y$ and $\partial V/\partial z$ are zero in the conductor, so that V must be constant throughout the volume of any conductor. The distribution of the charges on any conductor or system of conductors therefore may be obtained by finding a solution of the equation, $\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0$, which makes V constant over the surface of each conductor. The surface density of the charge on the conductors, Poisson showed, is proportional to the electrical force on a particle of electricity just outside the conductor, and so can be obtained when the function V is known in the space between the conductors.

Poisson's mathematical theory of electrostatics was developed with great power by George Green (1793–1841), a self-taught mathematician, in a paper published at Nottingham, England, in 1828. In this paper he proved the theorem connecting volume and surface integrals, since known as Green's theorem, which is of immense value in nearly all branches of physics.

Faraday's Work on Electrostatics.—The progress of electrostatics since Green's time has been mainly mathematical development, largely due to Lord Kelvin and Clerk Maxwell, but in 1837 Faraday (1791–1867) made a fundamental experimental discov-

ery. Faraday found that, when the space around a charged conductor is filled with different insulators, such as sulphur or wax instead of air, the charge required to produce the same electric forces as with air is considerably increased. This property of the insulator he called its specific inductive capacity. Faraday also investigated the whole subject of electrostatics, and his experiments were of immense value in establishing clear ideas which were made use of in the development of the mathematical theory.

Bennet's Gold Leaf Electroscope.—A useful instrument called a gold leaf electroscope was invented by Bennet in 1787. This instrument consists simply of two narrow strips of gold leaf attached to the lower end of a metal rod. When electrified the leaves repel each other and so diverge. Gold leaf is extremely thin and light so that Bennet's instrument is much more sensitive than a pair of cork or pith balls hung on linen threads. The leaf is also a good conductor and so is readily charged and discharged. A modern form is shown in fig. 4. A brass case *A* with glass windows in front and behind supports a plug *B* of hard rubber which is fitted into a hole in the top of the case. A brass rod *CD* passes through the plug and carries a brass disc at its upper end. The lower end is cut away to a horizontal V-shaped knife edge and two equal strips of genuine gold leaf *E, F* are gummed on, one on each side of the edge as shown. These strips may be about $\frac{1}{4}$in. wide and $1\frac{1}{2}$in. long. If an electrified body is brought near the disc *C* the electroscope is charged by induction and the leaves diverge. A positively charged body induces a negative charge on the disc and a positive charge on the leaves. If the disc is touched for a moment and then the charged body removed, the negative charge remains on the electroscope and the leaves remain diverged. If a negatively charged body is then brought near the disc, the leaves diverge further, but a positively charged body makes them collapse at first and then diverge again as it is brought nearer.

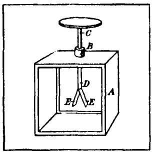


FIG. 4. GOLD LEAF ELECTROSCOPE FOR DETECTING PRESENCE AND SIGN OF CHARGE

Faraday's Ice-Pail Experiment.—One of Faraday's experiments known as the "ice-pail" experiment is of fundamental importance. A metal can (Faraday used an ice-pail, hence the name) is insulated and connected to a gold leaf electroscope. The can may be simply put on the disc of the electroscope as in fig. 5. A metal conductor supported by an insulating handle or hung from a silk thread is charged and lowered into the can. It is found that the leaves diverge when this is done and that the divergence does not alter when the conductor is moved about in the can, so long as it is not brought near to the opening at the top. If the charged conductor is removed the leaves collapse. If the charged conductor is allowed to touch the inside of the can, near the bottom, the divergence of the leaves does not change at the moment of the contact, but when the conductor is removed the leaves remain diverging to the same extent as when the conductor was first put in, and the conductor is found to be completely discharged.

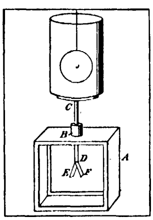


FIG. 5.—FARADAY'S ICE-PAIL EXPERIMENT. SHOWING CONDUCTOR SUSPENDED IN CYLINDER ON THE ELECTROSCOPE

Starting again with the electroscope discharged and the conductor charged, if the conductor is put in the can, without touching, the leaves diverge as before. If then the can is touched with the finger, while the charged conductor is inside, the leaves collapse. On removing the conductor the leaves diverge to the same extent as before, and if now the conductor is allowed to touch the can, either inside or outside, the leaves collapse, and both the conductor and the can are found to be completely discharged. These results were explained by Faraday as follows:—When the charged conductor is put in the can a charge of opposite sign is induced on the inside of the can and a charge of the same sign on the outside of the can and on the leaves. If the conductor is removed the leaves collapse because the two opposite charges on the can just neutralize each other. These induced charges are independent of the position of the conductor in the can, showing that, when a conductor surrounds a charged conductor, the induced charge on the outside conductor is independent of the position of the inside one. When the conductor is allowed to touch the can inside, near the bottom, the deflection of the leaves does not change, showing that the induced charge on the inside of the can is exactly equal and of opposite sign to the charge on the conductor, so that they just neutralize each other when the contact is made. All the charge on the conductor disappears, showing that there is no charge on the inside surface of a hollow charged conductor. In the second part of the experiment, when the can is touched the induced charge on the outside goes into the earth but the charge on the inside is attracted by the opposite charge on the conductor and remains. When the conductor is removed the charge on the inside goes to the outside and the leaves and produces the same divergence as before, because it is equal though of opposite sign to the induced charge previously on the outside. The charges on the can and on the conductor are now equal and opposite, so that, if the conductor is put inside without touching, the leaves collapse but diverge again when it is taken out. If the conductor is allowed to touch the can, the equal and opposite charges neutralize each other so that both are completely discharged.

Faraday's Other Experiments and Ideas.—Another important experiment of Faraday's showed clearly that the total charge produced is always zero. That is to say that positive and negative charges are always produced together in such amounts that the positive electricity is just enough to neutralize the negative electricity. To show this he constructed a large box, coated on the outside with tinfoil which was insulated and connected to a sensitive electroscope. He then went inside the box and generated charges within by means of frictional electric machines and by induction, but found that the electroscope on the outside was quite unaffected. He also performed the converse of this experiment. He took the electroscope inside the box and then had the whole box strongly charged so that long sparks could be taken from it while he was inside. He found that no electrical effects whatever could be detected inside the box.

Faraday introduced the idea of lines of force in the electric field around charged bodies, a line of force being a line drawn so as to be everywhere in the direction of the force on a charged particle. From a study of the distribution of these lines of force, he was led to suggest that the forces between charges are transmitted through the field by a system of stresses, consisting of a tension along the lines of force and a pressure perpendicular to them. This idea was afterwards elaborated mathematically by Clerk Maxwell, who showed that the observed forces on charged conductors could be represented accurately in this way.

MAGNETISM

The science of magnetism is so closely related to that of electricity—frequently both were advanced by the same observers—that it cannot be passed over without mention. Since, however, a full history of the early development of this science is given under MAGNETISM, a reference to that article must suffice.

CURRENT ELECTRICITY

The electrical phenomena so far considered have been almost entirely such as depend on the attractions and repulsions between charges on conductors. The movement of these charges along the conductors will now be considered.

Galvani.—In 1780 Luigi Galvani (1737–1798) of Bologna discovered a new type of electrical phenomena. He was studying frogs' nerves, and had dissected and prepared a frog which was laid on a table on which was an electric machine. It was noticed that, if the nerves of the frog were touched with a scalpel and, at the same moment, a spark was taken from the machine, the frog's legs were violently convulsed. Galvani found that lightning flashes produced the same effect. A little later he found that, if the feet of a dead frog, supported by a brass wire driven into its spinal marrow, were allowed to touch an iron plate, when the brass wire also

touched the plate the frog's legs contracted suddenly. Galvani found that the same effect could be produced with any other pair of metals besides brass and iron but that electrical insulators gave no such effect. He found that the contractions were produced when the wire in the spinal marrow was connected to the plate on which the frog's feet rested by any conductors. Galvani considered that when the wire and plate were connected there was a flow of electricity from the nerves to the muscles of the frog which caused the muscles to contract.

Volta.—These phenomena were investigated by Alessandro Volta (1745–1827) who supposed that the flow of electricity was due to the contact of the two different metals, *e.g.*, brass and iron when connected by a moist conductor such as the frog's body. He found that powerful electric effects could be produced by a series of such metallic pairs. He made a pile of a large number of copper, zinc and moist paper discs arranged in the following order:—Copper, zinc, paper, copper, zinc, paper, copper, zinc, paper and so on. Volta found that if the bottom and top discs were touched one with each hand a distinct shock was felt not unlike that of a Leyden jar but that the sensation continued as long as the pile was touched. In the series of discs, (+) Cu, Zn, P, Cu, Zn, P, ... Cu, Zn, P (—), the left hand end was positively charged and right end negatively charged. The fact that this is so could be demonstrated by connecting either end to an electroscope. It was found that if the paper discs were moistened with dilute acids or salt solutions the electrical effects were intensified. Volta published his discovery in 1800.

Electrolysis.—In the same year (1800) Nicholson and Carlisle in England while repeating Volta's experiments found that if two wires connected to the ends of the pile were dipped into water hydrogen gas was evolved from the negative wire and the positive wire became oxydized. Using platinum wires they obtained hydrogen from the negative wire and oxygen from the positive wire. It appeared that the electricity flowing through the water from the one wire to the other decomposed it into its elements in such a way that they appeared separately one at each wire, whatever the distance between the wires. Such decompositions are called electrolysis.

Cruickshank (1745–1800) soon afterwards found that metallic salts in solution can be decomposed in the same way. For example, with a solution of copper sulphate, copper is deposited on one wire, and sulphuric acid and oxygen appear at the other. Wollaston (1766–1828) showed that the same decompositions on a very small scale could be produced by electricity from a frictional machine, and in 1801 Pfaff (1773–1852) showed that a Leyden jar could be charged by means of a Voltaic pile having a very large number of elements. Thus the identity of frictional and Voltaic electricity was established.

Humphry Davy (1778–1829) studied the action of Voltaic piles, and concluded that chemical action on the zinc accompanies the generation of electricity, and is in some way the cause of it. Davy and Grothus explained the decomposition of water and other bodies by supposing that hydrogen atoms in water molecules are positively charged, and the oxygen atoms negatively. At the negatively charged wire hydrogen atoms are separated, giving up their positive charges to the wire. The oxygen atoms set free combine with hydrogen atoms in other molecules, and the oxygen atoms from these with hydrogen atoms in still other molecules, and so on, until oxygen atoms appear at the positive electrode. Thus we may imagine a row of water molecules extending from the negative to the positive electrode. If now the hydrogen in each molecule moves into the next one in the row, the result is that we get free hydrogen at one end and free oxygen at the other.

This view was opposed by La Rive (1801–1873), who showed that metals could be made to pass from a salt solution through pure water to a negatively charged electrode. La Rive considered that salts in solution were partially dissociated into oppositely charged particles, and that the negative particles moved through the liquid to the positive electrode and the positive particles to the negative electrode. These electrolytic decompositions led Berzelius (1779–1848) to propose a theory of chemical affinity according to which the atoms in the molecules of compounds are oppositely charged and are held together by electrical attraction.

Magnetic Field Currents.—In 1820 a new discovery of the first magnitude turned the progress of electrical science into a new direction. Hans Christian Oersted (1777–1851) discovered that a wire carrying a current exerts a force on a magnet, or produces a magnetic field. He found that, if the wire is placed in the meridian, above a compass needle, when a current flows in the wire from south to north, the north pole of the needle is deflected towards the west. The direction of the force on the north pole was along circles in planes perpendicular to the wire with their centres at the wire. Oersted also found that the magnet exerted a force on the wire carrying the current.

This subject was taken up by Biot (1774–1862) and Savart (1791–1841) in France, and then by Ampère (1775–1836). Ampère one week after the news of Oersted's discovery arrived in Paris, showed that two parallel wires, carrying currents in the same direction, attract each other, but repel when the currents are in opposite directions. During the next few years Ampère investigated the subject experimentally and mathematically, and in 1825 published an account of his researches in a memoir which has excited the admiration of mathematicians and physicists ever since. He showed that the forces, between currents and magnets, and between one current and another, could be represented by supposing that each element of a circuit exerts a force on a magnetic pole and on every other current element.

A current element of length ds at a point O carrying a current i produces a magnetic field of strength $ids \sin \theta / r^2$ at a point P, where $r = OP$ and θ is the angle between the current element and OP. The direction of this field is perpendicular to the plane containing ds and OP. The force on a current element in a magnetic field of strength H is equal to $Hids \sin \phi$ where ϕ is the angle between ds and H. This force is perpendicular to H and ds. Ampère assumed that the force between two current elements is along the line joining them. This assumption is not now believed to be correct, but his theory nevertheless gave correct results for the force exerted by one circuit on another. Ampère called the theory of the mutual action of currents *electrodynamics*.

Thermoelectricity and Ohm's Law.—In 1822, Seebeck (1770–1831) of Berlin discovered that a current is produced in a circuit of two metals when one of the junctions is made hotter than the other one. This discovery initiated the branch of electricity known as thermoelectricity. In 1834 Peltier (1785–1845) discovered that, when a current is passed across a junction between two metals, heat is absorbed when the current is in one direction and evolved when it is in the other direction.

In 1826 Georg Simon Ohm (1787–1854) published a paper on the flow of electricity through conducting wires in which a result since known as Ohm's Law was established. Ohm argued that the flow of electricity along a wire was analogous to the flow of heat along a rod, one end of which was hotter than the other. The quantity of heat flowing per second is proportional to the difference of temperature, so Ohm suggested that there must be an electrical quantity, analogous to temperature, concerned. He showed that this quantity, which he called electroscopic force, increases by equal increments on passing from one copper plate of a Voltaic pile to the next. This shows that Ohm's electroscopic force is the same thing as electrostatic potential difference. Ohm showed that the current through a wire is equal to the electroscopic force acting on the wire multiplied by a constant. This constant is now called the conductivity of the wire and its reciprocal the resistance. The resistance is proportional to the length and varies inversely as the cross section of the wire. The resistance of a wire of unit length and unit cross section is called the specific resistance of the material of the wire.

Electromagnetic Induction of Currents.—Soon after Oersted's discovery of the magnetic field of currents Faraday began an investigation of the subject. It occurred to him that an effect analogous to electrostatic induction of charges on conductors might be produced by currents, *i.e.*, a current flowing in a circuit might induce a current in another circuit near it. Oersted's discovery shows that a current excites a field in the surrounding space which might be expected to produce effects on bodies in it. In 1831, Far-

aday found that, when a current is started in a coil of wire, a momentary current is induced in another near-by coil. When the primary current is stopped, an induced current is again obtained but in the opposite direction. He showed that the effect is due to the magnetic field of the primary current, and that the induced current in any circuit is proportional to the rate of change of the number of unit tubes of magnetic force passing through the circuit. He mounted a copper disc between the poles of a magnet, so that the tubes of force passed through the disc. The axle of the disc and a point on its circumference were connected by sliding contacts to wires leading to a galvanometer, and, when the disc was made to rotate with uniform velocity, the galvanometer indicated a steady current. This apparatus was the first dynamo, or electric generator, and all the generators now used for the production of currents for technical purposes work on the same principle.

The mathematical theory of electromagnetic induction of currents was developed by Neumann and Weber (1804–1890). It was shown by Neumann that the mutual potential of two circuits is equal to the number of unit tubes of magnetic force, due to one of them, which pass through the other one multiplied by the current in it. According to Faraday's law, the currents induced depend on the variation of this quantity, so that the induced currents can be calculated from the mutual potential energy. Weber supposed that a current in a wire consists of a flow of positively charged particles in one direction, together with an equal flow of negative particles in the opposite direction. He deduced an expression for the force exerted by one such particle on another one at any distance, and showed that the mutual action of circuits including the induced currents could be explained in this way. Weber's law of force gave correct results, in many cases, but it has been replaced by other conceptions in the modern theory. Weber's idea that a current consists of a flow of particles of electricity reappeared at a much later date in the modern electron theory.

Faraday's Laws of Electrolysis.—In 1833, Faraday published a series of researches on electrolysis. He found that the amount of any element deposited at the electrodes is proportional to the quantity of the electricity passed through the electrolyte. Also, the amount deposited by a given quantity of electricity is proportional to the atomic weight divided by the chemical valency. Thus, if a certain quantity of electricity deposits one gram of hydrogen, it will deposit 8 grams of oxygen and 108 grams of silver. The atomic weights of these elements being 1, 16 and 108, and the valencies 1, 2 and 1, respectively. Faraday pointed out that this result showed that all monovalent atoms in solution carry the same charge of electricity, the charge now called the ionic charge, and that divalent atoms carried twice and trivalent atoms three times this ionic charge. Faraday called the wires or plates by means of which the current was passed through the liquid to be electrolysed the *electrodes*. The positive electrode he named the *anode* and the other the *cathode*. Bodies which are decomposed when a current is passed through them he called *electrolytes*, and the parts into which they are decomposed, which move towards the electrodes, *ions*. Faraday supposed that chemical affinity is due to the charges carried by the atoms, a positively charged atom combining with a negatively charged one.

A question which had been discussed ever since Volta's pile was discovered was the nature of the forces which cause the flow of electricity when the ends of the pile are connected. Volta showed that when a copper plate and a zinc plate are put in contact and then separated they are oppositely charged, and he considered that the driving force in his pile was at the junction between the two metals used. When it was found that chemical action accompanies the flow of electricity through electrolytes, so that in the pile there is chemical action between the zinc and the acid or salt solution by which zinc is dissolved, it was suggested that the chemical affinity between the zinc and the solution is the source of the chemical energy. If a plate of pure zinc and one of copper are placed in dilute sulphuric acid so that they do not touch each other, the zinc does not dissolve in the acid; but, if the two plates are connected by a wire, the zinc begins to dissolve and hydrogen gas is liberated at the surface of the copper plate. A current flows through the wire, from the copper to the zinc, and, through the acid, from the zinc to the copper. The chemical action is represented by the equation $Zn+H_2SO_4=ZnSO_4+H_2$, and the amount of zinc dissolved and hydrogen liberated are determined by the amount of electricity which flows round the circuit, in accordance with Faraday's laws of electrolysis.

It was argued by Peter Roget (1779–1869), and later by Faraday and La Rive, that the electrical energy supplied by such a cell or element of a Voltaic pile must come from the chemical affinity between the acid and zinc which combine in the cell. If the current merely came from the contact between two metals, Faraday said, it would be a "creation of power like no other force in nature."

Magnetism and Light.—In 1845 Faraday placed a block of glass between the poles of a powerful magnet and then passed a beam of plane polarized light through the block along the direction of the magnetic field. He found that the plane of polarization of the light was rotated as it passed through the glass. By this discovery the sciences of electricity and magnetism were linked with optics. Faraday discussed the nature of light waves, suggesting that they might turn out to be transverse vibrations travelling along his lines of electric and magnetic force. He thus brilliantly foreshadowed the electromagnetic theory of light, which was afterwards worked out by Clerk Maxwell largely as the result of a translation of Faraday's ideas into mathematical form. Faraday, in 1845, also discovered that all substances have magnetic properties in greater or less degree. Some bodies tend to move, in a magnetic field, towards the stronger parts of the field; these Faraday called paramagnetic bodies. Other bodies, notably bismuth, he found tend to move into the weaker parts of the field; these he called diamagnetic bodies. Faraday's experimental work ended in 1855 when he retired. He died in 1867. His collected scientific papers, published in four volumes, form a noteworthy monument to the greatest of all experimental philosophers.

In 1847, Weber showed that diamagnetism could be explained by supposing that currents are induced in the molecules of diamagnetic bodies when they are placed in a magnetic field. Ampère had previously suggested that the magnetic properties of iron atoms may be due to currents flowing round small circuits in the atoms. Weber supposed that paramagnetic atoms have such currents always, but that diamagnetic atoms normally have no currents but acquire them when put in a magnetic field. The induced currents produce a field opposite to the inducing field so that the resultant field in diamagnetic bodies is less than in non-magnetic bodies. In paramagnetic bodies there is no resultant field when they are not magnetized because the atomic circuits are orientated at random. When put in a field, the atomic circuits tend to turn so that their fields are in the same direction as the inducing field, so giving a resultant field greater than that in a non-magnetic body. (*See* MAGNETISM.)

Electricity and the Conservation of Energy.—The principle of the conservation of energy was finally placed on a solid foundation about 1841 by the labours of James Prescott Joule of Manchester. He applied it to electrical circuits, and showed that the chemical energy, used up in a battery sending a current through a wire, was approximately equivalent to the heat generated in the circuit by the flow of the current. He showed that the heat generated in a wire was proportional to the square of the current in it.

Helmholtz (1821–1894) in 1842 showed that the chemical energy used up in a battery may not be exactly equal to the electrical energy developed, because some heat energy may be absorbed from surrounding bodies. In 1847 Helmholtz published a great memoir, on the conservation of energy, in which he applied the principle to electrostatic and magnetic problems among others. He calculated the electric and magnetic energies by assuming that the work required to produce the final state was stored up in the system. He showed that the energy of a system of charged conductors is equal to $\frac{1}{2}\Sigma EV$ where E is the charge and V the potential of a conductor. The potential is the function, used by Poisson and Green, which is equal to the work required to bring a unit charge from a great distance to the conductor. Helmholtz also considered systems involving currents, and showed that the

existence of Faraday's induced currents followed from the principle of the conservation of energy.

The theory of the energy of electromagnetic systems was worked out by William Thomson (Lord Kelvin) in a series of papers (1847–1853). He defined the strength of the magnetic field inside a piece of iron as the force on a unit pole put in a long hole bored in the iron along its direction of magnetization. The *magnetic induction* in the iron he defined as the field strength in a slot cut across the direction of magnetization. The ratio of the magnetic induction to the field strength is the *permeability* of the iron. Thomson showed that the magnetic energy could be regarded as distributed throughout the field with density $\mu H^2/8\pi$ where μ is the permeability and H the field strength.

He showed that the energy of the magnetic field of a circuit carrying a current i, in air, is equal to $\frac{1}{2}Ni$, where N is the number of unit tubes of magnetic force passing through the circuit. N is proportional to i so that if we put $N=Si$ we get $\frac{1}{2}Si^2$ for the energy. The quantity $S=N/i$ is called the self induction of the circuit.

In 1848 Kirchhoff (1824–1887) discussed the theory of the flow of currents in conductors, basing his theory on Ohm's law. He finally identified Ohm's electroscopic force with electrostatic potential difference, the work required to move a unit charge from one point in the electric field to another. The electromotive force in a circuit is the work required to move a unit charge once round the circuit. Ohm's law therefore means that the current in a circuit is proportional to the electromotive force acting in the circuit. The resistance of the circuit is defined to be the ratio of the electromotive force to the current.

Oscillatory Discharges.—In 1853 Thomson (Lord Kelvin) published a theory of the discharge of a Leyden jar, which was of fundamental importance. Several observers, Wollaston (1801), Savary (1827), Joseph Henry (1842) and Helmholtz, had suggested that when a jar is discharged the electricity oscillates backwards and forwards from one coating of the jar to the other. These suggestions were based on observations of effects produced by the discharge. For example, Wollaston found that, when a jar is discharged through water between two wires, oxygen and hydrogen appear on both wires, as if the current went both ways through the water.

Lord Kelvin supposed that the current, in a wire connecting the two coatings, is proportional to the potential difference between the coatings less the induced electromotive force in the wire, due to its self induction. When the jar is charged and there is no current in the wire, the energy is all electrostatic energy, but when the jar is discharged and there is a current in the wire, the energy is all magnetic energy of the field of the current. The energy changes from electric to magnetic and back again, just as when a pendulum oscillates the energy changes from potential to kinetic and back again.

Kelvin showed that the discharge should be oscillatory and that the periodic time is $2\pi\sqrt{CS}$, where C is the capacity of the jar and S the self induction of the wire. The number of oscillations per second with an ordinary jar and a short wire is very large, of the order of ten millions. It was soon afterwards shown by Fedderson that the spark, that occurs when a jar is discharged, is really a series of sparks. He examined the spark in a rapidly rotating mirror and so was able to see the successive sparks separately. The time between the sparks agreed with that given by Kelvin's theory.

Kelvin also worked out the theory of the propagation of electrical signals along long wires, such as submarine cables, and in 1857 Kirchhoff worked out the propagation of an electrical disturbance along a wire in air, and showed that the velocity of propagation, in centimetres per second, should be equal to the ratio of the electromagnetic unit of electricity to the electrostatic unit. This ratio had been found experimentally, by Weber and Kohlrausch in 1856, to be equal to $3{\cdot}1\times10^{10}$, which is nearly equal to the velocity of light in centimetres per second. Thus it appeared, as Kirchhoff pointed out, that the velocity of propagation of an electric disturbance along a wire in air is equal to the velocity of light in air.

In 1851 Kelvin worked out the thermodynamical theory of thermoelectricity, and discovered that there is an absorption or an evolution of heat in a wire when there is a temperature gradient and a current of electricity along it. The heat absorbed per unit quantity of electricity per unit rise of temperature was called the *specific heat* of electricity in the wire. It is positive in some metals and negative in others.

ELECTROMAGNETIC WAVES

About 1855 James Clerk Maxwell (1831–1879) began the study of electromagnetic phenomena which resulted in his discovery of the electromagnetic theory of electric waves and light, the theory which is of fundamental importance in practically all branches of modern physics. Maxwell studied Faraday's *Experimental Researches*, and the writings of Green, Stokes and Kelvin. He adopted Faraday's idea about lines of force in electric and magnetic fields, and, like Faraday and Kelvin, believed that the actions between charges and between magnetic poles are transmitted along the lines of force through the field. He concentrated his attention on the fields excited by charges rather than on the charges themselves, regarding the charges as merely singularities in the field.

Maxwell's Equations.—According to Faraday, the current induced in a wire circuit is proportional to the rate of change of the number of unit tubes of magnetic force passing through the circuit. Also, according to Ohm and Kirchhoff, the current is proportional to the electromotive force acting round the circuit. Maxwell supposed that Faraday's result could be applied to any closed curve in a magnetic field, and not only to closed metallic circuits. He supposed that, if the number of unit magnetic tubes through a closed curve is changing, there will be an electromotive force acting round the curve, so that work must be done to move a charge round the curve against the electromotive force. Since, however, the strength of an electric field is merely the force on a unit charge in it, it follows that a varying magnetic field induces an electric field, the lines of force of which form closed curves surrounding the lines of the varying magnetic field. Thus Maxwell was led to his first fundamental equation of the electromagnetic field, which is, in vector notation (*see* VECTOR ANALYSIS):

$$\operatorname{curl} F = -\mu\dot{H}$$

or, in the Cartesian co-ordinates used by Maxwell:

$$\frac{\partial F_z}{\partial y}-\frac{\partial F_y}{\partial z}=-\mu\frac{\partial H_x}{\partial t}$$

$$\frac{\partial F_x}{\partial z}-\frac{\partial F_z}{\partial x}=-\mu\frac{\partial H_y}{\partial t}$$

$$\frac{\partial F_y}{\partial x}-\frac{\partial F_x}{\partial y}=-\mu\frac{\partial H_z}{\partial t}$$

where F is the electric, H the magnetic field strength, and μ the magnetic permeability of the medium. The meaning of these equations is that the work, required to take a unit charge once round a small plane closed curve against the electric field F, is equal to the rate of diminution of the number of unit tubes of magnetic force passing through the curve.

Maxwell's second fundamental relation was derived from the theory of the magnetic field of currents. The work required to take a unit magnetic pole once round a current, against the magnetic field of the current, is equal to 4π times the current. This gives curl $H=4\pi i$, where i is the current density. Maxwell did not suppose that the only sort of current is a current in a metallic conductor. Faraday's ideas and experiments on insulators lead him to suppose that, when the electric field in an insulator is changing, there is a current in the insulator. For example, when a condenser, consisting of two parallel metal plates with any insulator between them, is being charged, there is a current flowing into one plate which becomes positively charged, and out of the other plate which becomes negatively charged. Maxwell supposed that the current flows in the insulator as well as in the wires leading to the plates. Each unit tube of electric force, which goes from one plate to the other, starts on a charge $1/4\pi$ and ends on a charge $-1/4\pi$, thus the current through the insulator, which Maxwell

called a *displacement current*, is equal to the rate of increase of the number of unit tubes divided by 4π. Along a unit tube of section α, $KF\alpha = 1$ so that the current density in the insulator is equal to $K\dot{F}/4\pi$. In any medium the total current density is then the sum of the conduction current and the displacement current or $\sigma F + K\dot{F}/4\pi$, where σ is the conductivity. The equation curl $H = 4\pi i$ therefore becomes curl $H = 4\pi\ (\sigma F + K\dot{F}/4\pi)$, so that, for an insulator in which $\sigma = 0$, we have

$$\text{curl } H = K\dot{F}$$
$$\text{curl } F = -\mu\dot{H}$$

Maxwell showed that these equations give the equation

$$\frac{\partial^2 F}{\partial x^2} + \frac{\partial^2 F}{\partial y^2} + \frac{\partial^2 F}{\partial z^2} = \Delta F = \mu K\ddot{F} \text{ and } \Delta H = \mu K\ddot{H}.$$

These equations show that an electromagnetic disturbance, or wave, travels through the medium with velocity equal to $1/\sqrt{\mu K}$. Maxwell showed that $1/\sqrt{\mu K}$, for air, in cms. per sec., is equal to the ratio of the electromagnetic unit of charge to the electrostatic unit, which was known to be about 3×10^{10} and so is equal to the velocity of light in air in centimetres per second. It therefore appeared that the velocity of electric waves in air should be equal to the velocity of light in air. Maxwell therefore suggested that light consists of electric waves of short wave length.

The velocity in any insulator is $1/\sqrt{\mu K}$, so that, since μ is practically the same in all insulators, it follows that the velocity should vary inversely as $\sqrt{K}$ for different insulators. Taking $K = 1$ for air, it follows that the refractive index, ν, of any insulator should be given by $\nu = \sqrt{K}$. It has been found that this is the case, provided ν and K are both measured with electrical oscillations of the same frequency. Maxwell also applied his theory to metallic conductors and crystalline insulators and showed that it leads to results in agreement with the facts.

Kelvin and Maxwell both endeavoured to devise dynamical models of the electromagnetic field, or of the medium usually called the aether, of which the field was supposed to be a modification. Indeed, Maxwell's theory of light was first obtained by means of such a dynamical model. The aether was supposed to be an elastic solid, or a fluid filled with vortex filaments or some such dynamical medium. Such models served a useful purpose in aiding the development of the theory, but they have not proved to be of permanent value. It is now generally realized (*see* SCIENCE; ENERGY; ATOM) that the electromagnetic field, with its singularities, the electric charges, is the fundamental entity in terms of which phenomena are to be explained.

In 1873, Maxwell published a great treatise on electricity which contained the results of many new researches. He developed Faraday's ideas on stresses in the electric and magnetic fields and showed that the observed effects can be explained by supposing that there is a tension along the lines of force and an equal pressure at right angles to them. He also worked out a dynamical theory of a system of current circuits taking the magnetic energy to be kinetic and the electrostatic energy to be potential energy. Maxwell's treatise contained a very valuable account of experimental methods as well as of electrical theories, and it has been the model for later treatises on the subject.

In 1876, H. A. Rowland (1848–1901) showed experimentally that a moving electrostatic charge produces a magnetic field like a current in a conductor. In this celebrated experiment, two parallel disks forming a condenser were oppositely charged, and one of them was made to rotate about its axis. The field, due to the rotating disk, was measured by means of a suspended magnetic needle which it deflected. Rowland's result has since been confirmed by Rowland and Hutchinson, H. Pender, Eichenwald and E. P. Adams.

The Development of the Electromagnetic Theory.—In 1881, J. J. Thomson worked out the magnetic field due to a moving charged sphere. He supposed that the magnetic field was due to the displacement currents in the insulator surrounding the moving sphere. The energy of the magnetic field was proportional to the square of the velocity of the sphere, and J. J. Thomson pointed out that this energy would cause the sphere to have an apparent mass greater than its actual mass. The additional mass due to the energy of the field is now called the electromagnetic mass. J. J. Thomson supposed the velocity of the charged sphere to be small compared with that of light. The electric and magnetic fields when this is not the case were worked out later on Maxwell's theory by Oliver Heaviside and G. F. C. Searle. It was found that, as the velocity approaches that of light, the fields become concentrated near to the plane through the sphere perpendicular to its direction of motion. Horace Lamb, Heaviside and Lord Rayleigh considered the currents induced in conductors by rapidly alternating fields, and showed that the induced currents are confined to a layer near the surface of the conductor.

In 1883, FitzGerald (1851–1901) showed that, on Maxwell's theory, a coil carrying a rapidly alternating current should radiate electric waves into the surrounding space, and he suggested that the oscillatory discharge of a Leyden jar might be used to produce a sufficiently rapidly alternating current. Maxwell had shown that electric waves should travel with the velocity of light, but he had not suggested any way of producing such waves. FitzGerald's suggestion was thus of fundamental importance.

In 1884, John Henry Poynting published an important paper on the flow of energy in the electromagnetic field. Consider a tube of force in a magnetic field, and suppose that the strength of the field in the tube is increasing. Then, if we suppose that the energy density in a magnetic field of strength H is $\mu H^2/8\pi$, where μ is the permeability, the energy density in the tube will be increasing. Energy must therefore be flowing into the tube from outside. When H is increasing, however, there is an electric field round the tube, so that at the surface of the tube we have a magnetic field along the tube and a perpendicular electric field. We therefore conclude that there is a flow of energy in the electromagnetic field, where there is a magnetic field and a perpendicular electric field, and that the direction of the flow is perpendicular to the plane containing the two fields.

Poynting showed that the rate of increase of the electromagnetic energy inside a closed surface could be expressed, by using Maxwell's equations and Green's theorem, as a surface integral over the closed surface, which he took to represent the inward flow of energy. The elements of the integral were equal per unit area to $(1/4\pi)FH \sin\theta$ where F and H are the components of the electric and magnetic fields along the surface, and θ is the angle between F and H. The flow of energy, per unit area, per unit time, through the surface, is therefore equal to $(1/4\pi)FH \sin\theta$. This result is called Poynting's theorem and it is fundamental in modern electromagnetic theory. Poynting showed that, when power is transmitted along a pair of wires, the energy flows in the insulator between the wires, and not in the wires. The energy which gets into the wires is converted into heat and wasted.

Poynting and J. J. Thomson, following Faraday and Maxwell, were inclined to believe in the physical reality of the lines of force in electric and magnetic fields. When the number of unit tubes passing through a circuit increases, they supposed the increase must be due to tubes moving across the circuit from outside. J. J. Thomson in 1893 published an important treatise entitled *Recent Researches in Electricity and Magnetism*, in the first chapter of which he discussed electromagnetic theory from the point of view that the electromagnetic field consists of moving tubes of electric force. The magnetic field, he assumed, is a secondary effect due to the motion of the electric tubes.

The forces on currents in a magnetic field were explained by supposing that the moving tubes of electric force have momentum which they impart to a conductor when they are absorbed in it. J. J. Thomson showed that the momentum in the field is proportional to Poynting's flow of energy and in the same direction. This momentum in the field is called the electromagnetic momentum, and it is of fundamental importance in electromagnetic theory. Its presence in the field can be proved without assuming the existence of moving tubes of electric force, and the idea of such moving tubes, like the earlier dynamical models of the field, has not proved to be of permanent value.

Hertzian Waves.—About 1886, Heinrich Hertz (1857–1894),

a pupil of Helmholtz, began a series of researches which finally established Maxwell's theory of electric waves and light on a solid foundation. FitzGerald had shown theoretically how to produce electric waves, but no way of detecting such waves was known. Hertz discovered that the waves emitted by an electrical oscillation of very high frequency could be detected by means of a wire circuit with a very narrow gap in it. The waves induced electrical oscillations in the circuit, and, if the size of the circuit was properly chosen, the induced oscillations were sufficiently powerful to cause sparks to pass across the gap. Hertz's oscillator consisted of two conductors, connected by a straight wire with a spark gap in it. The conductors were charged oppositely, by an induction coil, so that sparks passed across the gap. Sparks were then obtained at the gap of the detecting circuit when it was at considerable distances from the oscillator. Hertz supposed that the electric charges oscillated from one side of the oscillator to the other through the sparks, and that these oscillations generated electric waves which were detected by the induced sparks in the detecting circuit. He showed that the waves could be stopped by metallic screens, and that they could be reflected and refracted like light waves. He found that standing waves could be obtained by reflecting a beam of the waves back at normal incidence on a plane reflector. He calculated the frequency of his oscillator, measured the distance between the nodes in the standing waves, so getting the wave length, and found that the product of the wave length and the frequency was equal to the velocity of light. The refractive index, for the waves, of a large pitch prism was found to be approximately equal to the square root of the specific inductive capacity of the pitch in accordance with Maxwell's theory.

In 1888, Hertz showed that the waves from his oscillators were plane polarized as was to be expected. The electric field in the waves is parallel to the wire joining the two conductors, and the magnetic field is perpendicular to the electric field. Both fields are perpendicular to the direction of propagation. In 1889, FitzGerald and Trouton examined the reflection of electric waves at the surface of an insulator and found that when the axis of the oscillator was in the plane of incidence and the angle of incidence had a certain value, then there was no reflection. On then turning the oscillator so that its axis was perpendicular to the plane of incidence, strong reflection was obtained. These results are analogous to those obtained when plane polarized light is reflected from glass. When the plane of polarization is perpendicular to the plane of incidence, the angle of incidence can be adjusted so that there is no reflection, and on turning the plane of polarization through a right angle there is strong reflection. FitzGerald and Trouton's results therefore show that the electric vibration in light is perpendicular to the plane of polarization.

Hertz's conclusions have been confirmed by many subsequent researches, and improved methods of generating and detecting electric waves have been developed. By using very small oscillators, electric waves only a fraction of a millimeter long have been obtained and studied, and from large oscillators waves many kilometers long can be obtained easily. The use of electric waves for signalling purposes was initiated in 1896, by Marconi in Italy, and has developed with remarkable rapidity. (*See* WIRELESS, COMMUNICATION BY; and BROADCASTING: *Technical Aspects.*)

Electrical Effects in Conductors.—In 1879, E. H. Hall of Harvard made an important discovery. He found that, when a conductor carrying a current is placed in a magnetic field, perpendicular to the current, an electromotive force is produced in the conductor, perpendicular to the current and to the magnetic field. This effect, known as the *Hall effect,* is small, and its direction and magnitude depend on the material of the conductor used. If the current density in the metal is i, and the strength of the magnetic field H, then there is a transverse force on the conductor equal to Hi per cubic centimetre. This force is presumably due to the force, on the moving electricity in the conductor, which is transferred in some way to the conductor. The transverse forces on moving electricity are in the same direction, for both the positive and negative charges if these move in opposite directions, and the Hall effect is generally believed to be produced in some way by these transverse forces. A satisfactory theory of the Hall effect, however, has not been developed. There is no Hall effect in liquid metals.

Several other related effects have since been discovered. The *Ettinghausen effect,* discovered in 1887, is a transverse temperature gradient, which accompanies the Hall effect in a conductor carrying a current in a transverse magnetic field. In 1856, Kelvin found that the electrical resistance of an iron wire is altered by a magnetic field. This effect has since been found to occur with any metal. The resistance is increased by a small amount proportional to the square of the field strength. The effect is especially large in bismuth. The *Nernst effect,* discovered in 1886, is a transverse electromotive force, produced in a conductor through which a current of heat is flowing in a transverse magnetic field. The *Righi-Leduc effect,* discovered in 1887, is the thermal analogue of the Hall effect. A transverse temperature gradient is produced in a conductor, along which heat is flowing, in a transverse magnetic field. The thermal conductivity of metals also is found to be slightly altered by a magnetic field.

In the electromagnetic theory of Maxwell and Hertz, the electrical properties of material bodies were taken into account by regarding them as continuous media having conductivity, specific inductive capacity and magnetic permeability. The values of these properties differ for different substances, and if they are known for the bodies present in a system, the theory enables the electrical phenomena to be expected in the system to be worked out. The theory has been developed since Hertz's time, by endeavouring to formulate a theory of the nature of material bodies, by means of which their electrical properties can be explained.

THE ELECTRON THEORY

The modern theory is called the *electron theory* and was first formulated by H. A. Lorentz, in 1892. It has since been developed by H. A. Lorentz himself and many other physicists. H. A. Lorentz assumed that there is no such thing as magnetism, but that all magnetic fields are due to currents. He supposed that material bodies contain enormous numbers of minute atoms of electricity, to which their electrical properties are due. These electrons are supposed to excite a field in the space around them. Lorentz regarded space as filled with a medium called the aether which he supposed was at rest, even inside a moving body. The electrons are supposed to be extremely small, so that, even in a dense substance like gold, they occupy only a minute fraction of the space. The electrical properties of the aether, or space, inside material bodies are supposed to be identical with those in empty space. Each electron is supposed to excite its field exactly as if the other electrons were not present, so that the resultant field at any point is simply the resultant, or vector sum, of the fields due to all the electrons present. If a point is selected at random in a material body, there will almost always be nothing at the point except the electromagnetic field excited by the electrons. If the point happens to be inside an electron, there will be at it a certain density of electricity in addition to the electromagnetic field. The electrical properties of material bodies are due to the electrons in them. When these properties are measured, the values obtained are average values over volumes containing enormous numbers of electrons. It is impossible to examine the microscopic structure of the distribution of the charges and field in a piece of matter.

Lorentz first obtained the electromagnetic equations for space, or aether, containing nothing but electricity and the field which it excites, and then showed how these equations could be transformed into equations expressing the relations between the average values which can be observed experimentally. He supposed that conductors contain some free electrons which drift along in an electric field, so producing a conduction current. The electrons in insulators, he supposed, are not free, but are acted on by restoring forces proportional to the displacement of the electrons from their equilibrium positions. Lorentz supposed that the field excited by an electron is propagated out from it with the velocity, c, of light in empty space. Thus the field due to a charge at a point P, at a time t, is not the field excited by the charge at the time t, but that excited by the charge at the time $t-r/c$, where r

is the distance of the charge from P at the time $t-r/c$. The distance r is different for different parts of an electron, and this has to be taken into account.

Lorentz applied his theory to the problem of optical and electrical phenomena on a moving system, *e.g.*, the earth, which is moving through space. He showed finally that no observable effects were to be expected, which was in agreement with all experimental results. The fact that no effects due to the motion of the earth through space can be detected is the basis of Einstein's *theory of relativity*, which may be regarded as a development of H. A. Lorentz's electromagnetic theory. (*See* RELATIVITY.)

According to the electron theory, the dielectric current in an insulator is the sum of the dielectric current which would be obtained in a vacuum and that due to the displacement of the electrons. When an insulator is moving in a magnetic field, there is a force on the moving electrons which produces a displacement, but there is no effect on the aether or space, since it is not supposed to move. The induced electromotive force in an insulator, moving in a magnetic field, is therefore less than that to be expected on Hertz's theory, according to which the aether was supposed to move with the moving body. It can be shown, by the electron theory, that the induced electromotive force in an insulator, moving in a magnetic field, is equal to that in a conductor multiplied by the factor $(K-1)/K$, where K is the specific inductive capacity of the insulator. According to the Maxwell-Hertz theory, the induced electromotive force should be equal to that in a conductor. It was shown experimentally, by H. A. Wilson in 1905, that the induced electromotive force in an insulator, moving in a magnetic field, is equal to $(K-1)/K$ of that in a conductor, in agreement with the electron theory.

H. A. Lorentz regarded the negative electrons as small spheres, of negative electricity, which he supposed contracted, in the direction of motion, into spheroids when they moved. He calculated the electromagnetic momentum of such an electron, and showed that the corresponding mass, m varied with the velocity, according to the formula

$$m=m_0/\sqrt{1-v^2/c^2};$$

where m_0 is the mass when at rest, v the velocity of the electron, and c that of light in a vacuum. It was shown later that the mass actually does vary with the velocity in this way, but this is not now regarded as supporting H. A. Lorentz's conception of an electron, because it is believed that the mass of any kind of particle must vary with its velocity in the same way.

CONDUCTIVITY OF SOLUTIONS

Knowledge of the conductivity of salt solutions has been advanced by several observers since Faraday discovered his laws of electrolysis. A gram molecule, or mol, of a salt is a quantity of the salt equal to its molecular weight in grams. Consider a solution containing m gram molecules of a salt per cu.cm. When a current is passed through the solution, part of the salt, the anion, is deposited on the anode, and part on the negative electrode, or cathode. The quantity of electricity required to deposit one gram molecule of the anion, or the cation, is proportional to the chemical valency of the ion. Let F denote the amount of electricity required to deposit one gram molecule, or mol, of a univalent ion, so that the amount of electricity associated with one mol of an ion of valency V is VF.

The amount of electricity required to electrolyze one gram molecule of a salt is always some multiple, N, of F, depending on the valency of the ions. N may be called the valency of the salt, and the molecular weight of the salt divided by N is called a gram equivalent of the salt. In the solution containing m mols of salt per cu.cm., the charge associated with the anion is $-mNF$, and that with the cation is $+mNF$. When a current is passed through the solution, the anion moves towards the anode, and the cation towards the cathode. The velocities are proportional to the electric field strength, X, so that, if u is the velocity of the anion, due to unit field, and v that of the cation, then $i=XmNF(u+v)$, where i denotes the current density. If M denotes the number of gram equivalents of the salt per cu.cm., $M=mN$, so that $i=XMF(u+v)$. The velocities u and v here are the average velocities for all the anion and cation molecules; if at any instant some are not charged, and so not moving, the velocities of those which are charged will be greater than u and v.

If the solution is contained in two vessels connected by a tube and the anode is put in one and the cathode in the other, then, when a current is passed, the relative amounts of the anion and cation which pass through the tube will be proportional to the velocities u and v. These amounts can be determined by analysing the solutions in the two vessels, so that the ratio u/v can be found. In this way Hittorf, during the years 1853–1859, determined the ratio u/v for many salts.

In 1876–77, Kohlrausch (1840–1910) determined the specific conductivities of a great many salt solutions. He found that if m denotes the mols per cu.cm. in a solution of any salt, and k its conductivity, then, as m is diminished, the ratio k/m increases but becomes constant for dilute solutions. The conductivity is equal to the current density i divided by the electric intensity, X, and so is equal to $mNF(u+v)$. For dilute solutions of different salts, Kohlrausch found that the values of k/m, or $NF(u+v)$, could be expressed as the sums of two numbers, one for the anion and one for the cation. Since N and F are known, Kohlrausch's measurements enabled $u+v$ to be calculated, and so, with Hittorf's values of u/v, both u and v were determined.

In 1887, Arrhenius suggested that in dilute salt solutions the salt is completely dissociated into ions. For example, in a dilute solution of sodium chloride, NaCl, there are no molecules of NaCl but only positively charged sodium atoms, Na^+, and negatively charged chlorine atoms, Cl^-. These charged atoms, or ions as they are now called, have chemical properties quite different from those of the uncharged substances. For example the Na^+ ions do not act chemically on water as metallic sodium does. By means of this theory Arrhenius explained the results of Hittorf and Kohlrausch, and his theory has since been confirmed by many other experimental investigations. (*See* ELECTROLYSIS.)

ELECTRICAL RADIATIONS

The electric sparks which pass through the air between oppositely charged conductors when they are brought near together attracted attention in very early times. When Franklin showed the identity of atmospheric electricity and ordinary electricity lightning came to be regarded simply as enormous electric sparks.

Electricity in Gases.—In 1752 Watson passed electricity through a partially exhausted tube, three feet long and three inches in diameter, and found that the discharge passed much more easily than in air at atmospheric pressure and presented a very different appearance. The sparks became thicker and fainter, and looked like flame. In 1838 Faraday observed that when a discharge is produced in rarefied air the negative electrode is covered with a glowing layer which is separated from a glowing column extending from the positive electrode by a dark space. This dark space is known as the Faraday dark space. The layer at the negative electrode is called the negative glow and the luminous column extending from the positive electrode is called the positive column.

The invention of mercurial air-pumps about 1850 enabled higher vacua to be obtained, and the electric discharge through gases was soon examined in much higher vacua than hitherto by Geissler, Plücker and Hittorf. It was found that as the pressure was reduced the negative glow became thicker and moved away from the negative electrode, leaving a well defined dark space between the electrode and the glow. This dark space, which is now called the Crookes dark space, becomes wider as the pressure is reduced, and, when its boundary gets near to the glass walls of the discharge tube, the glass emits a greenish light. The distribution of this light on the glass is altered when a magnet is brought near. Hittorf in 1869 placed a solid body in the Crookes dark space, between the cathode and the glass, and found that it cast a sharply defined shadow in the light emitted by the glass. He concluded that the cathode emits rays in straight lines, which cause the glass to glow where they fall on it. These rays are known as the cathode rays. Goldstein in 1876 showed that the cathode rays proceed from the cathode in directions perpendicular to its surface, so that, for example, a plane cathode emits a parallel beam of the

rays. Cromwell Varley in 1871, suggested that the cathode rays consist of negatively charged particles.

The cathode rays were investigated with great skill by Sir William Crookes about 1879. He reduced the pressure in his discharge tubes until the Crookes dark space filled the whole tube, and devised several beautiful experiments to illustrate the properties of the rays. Crookes showed that the rays can be concentrated on a small area, by using a concave cathode, and that a body placed near the centre of curvature of the cathode becomes intensely heated. He found that the rays cause bright phosphorescence of many substances, notably zinc and calcium sulphides and calcspar. He showed that a narrow beam of the rays can be obtained by passing them through a slit. Such a narrow beam is deflected by a transverse magnetic field, just as a flexible conductor, carrying a current flowing towards the cathode, would be deflected. Crookes adopted Varley's view that the cathode rays are rapidly moving negatively charged particles.

Hittorf had found that cathode rays can pass through very thin metal foil, and their penetrating power was thoroughly investigated in 1894 by Lenard, who obtained results of fundamental importance. He found that the mass per sq.cm. of a layer which stops one half of the rays is nearly the same, whatever the nature of the matter of which the layer is made. For example the mass is nearly the same for a layer of air and for one of gold. Lenard found that the rays could be passed out into the air through a small window of aluminium foil, in the wall of the discharge tube, and could penetrate through air at atmospheric pressure for several centimetres. If the cathode rays consist of negatively charged atoms it is hard to see how they can have such penetrating power, so Lenard and other observers were inclined to regard them as some form of aethereal vibration analogous to light.

Crookes' celebrated experiments on cathode rays aroused general interest, among physicists, in the passage of electricity through gases, and attempts were soon made to formulate a general theory of the nature of gaseous conduction of electricity. Faraday's laws of electrolysis show that the charge associated with the ions in solution is always a multiple of the same quantity of electricity, the ionic charge, and in 1881 Helmholtz revived this idea of Faraday's, and pointed out that, if it is admitted that elementary substances are composed of atoms, we can scarcely avoid the conclusion that electricity is also made up of equal atoms. It was natural to suggest that conduction through gases is analogous to conduction through salt solutions, and that conducting gases contain positively and negatively charged particles, or ions, which move in opposite directions in an electric field, so producing a current. W. Giese of Berlin in 1882 definitely put forward such a theory, and applied it very successfully to the explanation of the electrical conductivity of the gases from a flame. He supposed that some of the molecules in a flame dissociate into two parts, one positively charged and the other negatively charged, and that the conductivity of the flame and the gases coming from it is due to the presence of these ions. The gradual disappearance of the conductivity as the gases moved away from the flame, Giese attributed to the recombination of the ions, and he showed that, when the conducting gas was passed through a strong electric field, its conductivity disappeared. He explained this by supposing that the positive ions were attracted to the negative electrode, and the negative ions to the positive electrode, so that the ions were removed from the gas as it passed through the field.

Similar ideas were developed by Schuster in 1884 to explain the conductivity of gases at low pressure. He showed that, when a discharge is passed between electrodes near one end of a discharge tube, the gas near the other end of the tube becomes conducting, and he attributed this to the diffusion of ions formed in the discharge throughout the gas in the tube. In 1887 Hertz discovered that ultra-violet light facilitates the passage of sparks between two oppositely charged electrodes. It was soon found that the effect is due to the light which falls on the negative electrode, and that, when ultraviolet light falls on a negatively charged conductor, the negative electricity escapes from the conductor through the surrounding gas. The light has no action on a positively charged conductor. (*See* PHOTOELECTRICITY.)

X-rays.—In 1895 W. C. Röntgen of Munich discovered a new kind of radiation now known as X-rays, or Röntgen rays. Röntgen found that when cathode rays strike a solid body the new radiation is emitted. The X-rays travel in straight lines and are remarkably penetrating. They affect a photographic plate, and cause certain substances to fluoresce brightly. They pass through light bodies, like wood or aluminium, with little absorption and without appreciable deviation. The absorption of the X-rays is nearly proportional to the density of the absorbing substance. If, for example, the X-rays from a point source are passed through a man's hand, and then fall on a fluorescent screen, a shadow of the hand is obtained, in which the bones can be seen sharply outlined.

In 1881 J. J. Thomson pointed out that, according to Maxwell's electromagnetic theory, the sudden stopping of rapidly moving charged particles, such as the cathode rays were supposed to be, should produce electromagnetic waves like light, and he suggested that the fluorescent light emitted by glass, when struck by the cathode rays, was caused by such electromagnetic radiation emitted by the cathode rays. Soon after the discovery of X-rays Schuster, Wiechert and Stokes independently suggested that they are very short light waves produced in the manner predicted fifteen years earlier by J. J. Thomson. This theory has since been abundantly verified, and the study of X-rays has developed into a most fruitful and interesting branch of Optics. (*See* RÖNTGEN RAYS.)

In 1896, J. J. Thomson found that, when X-rays are passed through any insulator, they render it conducting. J. J. Thomson and E. Rutherford, working together, investigated the conductivity of gases due to X-rays, and they showed that it could be explained in the same way as the conductivity of the gases from flames had been explained by Giese in 1882. It was supposed that the X-rays caused the gas molecules to dissociate into positively and negatively charged particles, or ions, which moved through the gas in opposite directions in an electric field, so causing an electric current through the gas. Thomson and Rutherford further supposed that the positive and negative ions in a gas will attract each other, and so tend to meet and combine, so disappearing. This process is called recombination. The number of pairs of ions which disappear in this way is proportional to the product $n_1 n_2$, where n_1 is the number of positive ions per cu.cm. in the gas, and n_2 the number of negative ions. It may be put as $\alpha n_1 n_2$, where the constant α is called the coefficient of recombination. Thomson and Rutherford showed that the relation between the current i and the potential V agreed nearly with the equation

$$qde-i=\frac{\alpha d^3 i^2}{e(k_1+k_2)^2V^2}$$

where d is the distance between the parallel plates used as electrodes, and k_1 and k_2 are the mobilities of the ions, defined so that the velocities of the positive and negative ions in a field of strength F are k_1F and k_2F respectively. Ingenious methods of measuring α, k_1 and k_2 were soon devised by Rutherford, J. Zeleny, P. Langevin and many others, and the ionic theory of gaseous conduction became firmly established in a few years. (*See* ELECTRICITY IN GASES.)

The problem as to the nature of the cathode rays was finally solved in 1897, with epoch-making results. The idea, derived from Faraday's work on electrolysis, that electricity consists of equal indivisible atoms was generally believed to be probably true, and it was supposed that the charges on gaseous ions were equal, like the charges on ions in solutions, to small multiples of the charge of one electric atom. The ratio of the quantity of electricity, required to deposit any mass of an ion in electrolysis, to this mass is equal to the ratio of the charge to the mass of one ion. It was known that 96,500 coulombs is required to deposit one mol of any univalent ion. The ratio of the charge to the mass for any ion of molecular weight, M, is therefore equal to $9{,}650/M$ electromagnetic units of charge per gram. For an hydrogen ion, the lightest atom known, the ratio is 9,650 since for hydrogen $M=1$ approximately. According to the view that cathode rays are negatively charged particles, and that electricity is atomic, we should expect

the ratio of the charge, e, to the mass, m, of cathode ray particles to be not much greater than e/m for hydrogen ions, or 9,650 electromagnetic units per gram. Schuster, about 1884, had tried to estimate e/m for cathode rays from their deflection by a magnetic field, and some of his results indicated values much larger than 9,650, but he believed the rays to be charged atoms, and supposed the large values of e/m to be erroneous.

In 1897 reliable methods of estimating e/m for cathode rays were devised and carried out independently by E. Wiechert, W. Kaufmann and J. J. Thomson. Kaufmann measured the potential difference, P, between the anode and cathode of his discharge tube, and deflected the cathode rays by means of a uniform magnetic field of known strength, H. The kinetic energy of the rays, $\frac{1}{2}mv^2$, is equal to Pe, and, since the transverse force on a charged particle moving perpendicular to a magnetic field H is equal to Hev, we have $Hev=mv^2/r$, where r is the radius of the path of the rays in the field. The equations $Pe=\frac{1}{2}mv^2$ and $He=mv/r$ give $e/m=2P/H^2r^2$ and $v=2P/Hr$. Kaufmann measured P, H and r, and so determined e/m and v. He found that e/m was about 2×10^7 electromagnetic units per gram, and that the velocity of the rays was of the order of one-tenth that of light. J. J. Thomson obtained quite similar results by several ingenious methods. (*See* ELECTRICITY IN GASES and ELECTRON.) He showed that e/m is the same, with cathodes of different metals and with different gases in the discharge tube. Shortly afterwards J. J. Thomson and Lenard independently measured e/m for the electrically charged particles emitted by metals when exposed to ultra-violet light, and J. J. Thomson measured the ratio for the negative charge escaping from hot bodies in a vacuum. In both cases it was found nearly equal to that for cathode rays.

Lecturing at the Royal Institution on April 30, 1897, J. J. Thomson pointed out that it is impossible to explain Lenard's results on the penetrating power of cathode rays by supposing that they are charged atoms, and that it is therefore necessary to assume that they are much smaller than atoms. If we assume that the charge on a cathode ray particle is equal to that on a monovalent ion in solution, *i.e.*, to one atom of electricity, it follows, since $e/m=2\times10^7$ for cathode rays, and $e/m=9{,}650$ for hydrogen ions, that the mass of the cathode ray particles is only $\frac{1}{2000}$ of that of one hydrogen atom. The cathode rays therefore appear to consist of negatively charged particles much lighter than the atoms of any element. They can be obtained from different kinds of matter, and must therefore be one of the constituents of ordinary matter. That the cathode rays carry a negative charge was proved by Perrin, and by J. J. Thomson, by collecting them in an electrode, which received a negative charge. It was also shown that they are deflected towards the positive electrode in an electric field. J. J. Thomson's views on the nature of cathode rays have been abundantly confirmed by subsequent researches. Wiechert and Kaufmann put forward similar views at nearly the same time, and so share with J. J. Thomson the honour of the great discovery which may be said to be the starting point of a new era in modern physics. FitzGerald pointed out that J. J. Thomson's cathode ray particles might be regarded as the negative electrons of H. A. Lorentz' electron theory; this suggestion has proved to be correct and cathode ray particles are now usually called electrons.

Since matter contains these electrons, it is natural to suppose atoms are built up out of them and positive electricity. J. J. Thomson rapidly developed a theory of the constitution of atoms, according to which an atom consists of a definite amount of positive electricity, together with enough electrons to make the atom electrically neutral. He supposed the electrons to describe orbits in the atom, or to oscillate about positions of equilibrium. The number of electrons in an atom, J. J. Thomson supposed, increases with the atomic weight. He supposed that the electrons are arranged in groups, or layers, and that the chemical properties of the atom are largely determined by the number of electrons in the outermost layer. The chemically inert atoms helium, neon, argon, xenon and krypton, J. J. Thomson supposed, contain especially stable arrangements of electrons. An atom with one electron less than an inert atom tends to attract an additional electron, so becoming negatively charged, while an atom with one more electron easily loses an electron, so becoming positively charged. Atoms which easily lose an electron combine readily with atoms which tend to acquire an electron. In this way J. J. Thomson was able to explain many of the properties of atoms, and especially the way in which their properties vary periodically with the atomic weight. The general validity of these ideas has since been abundantly confirmed, and J. J. Thomson is generally regarded as the founder of the modern theory of the constitution of atoms. (*See* ATOM.)

Positive Rays.—Goldstein in 1886 had observed that, if a small hole is made in the cathode of a highly exhausted discharge tube, rays pass through the hole, moving in the opposite direction to the cathode rays. These rays were shown by Wien, in 1897, to consist of positively charged particles. The value of e/m for these positive rays was found to be of the same order as e/m for the ions in solutions. For example, in hydrogen, Wien got positive rays for which e/m was about 9,650 as for hydrogen ions. These positive rays are therefore regarded as positively charged atoms, or atoms which have lost one or more electrons. They have since been thoroughly investigated by Wien, J. J. Thomson and F. W. Aston, and results of immense importance have been obtained. Aston in 1919 developed a very accurate instrument, called the *mass spectrograph*, by means of which it is now possible to determine e/m for positive rays to within one part in ten thousand. He has determined the ratio m/e for the positive rays of many elements, and finds that, taking m/e for oxygen equal to 16, the values for other elements are always equal to integers, or, in the case of rays which have lost more than one electron, to integers divided by the number of electrons lost. It thus appears that all atomic weights are almost exactly integers, when $O=16$ is taken as the standard. Elements for which the chemical atomic weight is not an integer are mixtures of atoms having identical chemical properties, but different atomic weights. For example chlorine is a mixture of atoms of atomic weights 35 and 37, its chemical atomic weight being 35·46. Atoms having the same chemical properties but different atomic weights are called *isotopes*. (*See* ISOTOPES; and POSITIVE RAYS.)

Formation of Clouds on Ions.—In 1887 Helmholtz showed that the gas, through which an electric discharge has just been passed, causes condensation of supersaturated steam. In 1896, C. T. R. Wilson found that the ions, produced in moist air by X-rays, give rise to a cloud when the air is suddenly expanded (to produce supersaturation of the water vapour in it). The cloud consists of minute drops of water formed by condensation on the ions. In this way it is possible to study the distribution of the ions in the air, and C. T. R. Wilson has obtained many results of extraordinary interest. For example, when a narrow beam of X-rays is passed through the air, it is found that the ions formed are not uniformly distributed along the beam, but lie on narrow curved tracks. These tracks begin in the X-ray beam, and curve about in an irregular manner, finally ending in a cluster of ions. It is supposed that the X-rays cause the ejection of an electron, from an atom, with high velocity, and that this electron moves through the air, ionizing the atoms which it strikes until it is brought to rest. Thus C. T. R. Wilson's method enables the path of a single electron through the gas to be examined and photographed. (*See* ELECTRICITY IN GASES; and NUCLEUS.)

The formation of clouds on the ions in a gas makes it possible to determine the charge on one ion, or the charge of the atom of electricity. Such a determination was first made by J. S. Townsend in 1897. The weight of the droplets in the cloud was found by observing the rate at which they fell through the air. Sir G. G. Stokes had worked out the force on a small sphere, of radius a, moving with uniform velocity, v, through a medium of viscosity μ, and found it equal to $6\pi\mu av$. In the case of a droplet of radius a and density ρ, falling with uniform velocity v, we have, therefore, $6\pi\mu av=\frac{4}{3}\pi a^3\rho g$, where g is the acceleration of gravity. Townsend obtained a charged cloud in a gas, and determined its total charge, total mass and the mass of the individual droplets, and so was able to calculate the average charge per drop, which was about 3×10^{-10} electrostatic units of electricity. He later found

that some of the drops were positively and some negatively charged, and, allowing for this, found the average charge to be 5×10^{-10} electrostatic units. The charged clouds used by Townsend were obtained by passing the gases, evolved by the electrolysis of dilute sulphuric acid, over water. A similar investigation was carried out in 1898, by J. J. Thomson, on the clouds obtained by condensation of water on the ions produced in air by X-rays. He found the charge per drop to be about 6×10^{-10} electrostatic units.

A different method of finding the charge on the droplets was used by H. A. Wilson in 1903. The cloud of droplets was formed between two horizontal metal plates between which a vertical electric field could be maintained. The velocity with which the droplets fell was determined, both with and without the electric field. If v_1 is the velocity without any field, and v_2 that in a field F, then we have $\frac{v_1}{v_2}=\frac{mg}{mg+Fe}$, where e is the charge on the droplet and m its mass; m can be calculated from v_1, and so the value of e can be obtained. In this way it was found that drops were present, having charges nearly as 1:2:3, and this was explained by supposing that some drops carried one atom of electricity, and others two or three. Accurate results could not be obtained, mainly because the drops evaporate, so that m does not remain constant.

About 1910 an accurate determination of the ionic charge, e, was made by R. A. Millikan, who eliminated the error due to evaporation, by using droplets of oil. He was able to keep a single drop suspended in a vertical electric field for several hours, and to vary its charge by ionizing the air near it by X-rays. He showed that the charge on such a drop was always equal to a definite charge e multiplied by an integer which was varied from 1 to 15, or more. In this way Millikan finally found $e=4{\cdot}774\times10^{-10}$ electrostatic units, and his result is believed to be correct to about one part in one thousand. Independent values of the ionic charge, e, have been deduced from the observed distribution of the energy in the spectrum of black body radiation, and from direct measurements of the charge carried by α-rays, which are believed to be atoms of helium with a charge $2e$. These determinations agree well with Millikan's result. (*See* ELECTRON.)

Radioactivity.—A discovery of fundamental importance was made in 1896 by Henri Becquerel. He found that uranium and its compounds emit penetrating radiations, which can pass through considerable thicknesses of matter, and which affect a photographic plate, and produce conductivity in gases. This property of uranium is called radioactivity. This discovery excited great interest, and other elements were soon found which, like uranium, emit rays. Schmidt and Madame Curie in 1898 found thorium to be radioactive, and in the same year Madame Curie discovered two new intensely radioactive elements, in the mineral pitchblende, which she named polonium and radium.

In 1899 E. Rutherford showed that the rays from uranium are not all of the same kind. Part, which he called the α-rays, are very easily absorbed, and the rest, which are much more penetrating, he called the β-rays. Giesel, Becquerel and others found that the β-rays are deflected, by a magnetic field, in the same way as cathode rays, and Curie showed that they carry a negative charge. Becquerel showed that they are also deflected by an electric field, and that the ratio of the charge they carry to their mass is of the same order as for cathode rays. It was thus clear that the β-rays are high velocity electrons, a conclusion since abundantly confirmed. The properties of the α-rays have been investigated by Rutherford, W. H. Bragg and others, and it has been shown that they consist of helium atoms which have lost two electrons and so have a positive charge $2e$. A third type of radiation from radioactive elements was discovered by Villard in 1900. These rays are called γ-rays and are found to be of the same nature as X-rays, *i.e.*, they are electromagnetic waves of extremely small wave lengths. They are much more penetrating than the β-rays and than ordinary X-rays. The theory of radioactivity which is now accepted was put forward by Rutherford and Soddy in 1902. According to this theory, the atoms of radioactive elements decompose, with the emission of radiation, forming new atoms having different chemical properties. The atoms originally present, therefore, gradually diminish in number, so that finally none of them remain. For example it is found that one half of any number of atoms of radium decompose in 1,690 years. (*See* RADIOACTIVITY.)

When a narrow beam of α-rays is passed through a thin metal sheet, it is found that a few of the rays are deviated, or scattered, through large angles up to 180°. Rutherford showed that this scattering through could be exactly explained by supposing that the rays were deviated by passing very close to fixed positive point charges which repelled them. He was thus led to propose his nucleus theory of atoms, according to which an atom consists of a minute positively charged nucleus surrounded by a number of electrons describing orbits around it. This theory differs from that of J. J. Thomson, who supposed the positive electricity to be distributed over the whole volume of the atom. (*See* NUCLEUS.)

Characteristic X-rays.—Very soon after Röntgen's discovery of X-rays it was shown by Perrin that they excite the emission of similar secondary rays when they fall on matter. These secondary X-rays were carefully investigated by Barkla, who showed that elements of small atomic weight merely scatter the incident rays, whereas elements of higher atomic weight emit rays, different from the incident rays, and having properties characteristic of the emitting element. These characteristic X-rays can be obtained also by bombarding the element with high speed electrons. In 1912 Laue made a suggestion of fundamental importance. He proposed to pass a narrow beam of X-rays through a crystal, and suggested that the regular arrangement of the atoms in the crystal would result in diffracted beams of X-rays coming out in different directions, in much the same way as when light is diffracted by a grating. It was found that such is the case, and that, by studying the diffraction of X-rays by crystals, it is possible to determine both the wave lengths of the rays and the structure of the crystal. The study of crystals by this method has led to a great advance in our knowledge of their structure, largely as the result of work carried out by W. H. Bragg and his son W. L. Bragg. (*See* X-RAY.)

Since 1912 the wave lengths of the X-rays emitted by different elements have been measured accurately, and it is found that each element has a characteristic X-ray spectrum which may be regarded as a continuation of its spectrum in the visible and ultraviolet regions. H. G. J. Moseley in 1913 first measured the wave lengths of the X-rays emitted by a series of elements, and found that the wave lengths of corresponding lines in the X-ray spectra varied in a regular way with the atomic weight. He found that the square root of the frequency of vibration of the X-rays was a linear function of the atomic number of the element, the atomic number being the number giving the position of the element in a list of the elements in the order of their atomic weights. It was clear that the atomic number represents some fundamental physical property of the atoms. On Rutherford's nucleus theory, a neutral atom having N electrons describing orbits round the nucleus must have a nucleus with a positive charge Ne, where e denotes the ionic charge, since $-e$ is the charge on one electron. The only possible values of N are the integers 1, 2, 3, 4, . . . , and we should expect the atomic weight to increase with N, so that it was natural to conclude that the atomic number is equal to N. According to this $N=1$ for hydrogen, $N=2$ for helium, $N=3$ for lithium, and so on for all the other elements up to uranium for which $N=92$. This idea, suggested by Moseley's results on X-ray spectra, has proved of great value and is believed to be correct.

Radiation and the Quantum Theory.—One of the fundamental problems of modern physics is the explanation of the frequencies of the spectral lines emitted by the different elements. For most elements, the lines emitted are numerous, and have wave lengths ranging from the order of one Ångström unit, or 10^{-8}cm., for X-ray lines, up to many thousand Ångström units, for infrared lines. The problem is to show how an atom, consisting of a positive nucleus with a charge Ne and N electrons describing orbits round it, can emit the observed spectral lines having definite

invariable frequencies. Considerable progress towards the solution of this problem has been made, in recent years, by means of the quantum theory of spectra proposed by N. Bohr in 1913. Bohr's theory may be regarded as a development of the quantum theory of black body heat radiation put forward by Max Planck in 1900. The essential feature of Planck's theory was the assumption that the energy of an atom does not vary continuously, but can only have certain discrete values. In the case of an electron oscillating with frequency ν Planck supposed that its energy must be some multiple of a quantity proportional to ν. According to this, the energy E is given by $E=nh\nu$, where h is a constant and $n=0, 1, 2, 3, \ldots$. Bohr adopted this idea, and introduced the additional assumption that, when the energy of an atom changes from one of its possible values, E_n, to another smaller value, E_m, the difference is emitted as radiation of frequency ν, given by the equation $h\nu=E_n-E_m$. It was known that the frequencies of many spectral lines could be represented as the differences between two more fundamental frequencies, and Bohr's theory has proved of immense value. (*See* ATOM; SPECTROSCOPY; and QUANTUM THEORY.)

Since the radiation is emitted in amounts, $h\nu$, proportional to the frequency, this suggests that radiation is made up of elements, or quanta of energy, equal to $h\nu$. As we have seen, when ultra-violet light falls on solid bodies it causes the emission of electrons. Einstein in 1905 suggested that these electrons were ejected by the action of the quanta in the light, and that the kinetic energy of the electrons should be equal to $h\nu-A$, where A is a constant equal to the energy required to get an electron out of the solid. It was shown by O. W. Richardson and K. T. Compton, and independently by A. Ll. Hughes, in 1912 that the maximum energy of the electrons emitted is nearly equal to $h\nu-A$, and later more exact experiments by Millikan have proved Einstein's suggestion to be accurately true. In the case of X-rays, the frequency, ν is so large that A is negligible and the electrons are emitted with maximum energy $h\nu$, almost exactly. As we have seen, when electrons strike a metal target, X-rays are emitted. It was shown by Duane in 1917 that the greatest frequency, ν, of the X-rays emitted is given by $E=h\nu$, where E is the kinetic energy of the electrons.

A. H. Compton, in 1922, showed that, when X-rays are scattered by light elements, the frequency of the scattered is slightly less than that of the incident rays. The change of wave length is the same for all frequencies. Compton has shown that this effect can be accurately explained by supposing that the rays consist of quanta having energy and momentum, and that, during the interaction between the quantum and electron, the energy and the momentum are conserved. The quantum thus loses some energy, and so its frequency is diminished since its energy is equal to $h\nu$. (*See* COMPTON EFFECT.)

In recent years modifications of the quantum theory have been proposed, which promise eventually to make it intelligible. The idea that radiations such as light and X-rays, which obey all the laws of wave motion, may nevertheless consist of some sort of particles, or quanta, seems at first sight absurd. The electromagnetic field of which radiation consists, however, possesses energy and momentum, and so has the essential properties of matter, which suggests that radiation and material particles are really of the same nature.

Early in the 19th century Hamilton showed that the path of a particle in the field of force is determined by laws which can be expressed in the same mathematical form as those which determine the path of a ray of light in a medium, the refractive index of which varies from point to point. L. de Broglie, in 1925, suggested that a train of waves is associated with an electron, and moves along with it. The group of waves moves with the electron, but the waves in the group move with a different velocity, appearing at one end of the group and dying away at the other end. The wave velocity is thus not the same as the group velocity, just as is the case for waves of any kind in a medium in which the wave velocity depends on the wave length.

Wave Mechanics.—L. de Broglie's ideas have been developed by Heisenberg Schrödinger and Dirac who suppose that an electron actually consists of a train of waves. An atom is therefore pictured, in this new wave mechanics, as a positive nucleus surrounded by a continuous distribution of negative electricity which oscillates with definite frequencies. The radiation emitted is determined by the acceleration of the electricity, in accordance with the classical electromagnetic theory.

An isolated electron is regarded as a group of waves, and its path is determined by the laws of geometrical optics. Just as these laws suffice for large scale optical phenomena, but fail to account for interference and diffraction, so in the wave mechanics of atoms it appears that the individual electrons, or groups of waves, cannot be regarded as separated and describing orbits, but must be supposed to overlap, so that, instead of isolated electrons, we have a vibrating medium filling up all the space around the nucleus. The results deduced from the wave mechanics theory of atoms appear to agree with the facts of spectroscopy as well, or better, than the results deduced from Bohr's quantum theory. Wave mechanics may be said to provide a rational interpretation of the assumptions of the quantum theory of spectra, and much may be expected from this new theory. A remarkable experimental confirmation of the view that an electron may be regarded as a train of waves was carried out by C. J. Davisson in 1927. He found that a beam of cathode rays, falling on a crystal, gives diffracted beams in different definite directions, just as X-rays do. (*See* QUANTUM THEORY.)

IONICS

Since J. J. Thomson, in 1896, applied the ionic theory to the conductivity produced in gases by X-rays, it has been used, more or less successfully, for the explanation of every kind of gaseous conduction.

Conductivity of Flames.—The conductivity of flames has been studied by Arrhenius, A. Smithells, H. M. Dawson, H. A. Wilson, E. Marx, Lenard, Andrade, Moreau and other physicists. H. A. Wilson in 1899 showed that the negative ions in flames have a much greater mobility than the positive ions. The velocity of the positive ions is only a few centimetres per second due to one volt per centimetre, as first shown by Andrade, while that of the negative ions is about 4,000cm. per second. The negative ions in flames are therefore supposed to be free electrons and the positive ions charged atoms. The conductivity of alkali salt vapours in flames was shown by A. A. Noyes and H. A. Wilson, in 1922, to agree with that calculated by assuming that the salts are dissociated into the metal vapour which in turn partially dissociates into electrons and positively charged metal atoms. The theory of the dissociation of metal vapours into electrons and positively charged atoms was worked out in 1920 by Saha, who used it successfully to explain many results on the spectra of the sun and other stars. (*See* ELECTRICITY IN GASES.)

Ionization by Collision.—The motion of ions in gases, due to diffusion and to electric fields, has been very thoroughly studied by J. S. Townsend and his co-workers, and results of great importance obtained. It is found that the velocity of the ions, due to a field X, in a gas at pressure p, depends on X/p. In the case of the positive ions it is proportional to X/p, but in the case of the negative ions it increases more rapidly than X/p, and becomes very large when X/p is large. It appears that, when X/p is large, the negative ions are free electrons. When the velocity of these electrons is great enough, they ionize the gas by collisions with the molecules. The positive ions also appear to ionize the gas molecules in intense electric fields, and Townsend has shown that the production of sparks and continuous electric discharges through gases can be explained by ionization by collision. (*See* ELECTRICITY IN GASES.)

Critical Potentials of Atoms.—A new method of investigating the ionization of gases by rapidly moving electrons, introduced by Lenard in 1902, has led to results of fundamental importance. In Lenard's experiment, electrons, emitted by a hot wire or a plate illuminated by ultra violet light, in a gas at a low pressure, were accelerated by an electric field towards a wire grating. Some of the electrons passed through the grating and, if their velocity was great enough, ionized the gas on the other side of the

grating. This ionization was detected by means of an electrode, which was charged negatively and so repelled the electrons coming through the grating, so that they could not reach it. If the gas between the grating and the electrode was ionized by the electrons, the positive ions were attracted to the electrode, and so could be detected. The potential difference, P, between the source of the electrons and the grating was gradually increased, and it was found that there was no ionization until it was equal to a definite value depending on the nature of the gas. The value of P at which the electrons begin to ionize the gas is called the ionization potential of the gas molecules. It is found that in many cases the gas is caused to emit radiation when P is less than the ionization potential. The potential difference required to cause the gas to emit radiation of a definite wave length is called the radiation potential of the gas molecules for that wave length. The radiation and ionization potentials for many different elements and compounds have been determined by Franck and Hertz, A. Ll. Hughes, F. Horton, K. T. Compton, Foote and Mohler, and others. These potentials are called the critical potentials of the atoms or molecules.

According to the quantum theory an atom can only exist in certain definite states having definite energies, E_1, E_2, E_3 . . . It is found that the critical potentials of the atom are related to its possible energies, so that $Pe = E_n - E_m$, where e is the charge on the electron, so that Pe is the energy of the electrons. The measurements of the critical potentials have thus provided a remarkable confirmation of the quantum theory. (*See* ELECTRICITY IN GASES; and ATOMS.)

Thermionics.—The escape of electricity from bodies at high temperatures has been investigated very thoroughly since 1900. J. J. Thomson, in 1899, measured e/m for the negative ions emitted by a carbon filament in hydrogen at a very low pressure, and found it equal to 10^7 thus showing the ions emitted to be electrons. It is found that any metal and many compounds emit electrons when heated in a vacuum. In 1902, O. W. Richardson measured the current carried by the electrons emitted by several metals in a vacuum at different temperatures, and found it increased rapidly as the temperature was raised. He explained the variation of the current with the temperature by supposing that the metal contains free electrons having the same energy as gas molecules, and that those electrons which strike the surface of the metal from inside with a normal velocity greater than a definite value are able to escape. The subject has since been investigated by O. W. Richardson, H. A. Wilson, F. Horton, Wehneldt, C. J. Davisson and many others. The idea that the free electrons in a metal have the same energy as gas molecules has been abandoned, and the theory of the emission of electrons from hot bodies is now based on the analogy with evaporation. The thermodynamical theory of evaporation was applied to the emission of electrons from hot bodies by H. A. Wilson in 1903, and has since been developed by O. W. Richardson, H. A. Wilson, P. Dushman and others. The emission of electricity by hot bodies was called thermionics by O. W. Richardson, to whom a large part of our knowledge of this important branch of physics is due. (*See* THERMIONICS.)

Constitution of Atoms.—Since Faraday discovered his laws of electrolysis, which showed that atoms of electricity are associated with atoms of matter, the scope of electrical science has continued to expand, until it appears that the material universe contains nothing but atoms of electricity and the electromagnetic fields excited by these atoms. The positive nuclei of atoms have masses proportional to integers, so it is natural to conclude that they are built up of atomic units. These units must be identical with the nucleus of the hydrogen atom, which is a positively charged particle carrying the ionic charge e. The hydrogen nucleus was called a *proton* by Rutherford, so that we may say that matter is composed of protons and electrons. Each proton has, or is, a positive charge e, and each electron is a negative charge e. An atom of atomic weight $W(O=16)$ contains W protons, and, when it is electrically neutral, also W electrons. If the atomic number of the atom is N, the atom has N electrons outside the nucleus, and $W-N$ inside. The positive charge on the nucleus is therefore $\{W-(W-N)\}e$, or Ne. It is found that N is about one half of W, so that about half the electrons in an atom are inside the nucleus; *e.g.*, for oxygen $W=16$ and $N=8$, and for uranium $W=238$ and $N=92$.

Rutherford and his co-workers have recently found in their researches that swift α-rays knock protons out of some atomic nuclei. The α-ray, which is a helium nucleus for which $W=4$ and $N=2$, may enter the atomic nucleus and eject a proton. The atom must, in such a case, be changed into a new atom, with W increased by three. It appears therefore that atoms of greater atomic weight can be built up in this way. Radioactive processes on the other hand appear to involve the emission of α-rays by atomic nuclei, with decrease of the atomic weight. The atoms of the chemist, therefore, are really compounds of protons and electrons, so that protons and electrons are the only true elements. It is, however, customary and convenient to continue to speak of the chemical elements as elements, since the combination of protons and electrons in atomic nuclei is much more intimate than the combination of atoms in the molecules of compounds.

According to the recent developments of the quantum theory, it is suggested that protons and electrons consist essentially of groups of waves. Electromagnetic radiation also seems to consist of groups of waves, the quanta of energy $h\nu$ and frequency ν. Moreover, the energy of an electron or a proton is also equal to $h\nu$, where ν is the frequency of the waves in the particle. We seem therefore to be coming to a view of the universe, according to which there is nothing in it but groups of waves of energy $h\nu$ and frequency ν; but the nature of the difference between a positive charge and a negative charge remains obscure on such a view. The principle of the conservation of energy, on this theory, seems to mean merely that the sum of all the frequencies remains constant, since the total energy is $\Sigma h\nu$ or $h\Sigma\nu$. *In any case it is clear that electricity is the fundamental constituent of matter.*

PRACTICAL APPLICATIONS OF ELECTRICITY

This historical introduction to the subject will be concluded with a brief account of the history of the practical applications of electricity.

Telegraphy.—Immediately after Oersted's discovery of the action of a current on a compass needle Ampère, in 1820, suggested that the effect might be used for transmitting messages between distant points. Practical systems of electric telegraphy were developed about 1836 by Weber and Gauss in Germany, Cooke and Wheatstone in England, and Henry and Morse in the United States. A submarine cable across the English channel was laid down successfully by T. R. Crompton about 1851. A submarine cable across the Atlantic Ocean was laid successfully, after several earlier failures, in 1866. Lord Kelvin made the operation of long submarine cables possible by inventing his mirror galvanometer and syphon recorder besides other instruments. (*See* TELEGRAPHY.)

Dynamos and Motors.—Faraday's copper disk, rotating between the poles of a magnet and generating a steady current, was the forerunner of the modern dynamo or generator. Numerous inventors devised generators, notably Pixii (1832), Gramme, Siemens, Wilde, Varley and Wheatstone. Commercial machines, largely due to Siemens, Wilde and Gramme, came into use about 1866. Siemens, J. Hopkinson, Crompton, Elihu Thomson, Eickemeyer, Parker, Edison, Brush, Kapp, S. P. Thompson, Steinmetz and many other scientists and inventors rapidly developed the earlier crude dynamo into the modern efficient and reliable machine.

Alternating current generators were introduced and developed by Jablochkov, Lucien Gaulard, Zipernowsky, Blathy and S. Z. de Ferranti about 1883. Polyphase alternators were introduced by Ferraris, Nikola Tesla, Dolivo-Dobrowolsky and C. E. L. Brown about 1891. The idea of using alternating currents and transforming them from low to high potentials and vice versa, by means of transformers, was originally due to Jablochkov and Gaulard. In 1873, at Vienna, it was discovered that a Gramme ring type of dynamo can act as a motor when supplied with direct

current. Transmission of power by electricity was then seen to be possible, and was soon made practicable and carried out by S. D. Field, Edison and many others. Electric trams and street cars came into use about 1882, and the use of electric motors for driving all kinds of machines rapidly became general in Europe and America. At the present time (1928) single generators of 50,000 kilowatts or nearly 70,000 horse power capacity are fairly common.

Electric Lighting.—Commercial electric lighting was introduced by Jablochkov and by C. F. Brush about 1876. The electric arc, discovered by Sir Humphrey Davy many years before, was used as the source of light. Incandescent filament lamps were introduced by Edison, Lane Fox and Swann about 1878. The earlier carbon filament lamps have been replaced by much more efficient tungsten filament lamps in recent years. By filling the bulbs with argon, evaporation of the filament is diminished, so making it possible to increase greatly the efficiency by running the tungsten filament at a higher temperature. Electric street and house lighting is now widespread.

Neon and argon lamps are discharge tubes in which a current is passed through one or other of these rare gases at a pressure of a few millimetres. These lamps are now used for advertising purposes, and give a pleasing brilliant glow. Mercury arcs are discharge tubes of glass or fused quartz in which a current is passed through mercury vapour. They give a bright greenish light and are sometimes used for factory illumination. The quartz mercury arc gives strong ultra-violet light and is used for medical light treatments, for which purpose iron and carbon arcs are also much used. Enormously powerful arc lamps are now used in light-houses and search-lights.

The Telephone and Wireless Communication.—The telephone was invented in 1876 by Graham Bell, and was improved by Edison, Elisha Gray, Hughes and many others. At the present time, by means of telephones almost anyone anywhere on the same continent, or, in many cases, on other continents, can be engaged in conversation.

Communication by means of electric waves was developed in 1896 by G. Marconi. Marconi's wireless telegraphy was rapidly adopted for the purpose of communicating with ships at sea and from one ship to another. It is now used also for communicating between distant countries, *e.g.*, England and Australia.

Thermionic Vacuum Tubes. The emission of electrons by hot bodies in a vacuum, investigated by O. W. Richardson about 1900, has proved of great practical value in connection with wireless and other methods of communication, and also for other purposes. In 1905, J. A. Fleming invented the thermionic valve consisting of a hot filament and an electrode enclosed in an exhausted tube. This valve allows a current to flow through it from the electrode to the filament, but not in the reverse direction, and so can be used as a current rectifier. Fleming used it for rectifying the small rapidly alternating currents received in wireless telegraphy, and so was able to measure them with a galvanometer or to detect them with a telephone. In 1907 Lee de Forest invented the thermionic amplifier, which is a Fleming valve with a grating or grid between the electrode or plate and the filament. The current carried by the electrons between the plate and the filament depends on the potential of the grid, so that small changes of this potential may be made to produce considerable changes in the current. The thermionic amplifier rapidly came into use in long distance telephony and in wireless. By the use of these amplifiers continuous electrical oscillations can be maintained, and wireless telephony is made possible, and is now in general use. Programmes of an entertainment and of an educational character are now regularly broadcast, and are received by listeners provided with wireless telephone receiving sets. The thermionic amplifier plays an essential part in the systems of television recently developed. (*See* THERMIONICS; THERMIONIC VALVE; BROADCASTING: *Technical Aspects.*)

Coolidge X-ray and Cathode Ray Tubes.—The universal use of X-rays for medical and dental examinations and other purposes has made the manufacture and improvement of X-ray apparatus of commercial importance. An improved form of X-ray tube was invented by Coolidge. In this tube the cathode is a tungsten spiral heated by a current. The tube is almost perfectly exhausted, and the electrons emitted by the hot spiral are accelerated by potentials up to 200,000 volts, or more, and fall on an anti-cathode of tungsten or of molybdenum. Coolidge has also invented a cathode ray tube in which the electrons from a tungsten spiral fall on a thin nickel window and escape into the air outside the tube. Such a tube using 900,000 volts has been constructed. (*See* X-RAY.)

Domestic Applications.—In a modern home electricity is used for many purposes. The home is lit by incandescent electric lamps, and is provided with telephones and a wireless receiving set. Various machines driven by small electric motors are also in common use; *e.g.*, vacuum cleaners, sewing machines, washing machines and small refrigerating plants. Cooking by means of electrically heated ovens and stoves is becoming common, and electric toasters and irons are widely used. House heating by electricity is economical only where electricity is unusually cheap.

The manufacture of electric ignition, lighting and starting systems for motor cars now forms a large industry, especially in the United States where over 25 million cars are in operation. Each car has a generator, motor, secondary battery, and ignition and lighting accessories. The extraordinary perfection of modern electrical apparatus is well illustrated by the fact that it is not uncommon for the electrical apparatus in a motor car to require no repairs or adjustments while the car runs 5,000 or even 10,000 miles.

Industrial Applications.—Electro plating with copper and silver was introduced commercially soon after electrolysis was discovered, and has been popular ever since. Nickel or cobalt plating is now much used for protecting iron and steel, and chromium plating, which does not tarnish, has recently been introduced for the same purpose. (*See* ELECTROPLATING.)

The commercial preparation of many elements and compounds by electrolytic methods has been an important industry for many years; *e.g.*, copper and aluminum are made in large quantities by electrolysis. The manufacture of nitrogen compounds from atmospheric nitrogen, by means of long alternating current arcs in a current of air, is carried out on a large scale. The nitrogen and oxygen combine in the arc, and the oxides give nitric and nitrous acids with water. (*See* ELECTROCHEMISTRY; and NITROGEN, *Fixation of.*)

Electric furnaces have been used for commercial purposes ever since large supplies of electric power became available, and are rapidly increasing in favour. Such furnaces are of three types: arc furnaces, resistance furnaces and induction furnaces. In the arc furnaces, an arc, between carbon poles, is produced inside a box of refractory material. The substances which it is desired to heat are placed in the box, in the path of the arc. In this way all known solid bodies can be fused or volatilized easily. In resistance furnaces a current is passed, through the mixture to be heated, between graphite or other electrodes. The mixture may be made sufficiently conducting when cold by the addition of powdered graphite, or other suitable conductor, if necessary. All solids and liquids become conducting at very high temperatures. Such furnaces are used for the manufacture of calcium carbide and carborundum. In another type of resistance furnace, the current is passed through coils of wire surrounding the space to be heated. Such furnaces can be used only for temperatures below the melting point of the wire, but with tungsten wires temperatures above 2,500° C may be reached. In induction furnaces a current is induced in the material to be heated, by means of an alternating current in a coil surrounding the material but separated from it. The coil itself is kept cool. Sometimes the material to be heated is made to form a single conducting turn round the core of a transformer. By using high frequency alternating currents, metals like platinum and tungsten can be melted quickly in a crucible placed inside a coil of a few turns, through which the current is passed while the coil remains cool. Electric furnaces are much used for the manufacture of special alloy steels. (*See* ELECTRIC FURNACE.)

The high temperature of the electric arc is used for welding

and cutting refractory metals. The arc is usually struck between the parts to be welded or cut and an electrode of carbon, or of the same metal as the material to be welded. In "spot welding" the parts to be welded are clamped together between heavy copper electrodes, and a very large alternating current is passed between the electrodes for a fraction of a second, or longer if necessary.

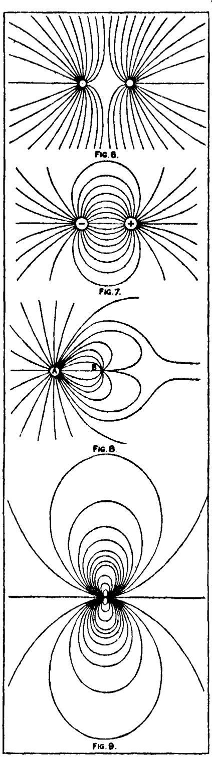
There are many minor but useful applications of electricity; *e.g.*, electrically driven or controlled clocks, electric firing of mines, electrical methods for geophysical exploration, electrical methods of recording, measuring and automatically controlling temperatures, electrical transmission of pictures and hand writing by wire and wireless methods, electric bells and fire alarms.

ELECTROSTATICS

The electrostatic unit of electricity is defined to be a quantity such that, when placed one centimetre from an equal quantity, in a vacuum, it repels with a force of one dyne. The force in dynes between two charges, e and e', at a distance of r centimetres apart, in a vacuum, is equal to ee'/r^2 dynes. The force between charges in air, or other gases, is practically equal to that in a vacuum.

The region near electric charges, in which there is a force on a charged particle, is called the electric field of the charges. The charges are said to excite a field in the space around them. The strength of the electric field is defined to be the force in dynes, per unit charge, on a charged particle put in the field, and the direction of the field is defined to be the direction of the force of the charged particle. The strength of the electric field at a point is also called the electric intensity at the point.

The electric intensity at the surface of a conductor, in which the electricity is at rest, is in a direction perpendicular to the surface of the conductor, because otherwise there would be a component of the intensity along the surface, which would set the electricity in the conductor in motion. The electric intensity inside the material of a conductor is zero, in electrostatics, because a current would be produced in the conductor if the intensity were not zero.



FIGS. 6 TO 9.—LINES OF FORCE DUE TO:
(6) two equal and similar charges;
(7) two equal and opposite charges;
(8) a positive charge of 4 units at A, and a negative charge of 1 unit at B;
(9) an electric doublet, i.e., two equal and opposite charges very close together

Lines of Force.—A line of force, in an electric field, is a line drawn so that its direction is everywhere along the direction of the field. The lines of force due to a charge at a point are straight lines drawn in any direction from the point. The electric intensity at any point due to two or more point charges may be obtained by finding the resultant of the forces on a charged particle at the point, due to the point charges. Each point charge is supposed to exert the same force on the particle as if the other point charges were not present. If we use rectangular axes, x,y,z and if X,Y,Z are the components of the electric intensity, then, if dx, dy, dz are the components of a displacement ds along a line of force, we have $dx/X = dy/Y = dz/Z$, because the resultant of X, Y and Z is along ds.

The lines of force due to two equal and similar charges are shown in fig. 6, and the lines of force due to two equal and opposite charges in fig. 7. Fig. 8 shows the lines of force due to a positive charge of 4 units at A and a negative charge of one unit at B. Fig. 9 shows the lines of force due to two large equal and opposite charges, near together, which form what is called an electrical doublet. Lines of force start from positive charges and end on negative charges. They cannot cross each other, since the intensity can have only one direction at any point. The lines of force map out the electric field, and a careful study of them enables one to form a much clearer conception of the distribution of the field.

Gauss' Theorem.—Let a closed surface S be drawn anywhere in an electric field, in a vacuum, and let there be a charge e at a point P inside it. Consider a small area α on the surface at A, and let $PA = r$. The field F at A, due to e, is e/r^2 along PA. Let AN be drawn normal to the surface at A, and let the angle between AN and PA produced be θ. Describe a sphere of unit radius, with P as centre, and draw lines from P to the boundary of the area and so as to mark out a cone with vertex at P, of which α is a section. Let this cone cut off an area ω on the sphere of unit radius.

The normal section of the cone at A is $\alpha\cos\theta$, so that $\omega = \alpha\cos\theta/r^2$, since the section of a cone is proportional to the square of the distance from the vertex. Also $F = e/r^2$, so that $e = Fr^2$ and $e\omega = (Fr^2)(\alpha\cos\theta/r^2) = \alpha F\cos\theta$. $F\cos\theta$ is the component of F along the normal to α. Denoting this component by N, we have $N\alpha = e\omega$. Now suppose the whole closed surface S divided up into small areas like α. Let the areas be $\alpha_1, \alpha_2, \alpha_3 \ldots$. Let $N_1, N_2, N_3, \ldots$ be the normal components of F at the areas, and let $\omega_1, \omega_2, \omega_3, \ldots$ be the corresponding areas cut off on the unit sphere. Then we have $N_1\alpha_1 = e\omega_1$, $N_2\alpha_2 = e\omega_2$, $N_3\alpha_3 = e\omega_3, \ldots$. Adding all these equations, we get

$$N_1\alpha_1 + N_2\alpha_2 + N_3\alpha_3 + \ldots = e(\omega_1 + \omega_2 + \omega_3 + \ldots).$$

But $\omega_1 + \omega_2 + \omega_3 + \ldots$ will be equal to the area of the surface of the unit sphere, or 4π, so that, finally, $N_1\alpha_1 + N_2\alpha_2 + \ldots = 4\pi e$, which may be written $\Sigma N\alpha = 4\pi e$.

If there is another charge e' inside the closed surface we shall have in the same way $\Sigma N'\alpha = 4\pi e'$. The total normal components of F due to both charges will be $N_1 + N_1'$, $N_2 + N_2'$, etc., so that, if we now let N denote the total normal component of F, we get $\Sigma N\alpha = 4\pi(e + e')$. If there is any number of charges inside the closed surface, then $\Sigma N\alpha = 4\pi\Sigma e$, where Σe denotes the sum of all the charges inside. The field due to negative charges is in the opposite direction to the field due to positive charges, so that in calculating Σe the numerical values of the charges are to be reckoned positive for positive charges and negative for negative charges. This theorem is due to Gauss and it is fundamental in electrostatic theory.

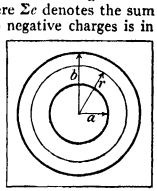


FIG. 10.—ELECTRICAL CAPACITY OF TWO CONCENTRIC SPHERES

Tubes of Force.—The meaning of Gauss' theorem may be made very clear by means of what are called tubes of force. Take a small area in an electric field and draw lines of force through a great many of the points on the boundary of this area. Since lines of force never intersect, these lines will enclose a tube shaped volume in the field, which is called a tube of force. Let P and Q be two points in a tube of force, and let α and α' be the cross sections of the tube at P and Q, and let F and F' be the electric intensities at P and Q. Apply Gauss' theorem to the closed surface made up of the two sections at P and Q and the part of the tube between them. The normal electric intensity is zero over the surface of the tube, so that $\Sigma N\alpha$ reduces to $F\alpha - F'\alpha'$. If there is no charge inside the tube then $\Sigma e = 0$, so that we have $F\alpha = F'\alpha'$. Thus it appears that, along any tube of force, the product of the electric intensity into the cross section is constant. The cross sections of the tubes of force are at our

disposal, since we can draw as many of them in the field as we choose. Let us then suppose the whole field divided into tubes of force, and let the cross sections be made equal to $1/F$, so that the number of tubes passing through any area drawn perpendicular to the field is equal to F. The product $F\alpha$ is then equal to unity for every tube. Such tubes, for which $F\alpha=1$, may be called unit tubes. The number of unit tubes passing through any small area in the field is equal to $F\alpha\cos\theta$, where θ is the angle between the normal to the area α, and the direction of the field F; for $\alpha\cos\theta$ is the area of the projection of α on to a plane perpendicular to F. If then N denotes the component of F along the normal to α, so that $N=F\cos\theta$, we see that $N\alpha$ is the number of unit tubes passing through the area. Gauss' theorem, $\Sigma N\alpha=4\pi\Sigma e$, therefore means that the number of unit tubes of electric force coming out of a closed surface is equal to the total charge inside multiplied by 4π.

Tubes of force start on positive charges and end on negative charges. At the surface of a conductor where the tubes start or end, the tubes are perpendicular to the surface. Consider the charge on the area of a conductor from which a tube of force starts. Imagine the tube produced a short distance into the conductor, and consider the part of the tube between a cross section just inside the conductor and another one just outside. Apply Gauss' theorem to this part of the tube, and let the area of cross section be α. If s is the charge per unit area on the conductor, or the surface density of the charge, then the charge inside is $s\alpha$. There is no field in the conductor, and the field outside is along the tube, so that $\Sigma N\alpha=F\alpha$, where F is the field strength just outside the conductor. Hence we have $F\alpha=4\pi s\alpha$, or $F=4\pi s$. For a unit tube we have $\alpha=1/F=1/4\pi s$.

Many of the facts of electrostatics discussed in the historical introduction can be easily shown to follow from Gauss' theorem. Consider a solid conductor of any shape, and apply Gauss' theorem to a surface drawn anywhere inside the surface of the conductor. There is no electric intensity at this surface if the electricity in the conductor is in equilibrium, so that $\Sigma N\alpha=0$, and therefore $\Sigma e=0$. Thus we see that, however strongly the conductor is charged, there will be no charge anywhere inside it, so that all the charge resides on its surface.

Now consider a hollow conductor bounded by two closed surfaces, one inside the other. If we imagine a closed surface drawn in the conductor between its inside and outside surfaces, and apply Gauss' theorem to this surface, we see that the total charge inside a closed hollow conductor is zero. Thus, for example, if a charged conductor is put inside the hollow conductor, there must be an induced charge on the inside surface equal and opposite to that on the charged conductor, as in Faraday's ice-pail experiment. If the hollow conductor were insulated and uncharged when the charged conductor was put inside it, a charge would appear on its outside surface equal to the charge put inside, because the total charge on the hollow conductor is zero.

The electric field outside a charged sphere is the same as if the charge on it were concentrated at its centre. For, if we describe a spherical surface of radius r outside the sphere and concentric with it, we see, by symmetry, that the field will be normal to this surface and uniform over it. Let the field be F, so that, by Gauss' theorem, $\Sigma N\alpha=F4\pi r^2=4\pi e$, where e is the charge on the sphere. Thus $F=e/r^2$, as if the charge were at the centre.

Potential Difference.—When a charged particle is moved about in an electric field, work has to be done against the forces on the particle. If an amount of work, W, is done on the system consisting of the charged conductors and the particle, when the particle is moved from a point A to another point B, the potential energy of the system is increased by W, and this energy can be got out of the system by allowing the particle to move back to B, doing work W as it moves back. The work required to move a charged particle from one point A to another one B in an electrostatic field is the same for all paths between A and B. For if not, the particles can be moved from A to B along one path and then back to A along another path, giving back more work, so that a supply of work could be obtained in this way without using up the energy of the system, which is impossible.

The potential difference between two points in an electric field is defined to be the work, in ergs, required to take a charged particle from one point to the other, per unit charged on the particle. The charge on the particle must be so small that it does not appreciably alter the field when it moves. The potential of the earth is usually taken to be zero, for convenience, in which case the potential at any point is equal to the work in ergs required to take a charged particle from the earth to the point, per unit charge on the particle.

Consider two points A and B very near together in an electric field of strength F. Let the angle between AB and the direction of F be θ. Then the work to take a unit charge from B to A is equal to $F\cdot AB\cdot\cos\theta$, so that the potential difference between A and B is given by $P_A-P_B=F\cdot AB\cdot\cos\theta$, so that

$$F\cos\theta=(P_A-P_B)/AB.$$

Thus we see that the component of the electric intensity along any direction is equal to the space-rate of decrease of the potential in that direction; *e.g.*, if F_x denotes the x component of the electric intensity, and P the potential, then $F_x=-\partial P/\partial x$.

The potential difference, due to a charge e, between a point at a distance r from the charge and a point at a great distance away is equal to e/r. The force on a unit charge at a distance r from the charge e is e/r^2, so that the work done on the charge by the field, when r is increased from r_1 to r_2, is between $e(r_2-r_1)/r_1^2$ and $e(r_2-r_1)/r_2^2$. If r_2 and r_1 are very nearly equal, either of these expressions is equal to $e(r_2-r_1)/r_1r_2$, or to $e/r_1-e/r_2$. If then $r_1, r_2, r_3, r_4, \ldots$ are successive values of r as it is increased, each one only slightly greater than the previous one, the work done on the unit charge as r increases is

$$\left(\frac{e}{r_1}-\frac{e}{r_2}\right)+\left(\frac{e}{r_2}-\frac{e}{r_3}\right)+\left(\frac{e}{r_3}-\frac{e}{r_4}\right)+\ldots,$$

which is equal to e/r_1 when the final value of r is very large. Thus the work obtained, when a unit charge is moved from a distance r_1 from the charge e, to a great distance from it, is e/r_1. The potential difference between a point at a distance r from the charge e and points at a great distance away is therefore equal to e/r. If the potential at a great distance away is taken equal to zero, which is often convenient, then we may say that the potential due to a charge e, at a distance r, is equal to e/r. This result may be obtained also as follows. If P denotes the potential, we have $e/r^2=-\partial P/\partial r$, so that $dP=-edr/r^2$, which, on integration, gives $P=\frac{r}{e}+$a constant. If we suppose $P=0$ at $r=\infty$, therefore the constant $=$zero and this becomes $P=e/r$.

The potential at a point due to any distribution of charges is therefore equal to $\Sigma(e/r)$, which denotes the sum of each element of charge divided by its distance from the point. This result is true only when the potential at a great distance is taken to be zero. It is not true, for example, when the earth is taken to be at zero potential. Since the electric field inside the material of a conductor is zero, in electrostatics, it follows that no work is required to move a charged particle from one point in a conductor to any other point in it, so that the potential must be the same throughout the conductor. If two or more conductors are connected together by conducting wires, they are then parts of one conductor, and so are all at the same potential. Conductors connected to the earth are at zero potential, when the earth is taken to be at zero potential.

Capacity.—The capacity of a conductor is defined to be the charge required to give it unit potential when all other conductors near are at zero potential. A system of two conductors separated from each other by a thin layer of insulator is called a *condenser*. The charges on the two conductors are usually approximately equal and of opposite sign, and the capacity of the condenser is then taken to be equal to the positive charge divided by the potential difference between the conductors.

To find the capacity of a conductor it is necessary to find its

potential and its charge when other conductors near are at zero potential. Consider a conducting sphere of radius a with no other conductors near. We have seen that the electric field outside a charged sphere is the same as if the charge were concentrated at its centre. If the sphere has a charge e the potential outside it is therefore equal to e/r, and so is equal to e/a at the surface of the sphere. The sphere therefore has a potential e/a when its charge is e. Its capacity is therefore equal to e divided by e/a, or to a. The capacity of an isolated sphere is therefore equal to its radius.

Next consider a sphere of radius a surrounded by a concentric thin hollow sphere of radius b. Describe a spherical surface of radius r between the two spheres (*see* fig. 10.) Apply Gauss' theorem to this surface. If F is the field at its surface we have $4\pi r^2 F = 4\pi e$, where e is the charge on the inner sphere. Hence $F = e/r^2$, so that the potential difference between the two spheres is equal to $e/a - e/b$. The capacity of the inner sphere is therefore equal to e divided by $e/a - e/b$, or to $1/(1/a - 1/b) = ab/(b-a)$. The capacity can therefore be made large by making the two radii nearly equal. The capacity of the outer sphere can easily be seen to be $ab/(b-a) + b$, or $b^2/(b-a)$.

The capacity of a condenser consisting of two equal parallel metal plates at a small distance d apart can be easily calculated approximately. If the potential difference between the plates is P then the electric intensity is P/d. The electric intensity close to the surface of a charged conductor, in the direction away from the surface, is equal to $4\pi s$, where s is the surface density of charge. Hence, if s is the surface density on one plate and s' that on the other, we have $4\pi s = P/d$, and $4\pi s' = -P/d$, so that $s = -s'$. The capacity per unit area is s/P, or $1/4\pi d$. This is the capacity between the plates at a distance from the edges. Near the edges the field between them is not uniform, and so is not equal to P/d.

Force on Surface of Charged Conductor.—The field F, close to the surface of a conductor on which the surface density is s, is equal to $4\pi s$, and just inside the surface it is equal to zero, so that the average field acting on the layer of charge is $F/2$; the force on unit area of the surface is therefore equal to $Fs/2$. This result may be obtained in another way as follows:—The field F may be regarded as made up of two parts, F_1, due to the layer of charge on the conductor, and F_2, due to other charges at a distance. Just inside the conductor the field F_1 is reversed in direction, and the total field is zero, so that $F_2 - F_1 = 0$, and therefore $F_1 = F_2$; so that $F_2 = F/2$. The force on the surface layer is equal to $F_2 s$, because the field due to the charge s cannot be supposed to tend to move it. Hence the force on unit area is $Fs/2$ or $2\pi s^2$ which is equal to $F^2/8\pi$.

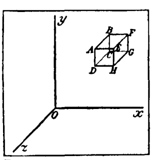


FIG. 11.—APPLICATION OF GAUSS' THEOREM TO A SMALL RECTANGULAR BLOCK

If there is a potential difference P between two parallel metal plates at a distance d apart, then they attract each other with a force $F^2/8\pi$ per unit area, or $P^2/8\pi d^2$ since $F = P/d$. The potential difference between the plates can therefore be found by measuring the attraction and the distance d. An instrument for measuring potential differences in this way was designed by Lord Kelvin and is called Kelvin's absolute electrometer. Instruments for measuring potential differences depending on the electrostatic attraction between a movable conductor and fixed conductors are called electrostatic voltmeters. The gold leaf electroscope may be used as an electrostatic voltmeter, if it is provided with some device for measuring the divergence of the leaves, and calibrated. The quadrant electrometer is an electrostatic instrument by means of which potential differences as small as one millionth of an electrostatic unit of potential difference can be measured. (*See* ELECTRICAL INSTRUMENTS.)

Specific Inductive Capacity.—So far we have been supposing that the insulator between the conductors was a vacuum or air. It was found by Faraday that the capacity of a condenser depends on the nature of the insulator between the plates; *e.g.* with glass between the plates instead of a vacuum, it may be 10 times as great. The ratio of the capacity of a condenser, with the space between the conductors completely filled with an insulator, to the capacity with a vacuum between the plates is called the specific inductive capacity of the insulator. It is denoted by K which is thus taken to equal unity for a vacuum.

Since the capacity is increased K times by the presence of the insulator it follows that, for a given charge, the potential difference, and therefore also the electric intensity between the conductors, is diminished K times. For example, in the case of a condenser consisting of two concentric spheres of radii a and b, the electric intensity between the spheres will be e/Kr^2 instead of e/r^2, where e is the charge on the inner sphere and r the distance from its centre. We have seen that *in vacuo* we can divide the field into unit tubes of force, starting from positive charges $1/4\pi$ and ending on negative charges $-1/4\pi$. In the same way we can divide the field between the two spheres in the medium of specific inductive capacity K into unit tubes of force, each starting from a charge $1/4\pi$ on the inner sphere. The number of these tubes will be $4\pi e$, so that the cross section α of a tube at distance r from the centre will be given by $\alpha = 4\pi r^2/4\pi e$. The intensity F is equal to e/Kr^2, so that $KF\alpha = 1$. Thus, in this special case, we see that, along the unit tubes, $KF\alpha = 1$, instead of $F\alpha = 1$, as in a vacuum.

In Faraday's ice-pail experiment, if pieces of any insulators, for example sulphur, glass and wax of any size and shape are put in the can, the experiment works in the same way as before. This shows that a charged conductor induces an equal and opposite charge on a hollow conductor surrounding it whatever the nature and distribution of the insulators in the space between the two conductors. This suggests that the number of unit tubes passing through any closed surface surrounding a conductor with charge e on it is equal to $4\pi e$, whatever the distribution of insulators in the space around it.

Generalization of Gauss' Theorem.—We therefore assume that, in any case, $KF\alpha = 1$ along a unit tube, and that the number of unit tubes coming out of a charge e is $4\pi e$. With these assumptions we can obtain the generalization of Gauss' theorem, which is true for any distribution of insulators between the conductors. Consider a closed surface of any shape, and let A be a small area on it. Let the electric intensity at A be F, and the specific inductive capacity K. Let the angle between F and the outward drawn normal to A be θ. The cross section of a unit tube at A is $\alpha = 1/KF$. The projection of this on A is $\alpha/\cos\theta$, or $1/(KF\cos\theta)$, so that the number of unit tubes, passing out through A, is A divided by $1/(KF\cos\theta)$, or $AKF\cos\theta$. Let $F\cos\theta = N$, so that $AKF\cos\theta = KNA$. The total number of unit tubes passing out through the closed surface is therefore ΣKNA, and this is equal to $4\pi\Sigma e$, so that we get $\Sigma KNA = 4\pi\Sigma e$ as the generalization of Gauss' theorem. The results deduced from this are found to agree with the facts, so it is believed to be correct. If we apply this generalized form of Gauss' theorem to a small rectangular block, with its edges parallel to rectangular axes x, y, z, we find that $\frac{\partial}{\partial x}(KF_x) + \frac{\partial}{\partial y}(KF_y) + \frac{\partial}{\partial z}(KF_z) = 4\pi\rho$, where F_x, F_y and F_z are the components of the electric field along directions parallel to the axes, and ρ is the density of electric charge inside the block.

In fig. 11, let $ABCDEFGH$ be the block, and let $AE = \delta x$, $AC = \delta y$, $AB = \delta z$. The charge inside the block is $\rho\delta x\delta y\delta z$, so that $\Sigma KNA = 4\pi\rho\delta x\delta y\delta z$. We may take the sides of the block for the small areas A so that the part of ΣKNA for the two sides $EFGH$ and $ABCD$ is $\frac{\partial}{\partial x}(KF_x)\,\delta x\delta y\delta z$, since the positive direction of x is into the block at $ABCD$ and out of it at $EFGH$. Adding up the similar expressions for the three pairs of opposite sides we obtain the above equation. It will be observed that the equations $\Sigma KNA = 4\pi\Sigma e$ and $\frac{\partial}{\partial x}(KF_x) + \frac{\partial}{\partial y}(KF_y) + \frac{\partial}{\partial z}(KF_z) = 4\pi\rho$ are merely two different mathematical ways of expressing the fact

that the number of unit tubes of electric force which come out of a charge e is equal to $4\pi e$.

If V denotes any vector with components V_x, V_y, V_z, then $\frac{\partial V_x}{\partial x}+\frac{\partial V_y}{\partial y}+\frac{\partial V_z}{\partial z}$ is called the divergence of the vector, and is denoted by div. V. It is equal to the number of unit tubes of the vector which start from unit volume. Hence we may write div. $KF=4\pi\rho$.

The electric intensity F close to the surface of a charged conductor where the specific inductive capacity is K may be found in the same way as *in vacuo*. Consider a cylinder of cross section α with its sides perpendicular to the charged surface. Apply Gauss' theorem to the volume enclosed by this cylinder and two cross sections of it, one just outside and one just inside the surface of the conductor. The tensity inside is zero, and outside it is perpendicular to the surface, so that we have $KF\alpha=4\pi\alpha s$, where s is the surface density of charge. Thus $F=4\pi s/K$, as was to be expected. The force on the charged surface is $Fs/2$, as *in vacuo*, and this is equal to $2\pi s^2/K$, or to $KF^2/8\pi$. The intensity F, due to a charge e in a medium of specific inductive capacity K, is got by applying Gauss' theorem to a sphere of radius r with the charge e at its centre. This gives $KF4\pi r^2=4\pi e$, or $F=e/Kr^2$, as was to be expected. Gauss' theorem of course makes $KF\alpha=1$, along a unit tube of force, since this was assumed in obtaining the generalized theorem.

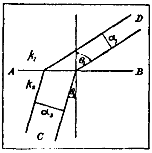


FIG. 12.—THE REFRACTION OF A TUBE OF FORCE AT THE INTERFACE OF TWO MEDIA HAVING DIFFERENT DIELECTRIC CONSTANTS, K_1 AND K_2

Refraction of Tubes of Force.—Consider the electric field at the boundary between two insulators, one of specific inductive capacity K_1, and the other of specific inductive capacity K_2. In fig. 12 let AB be the boundary, and let CD be a tube of force passing across it. Let $F_1\alpha_1$ and $F_2\alpha_2$ be the products of the intensity in and the cross section of the tube for each of the two media. Also, let θ_1 and θ_2 be the angles between the tube and the normal to the boundary. The potential must be the same in both media at the surface, so that we have $F_1\sin\theta_1=F_2\sin\theta_2$. We have also $K_2F_2\alpha_2=K_1F_1\alpha_1$. Also the projection of α_1 on the boundary is equal to that of α_2, so that $\alpha_2/\cos\theta_2=\alpha_1/\cos\theta_1$. These equations give $K_1/K_2=(\tan\theta_1)/(\tan\theta_2)$. Thus it appears that the tubes of force are refracted at a boundary between two different insulators.

The capacity of a condenser, consisting of two parallel metal plates at a distance d apart, with a uniform slab of an insulator of specific inductive capacity K and thickness t less than d, can be calculated easily. Consider a unit tube of force going from one plate to the other. $KF\alpha$ is constant along this tube, so that, since the tube is straight and α constant, the intensity will be K times smaller in the slab than in the air. If F is the electric intensity in the air, the potential difference between the plates is equal to $F(d-t)+Ft/K$. Also $F=4\pi s$, so that $P=4\pi s(d-t)+4\pi st/K$; the capacity per unit area is therefore

$$s/P=1/(4\pi(d-t)+4\pi t/K).$$

Energy of Charged Conductors.—Consider a system of insulated conductors, and let the charges on them be E_1, E_2, E_3, etc., and their potentials P_1, P_2, P_3, etc. The work required to charge the system may be calculated as follows:—Suppose that we start with all the conductors uncharged, and then charge them all together so that each charge is the same fraction f of its final value. Thus the charges are fE_1, fE_2, fE_3, etc., and during the charging process f increases from 0 to 1. The potentials will also be fP_1, fP_2, fP_3, etc., for the electric intensities clearly will be proportional to the charges. The work done, when f is increased from f to $f+df$ is $fP_1E_1df+fP_2E_2df+fP_3E_3df$; the total work is therefore

$$(P_1E_1+P_2E_2+P_3E_3+\ldots)\int_0^1 fdf=\tfrac{1}{2}(P_1E_1+P_2E_2+\ldots)=\tfrac{1}{2}\Sigma PE.$$

Thus the electrostatic energy of a system of charged conductors is equal to one half the sum of the products of the charges on and the potentials of the conductors. In the case of a condenser consisting of two conductors with charges E and $-E$ and potentials P_1 and P_2, the energy is therefore $\frac{1}{2}E(P_1-P_2)$.

Energy in the Electrostatic Field.—The electrostatic energy can be regarded as distributed throughout the electric field, between the conductors. To see this, consider a unit tube of force, starting from a conductor at potential P_1 and ending on another conductor at potential P_2. The charges on the ends of the tube are $1/4\pi$ and $-1/4\pi$, so that the energy associated with the tube is $(P_1-P_2)/8\pi$. Suppose the tube divided into a great many short elements, and let l be the length and α the cross section of an element. The potential difference between the ends of the tube is then given by $P_1-P_2=\Sigma Fl$, where F is the electric intensity in the tube. The energy is therefore $(\Sigma Fl)/8\pi$. But $KF\alpha=1$ all along the tube, so that we can multiply the values of F for each element by $KF\alpha$ at the element, and so get for the energy $(\Sigma KF^2l\alpha)/8\pi$. The volume of an element of the tube is $l\alpha$, so that, if each element contained energy per unit volume equal to $KF^2/8\pi$, the total amount of energy would be that actually present. It is generally supposed that the electrostatic energy is distributed throughout the field so that its density is $KF^2/8\pi$.

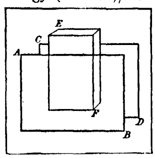


FIG. 13.—THE INTRODUCTION OF A DIELECTRIC, OTHER THAN AIR, BETWEEN TWO CHARGED CONDUCTORS, TO SHOW THE FORCE ON INSULATORS IN A NON-UNIFORM ELECTRIC FIELD

Force on Insulators in an Electrostatic Field.—There is a force on insulators in a non-uniform electric field. As a simple illustration of this, consider the case of a slab of an insulator of thickness t, partly between two equal parallel metal plates at a distance d apart, as shown in fig. 13; AB and CD are the plates, and EF the slab. Let the breadth of the slab be b, and the length of it between the plates x. The capacity of C between the plates is $\frac{A}{4\pi d}+\frac{bx(K-1)t}{4\pi d\{Kd-(K-1)t\}}$, where A is the area of each plate. The electrical energy W is $\frac{1}{2}PE$, where P is the potential difference between the plates, and E the charge on one plate or, since $E=PC$, it is $\frac{1}{2}P^2C$. Hence, if we suppose P kept constant, $\frac{dW}{dx}=\frac{1}{2}P^2\frac{dC}{dx}$. To keep the potential difference constant requires work, PdE or P^2dC, to be done, so that if f is the force on the slab then we have, by the conservation of energy,

$$P^2\frac{dC}{dx}dx=\tfrac{1}{2}P^2\frac{dC}{dx}dx+fdx$$

so that $$f=\tfrac{1}{2}P^2\frac{dC}{dx}=\tfrac{1}{2}P^2\frac{bt(K-1)}{4\pi d\{Kd-(K-1)t\}}.$$

If F is the electric intensity between the plates where there is no slab, and F' that inside the slab, then $P=Fd=KF'(d-t)+F't$,

so that $$f=\frac{bt}{8\pi}\,\frac{FdF'(K(d-t)+t)}{d\{Kd-(K-1)t\}},$$

or $$f=\frac{bt}{8\pi}FF'(K-1).$$

If the slab fills the whole distance between the plates so that $d=t$, then $F=F'$ and $f=\frac{btF^2}{8\pi}(K-1)$. If, instead of supposing P kept constant, we suppose the charges on the plates kept constant, then, since the electrical energy, $\frac{1}{2}PE$, is equal to $\frac{1}{2}E^2/C$, we have $fdx=-\frac{dW}{dx}dx=\frac{1}{2}E^2dC/C^2$, so that, since $P=E/C$, we get $f=\frac{1}{2}P^2\frac{dC}{dx}$, as before.

The theory of specific inductive capacity is discussed in the

section of this article dealing with the electron theory. The inductive capacity of a substance is sometimes called its dielectric constant. The following table gives the specific inductive capacities of several substances, that of a vacuum being taken as equal to unity:

Glass	5–10	Water	80
Hard rubber	3·1	Ice	3
Paraffin wax	2·1	Alcohol	26
Mica	5·6–6·0	Air	1·0006
Sulphur	4	Hydrogen	1·00026

Pyroelectricity.—It was discovered in 1700 that a tourmaline crystal put in hot ashes attracts the ashes. Aepinus in 1756 found the effect to be due to electrical charges on the ends of the crystal, which are positive on one end and negative on the other. A little later Canton showed that the charges are produced by a change of temperature, and that the charges due to cooling are opposite to those due to raising the temperature. Many other crystals have since been found to possess the same property which is called pyroelectricity. Haüy, about 1800, found that only hemihedral crystals with inclined faces develop pyroelectricity. Lord Kelvin in 1860 worked out a theory of pyroelectricity which is generally accepted. Kelvin supposed that the molecules of pyroelectric crystals contain equal positive and negative charges which do not neutralize each other, so that the molecules form electric doublets. The electric moment of a doublet, consisting of a charge e and a charge $-e$ at a distance d apart, is equal to de. In the crystal the molecules are arranged in a regular way, and Kelvin supposed that all the electric doublets lie in parallel directions, so that a crystal containing N molecules, each having an electric moment M, has a total moment NM. The moment per unit volume is called the polarization, or the intensity of electrification, so that, if it is denoted by P then $P=NM/V$, where V is the volume of the crystal.

The electric moment of a rod of length l and cross section a, polarized along its length, is equal to Pla, and is the same as that due to charges $+Pa$ at one end and $-Pa$ at the other end. If a crystal is kept at a constant temperature for a long time, the ends attract charges sufficient to reduce the electric moment to zero, so that the crystal becomes electrically neutral. It is still polarized, but has charges $-Pa$ and $+Pa$, on its ends, which have a moment equal and opposite to that due to the polarization. The neutralization of the polarization can be brought about immediately by passing the crystal through the conducting gases rising from a flame.

If the temperature of a crystal is raised, then its volume V increases, so diminishing P. Also, the molecular moment M may depend on the temperature. The charge Pa on the end of a crystal is equal to NMa/V, or to NM/l, so that, if we suppose that $l=l_0(1+\alpha T)$, where T is the temperature and α the coefficient of linear expansion along l, and that $M=M_0(1+\beta T)$, where β is a constant, then we have, for the charge Pa, or E,

$$E=NM_0(1+\beta T)/l_0(1+\alpha T),$$

or, approximately, $E=NM_0(1+(\beta-\alpha)T)$. Thus, if the temperature of a neutral crystal is changed from T_1 to T_2, it will acquire apparent charges, on its ends, given by

$$E=\pm NM_0(1+(\beta-\alpha)(T_2-T_1).$$

For a tourmaline crystal, Voigt found that the polarization P at 24° C is equal to $-33{\cdot}4$, in electrostatic units, and that it changes by $+1{\cdot}2$ for one degree rise of temperature.

Piezoelectricity.—J. and P. Curie in 1880 discovered that pyroelectric crystals become electrified when subjected to pressure or tension along the direction of the polarization. Tension produces the same effect as raising the temperature, and pressure the same effect as lowering it. Since $E=NM/l$, we might expect increasing l by tension to have the same effect as increasing it by raising the temperature, provided M also changes to the same extent in both cases. It appears that, in many cases,the effect of tension is nearly the same as that of a change of temperature which gives an equal change of length. Lippmann in 1881 pointed out that, since straining the crystal alters its polarization, we should expect an electric field to strain it, *i.e.*, to alter its size and shape. This was shown to be the case by J. and P. Curie. If a rapidly alternating electric field is applied to a pyroelectric crystal, the crystal is made to vibrate, and, if the frequency agrees with the natural frequency of the crystal, resonance occurs and the amplitude of oscillation becomes relatively large.

In the piezo effect, the quantity of electricity set free is proportioned to the pressure, so that the effect may be used to measure pressures. The effect is suitable for measuring rapidly changing pressures, since the movements of the crystal under pressure are so small that troublesome inertia effects, which take place when springs are used, are eliminated. In 1919 Sir. J. J. Thomson suggested the use of piezo crystals for recording explosive pressures, and many experiments have been carried out on these lines, a cathode ray oscillograph to measuring the rate of liberation of electricity. (*See* Keys "A Piezo-electric Method of Measuring Explosion Pressures," *Phil. Mag.* 1921.)

Electrets.—Eguchi in 1925 discovered that if certain mixtures of waxes are allowed to solidify in a strong electric field, they become electrically polarized. A mixture of Carnauba wax 45%, white resin 45% and white beeswax 10% is suitable. A slab of this mixture, formed in an electric field perpendicular to its surfaces, maintains a positive charge on one surface and a negative charge on the other. The charges do not diminish appreciably in several years. Such a polarized slab of wax is the electrical analogue of a permanent magnet and is called an electret. It is supposed that the wax molecules have electrical moments, and the field lines them up when the wax is liquid, and after it has solidified they remain all pointing in the same direction, even when the field is removed. The polarization is neutralized by charges attracted from surrounding bodies, as with pyroelectric crystals, but the neutralization does not become exact because the polarization very slowly diminishes.

ELECTROKINETICS

Electrokinetics is that part of electrical science which deals with the properties of electric currents. The chief effects produced by electric currents are magnetic effects, heating effects and chemical effects. The chemical effects are discussed in the article ELECTROLYSIS.

DIRECT CURRENTS

Electric currents in conductors may be classified as unidirectional, or direct, *i.e.*, flowing always in the same direction; or as alternating, *i.e.*, reversing their direction at regular intervals. We shall deal first with the former type.

Magnetic Effects of Currents.—If a current is passed through a coil of wire, it is found that a magnetic field is produced around the coil, similar to the field of a magnet. Consider a coil of N turns of thin wire wound uniformly on a straight uniform cylinder. It is found that such a coil produces a magnetic field similar to that due to a uniformly magnetized hard steel bar of the same size as the coil. If the bar is put inside the coil, then it is possible to adjust the current through the coil so that the field due to the coil is equal and opposite to that due to the bar at any point outside the coil. If m denotes the pole strength of the bar, and l its length, then its magnetic moment is ml, and we may consider that the coil also has a magnetic moment ml when the current is adjusted so that the coil gives a field equal to that of the bar at any point outside the coil. The north pole of the coil is the end at which the current goes round in the opposite direction to the hands of a watch placed with its back against the end of the coil. The current goes round the coil in the same direction as a corkscrew turning so as to move along the coil from the south pole to the north pole.

It is found that the magnetic moment of a coil is proportional to the cross section of the coil, to the number of turns of wire in it and to the strength of the current. If, then, M denotes the magnetic moment of the coil, N the number of turns of wire in it, A the cross section of the coil in square centimetres and C the current, we have $M=kNAC$, where k is a constant. The electro-

magnetic unit of current is defined so as to make the constant k equal to unity when the coil is in a vacuum, so that $M=NAC$ when C is expressed in electromagnetic units of current. Thus the electromagnetic unit of current is defined to be a current such that a small plane circuit, in a vacuum, round which it is flowing has unit magnetic moment per square centimetre of the area of the circuit. The magnetic field due to the circuit in air is practically the same as in a vacuum. Thus a coil of N turns, wound uniformly on a straight cylinder, will have a magnetic moment NAC, if A is the mean area of the turns of wire.

If the length of the coil is l cm. then its pole strength is NAC/l. The magnetic potential (*see* MAGNETISM) at any point is defined to be the work in ergs required to bring a unit north pole to the point from a great distance. The potential due to a pole m at a distance r cm. from it *in vacuo* is equal to m/r, just as the electrostatic potential due to a charge E is equal to E/r. The potential due to a small magnet of moment M at any point may be calculated easily. In fig. 14, let AOB be the small magnet, and let its north pole be at A and its south pole at B. Let $OA=OB=l$. Consider the magnetic potential at P, and let $OP=r$, and let the angle POA between OP and the axis of the magnet be denoted by θ.

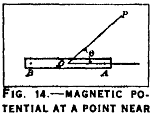


FIG. 14.—MAGNETIC POTENTIAL AT A POINT NEAR A SMALL MAGNET

If the pole at A is of strength m, and that at B of strength $-m$, then the potential at P is equal to $m/PA-m/PB$. If l is small compared with r, this is $m/(r-l\cos\theta)-m/(r+l\cos\theta)$, or $2ml\cos\theta/r^2$. But $2lm$ is the moment of the magnet, so that, denoting this by M, we have $M\cos\theta/r^2$ for the magnetic potential at P. The magnetic potential due to a small plane coil of wire having area A square centimetres and one turn is therefore $AC\cos\theta/r^2$, at a point at a distance r from the centre of the coil in a direction making an angle θ with the axis of the coil. The axis of the coil is a line drawn through its centre perpendicular to its plane. It is drawn in the direction in which a cork screw, turning with the current, would advance, or in the direction from the south to the north pole of the equivalent magnet. The solid angle of a cone may be defined to be numerically equal to the area which the cone cuts off on the surface of a sphere of unit radius with its centre at the vertex of the cone. The total solid angle round a point is thus equal to 4π. The area which a cone of solid angle α cuts off on a sphere of radius r is therefore equal to αr^2, for the area cut off varies as the square of the distance from the vertex.

The solid angle which a small plane circuit, of area A, subtends at a point P at a distance r from it, in a direction making an angle θ with the axis of the circuit, is therefore equal to $A\cos\theta/r^2$. For $A\cos\theta$ is the area of the projection of A on to the surface of a sphere with its centre at P and radius r. Denoting this solid angle by α, we see that the magnetic potential at P due to the circuit is equal to $C\alpha$. We can now show that the magnetic potential, at a point, due to a circuit of any size and shape is equal to the current flowing round the circuit multiplied by the solid angle which the circuit subtends at the point. In fig. 15, let ABC be a circuit of any size and shape, with a current C flowing round it, as indicated by the arrowheads. Divide the area of the circuit up into a large number of small areas, as shown, and suppose that the current C flows round all these small areas in the same direction. This requires equal and opposite currents C along all the dividing lines as indicated by the arrowheads. But two equal and opposite currents along a line are equivalent to zero current, and so produce no magnetic field. The field due to the circuit ABC is therefore the same as that due to all the small circuits into which it may be divided. The magnetic potential at a point due to each of the small circuits is equal to $C\alpha$, where α is the solid angle which the small circuit subtends at the point, so that the potential due to the whole circuit is equal to the current multiplied by the sum of all the small solid angles, which sum is equal to the solid angle subtended by the whole circuit.

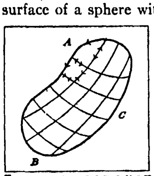


FIG. 15.—CIRCUIT CARRYING A CURRENT, EQUIVALENT TO A MAGNETIC SHELL

The magnetic potential at any point, due to any circuit carrying a current C in a vacuum, is therefore equal to $C\alpha$, where α denotes the solid angle subtended by the circuit at the point. The potential in air is practically the same as in a vacuum. If the potential at a point A is P_A, and P_B at another point B near to A, then, if the component of the magnetic field along AB is denoted by F, we have $F\cdot AB=P_B-P_A$, or if $P_A-P_B=\delta P$ and $AB=\delta x$, then $F=-\delta P/\delta x$. Thus the field strength in any direction is equal to the rate of decrease of the potential in that direction.

Now consider the magnetic field along the axis of a circular circuit, of radius r, carrying a current C. At a point on the axis at a distance x from the centre of the circuit, the solid angle subtended by the circuit is equal to that of a circular cone of semi-angle θ such that $\cos\theta=x/\sqrt{(r^2+x^2)}$. This solid angle is equal to $2\pi(1-\cos\theta)$, so that the magnetic potential at the point is given by $P=2\pi C[1-x/\sqrt{(r^2+x^2)}]$. The field F along the axis is therefore given by $F=-\dfrac{\partial P}{\partial x}=\dfrac{2\pi Cr^2}{(r^2+x^2)^{3/2}}$. At the centre of the circuit $x=0$, so that $F=2\pi C/r$.

Now let us investigate the work in ergs required to take a unit pole round a current C. In fig. 16, let A and B be the points at which the circuit carrying the current C cuts the plane of the paper. Let the closed curve be the path along which the unit pole is moved round the current and let its successive positions be the points numbered 1, 2, 3, 4, ... At each point the solid angle subtended by the circuit is indicated so as to show how it varies as the pole goes round the curve. At 1 and 2 the solid angle is less than 2π. At 3 and 4 it is between 2π and 4π. At 5 and 6 it is between 4π and 6π. At 7 and 8 it is between 6π and 8π. At 9 and 10 it is between 8π and $1\ \pi$. Thus we see that, as the pole goes round and round the closed curve threading through the circuit, the solid angle increases by 4π during each complete circuit of the curve. The work in ergs required to take the unit pole once round the closed curve is therefore equal to $4\pi C$. This result enables the magnetic field to be calculated easily in several important cases.

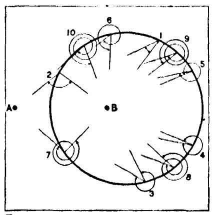


FIG. 16.—DIAGRAM SHOWING THE ANGLES SUBTENDED BY THE CIRCUIT A–B (SHOWN INTERSECTING THE PLANE OF THE PAPER) AT A UNIT MAGNETIC POLE WHICH MOVES (ANTICLOCKWISE) ROUND A CIRCUIT THREADING A–B

Positions 1 to 5 show the first revolution; 6 to 9, the second; and 10, the beginning of the third

In the case of the field due to a long straight wire, we see by symmetry that the lines of force are circles in planes perpendicular to the wire. If F denotes the strength of the field at a distance r from the wire, the work required to take a unit pole round the circle of radius r is $2\pi rF$, so that we have $2\pi rF=4\pi C$, or $F=2C/r$, where C is the current. The field inside a long straight wire with circular section of radius a, at a distance r from the axis is given by $2\pi rF=4\pi Cr^2/a^2$, so that $F=2Cr/a^2$. Now consider the field inside a uniformly wound, ring-shaped coil, having N turns of wire. In fig. 17, let the axis of the coil be at O, and describe a circle of radius r with its centre on the axis and in a plane perpendicular to the axis, so that the circle is inside the coil as shown. By symmetry the lines of force are circles round the axis. Let F be the field strength on the circle of radius r, inside the coil, so that we have $2\pi rF=4\pi NC$, where C is the current, for the total current through the plane of the circle is NC. Hence $F=2NC/r$. This result is true for a ring-shaped coil of any cross section, provided it is uniformly wound.

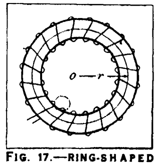


FIG. 17.—RING-SHAPED COIL OF WIRE CARRYING A CURRENT

The number of turns of wire per centimetre on the coil is $N/2\pi r$. Denoting this by n we have $F=2C2\pi rn/r=4\pi Cn$. If the length of the ring-shaped coil is very large, any short portion of it will be approximately straight, so that we see that the field inside a uniformly wound straight coil or solenoid, at any point not near the ends of the coil, is equal to $4\pi Cn$, where C is the current and n the number of turns per centimetre. The lines of force due to a straight uniform coil are shown in fig. 18. They pass through the coil, come out at or near one end, and go in at the other, forming closed curves. The field inside the coil is nearly uniform except near the ends. Outside the coil the field is like that due to a bar magnet with poles of strength nCA, where A is the area of the cross section of the coil in square centimetres.

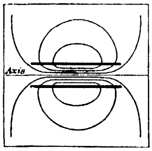


FIG. 18.—MAGNETIC FIELD DUE TO SOLENOID (WHICH IS SHOWN HERE AS THE SECTION, THROUGH ITS AXIS, OF A CYLINDER)

An indefinitely long coil gives a field inside equal to $4\pi Cn$. If we consider a length l of such a coil, we may regard the field in it as made up of the field due to the length l and that due to the rest of the coil. The field due to the rest will be approximately that due to a pole of strength nCA at one end of the length l, and one of strength $-nCA$ at the other end. Thus, if F denotes the field inside a coil of length l, at a distance x from one end, then we have

$$4\pi Cn = F + \frac{nCA}{x^2} + \frac{nCA}{(l-x)^2},$$

so that

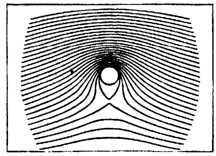
$$F=4\pi Cn\left(1-\frac{A}{4\pi x^2}-\frac{A}{4\pi(l-x)^2}\right).$$

This expression is approximately correct, provided $A/(l-x)^2$ and A/x^2 are small fractions. The foregoing equations are all for the magnetic field *in vacuo* due to circuits carrying a current C expressed in electromagnetic units of current. The fields in air, or in any nearly non-magnetic medium, are nearly the same as *in vacuo*. For magnetic fields in magnetic media *see* MAGNETISM.

The practical unit of current is the *ampere*, which is defined to be one-tenth of the electromagnetic unit of current. Thus, for example, the field inside a long coil having n turns of wire per centimetre is equal to $4\pi Cn/10$, when the current C is expressed in amperes.

Force on Currents in a Magnetic Field.—Since a current produces a magnetic field and so exerts a force on a magnetic pole, we should expect there to be a force on a current in a magnetic field. As a simple example, consider a circular wire, of radius r, carrying a current C, with a magnetic pole of strength m at the centre of the circle. The force on the pole will be $2\pi Cm/r$ dynes, in a direction perpendicular to the plane of the circuit. There must therefore be an equal and opposite force on the wire. The force on one centimetre of the wire is therefore equal to Cm/r^2. But m/r^2 is the field strength at the wire due to the pole, so we see that there is a force on a current C, in a perpendicular magnetic field F, equal to CF per centimetre. The direction of the force is perpendicular to the plane containing C and F. If the circuit and the pole are in a medium of magnetic permeability μ differing from unity, then the field F due to the pole m is equal to $m/\mu r^2$, so that the force per centimetre on the circuit is equal to μCF, instead of CF. (*See* MAGNETISM.) A magnetic field, parallel to a wire carrying a current, exerts no force on the wire, for the field is symmetrical about the wire so that there can be no force. The force on a wire carrying a current C in a magnetic field F is therefore equal to $\mu CF\sin\theta$ per centimetre, where θ is the angle between C and F, for $F\sin\theta$ is the component of F perpendicular to C. Fig. 19 shows the lines of force due to a current in a perpendicular magnetic field. On one side of the wire there is a stronger field than on the other, because the two fields are in the same direction on one side and in opposite directions on the other side. The force on the wire is in the direction from the stronger field to the weaker field. To a person looking along the direction of a current the field of the current is from left to right above the wire and from right to left below it. A magnetic field from left to right therefore gives a downward force on the wire.

Two straight parallel wires carrying currents in the same direction attract each other, but repel each other when the currents are in opposite directions. If d is the distance between the wires and C and C' the currents, then the field at one wire due to the other one is $2C/d$, so the force per centimetre is $2CC'/d$ dynes. Electrodynamometers are instruments for determining a current by measuring the force exerted by one portion of a circuit carrying the current on another portion. The current is passed through a fixed coil, and also through another coil which is suspended from a balance by means of which the vertical force between the two coils is measured. The current can be calculated when the distance between the coils and the size of the coils are known (*see* ELECTRICAL INSTRUMENTS).



FROM MULLER-POUILLET, "LEHRBUCH DER PHYSIK"

FIG. 19.—LINES OF MAGNETIC FORCE DUE TO AN ELECTRIC CURRENT (IN A WIRE) IN A PERPENDICULAR MAGNETIC FIELD

The concentration of these above the wire exerts a downward force on the latter

Units of Quantity and Potential Difference.—The *electromagnetic unit of quantity* of electricity, or charge, is defined to be the quantity carried by one electromagnetic unit of current in one second. The *practical* unit of quantity of electricity is called a *coulomb*, and is defined to be the quantity carried by one ampere in one second. It is therefore equal to one-tenth of the electromagnetic unit of quantity of electricity.

The *electromagnetic unit of potential difference* is defined to be a potential difference such that the work required to move one electromagnetic unit of charge across it is equal to one erg. The *practical* unit of potential difference is called a *volt*, and is defined to be a potential difference such that the work required to take one coulomb across it is equal to ten million ergs. Since the coulomb is one-tenth of an electromagnetic unit of charge, it follows that the volt is equal to one hundred million, or 10^8, electromagnetic units of potential difference. The potential difference, in electromagnetic units, between two points in an electric field is equal to the work per electromagnetic unit of charge required to move a charge from one point to the other.

Ohm's Law.—When a current flows through a wire, or other conductor, it is found that the current is proportional to the potential difference between the ends of the wire. The current can be measured with an electrodynamometer, or other suitable instrument, and the potential difference with a quadrant electrometer, or electrostatic voltmeter (*see* ELECTRICAL INSTRUMENTS). This result is known as Ohm's Law. The ratio of the current to the potential difference is called the conductivity of the wire, and the reciprocal of the conductivity is called the resistance. The practical unit of resistance is called an ohm, and is defined to be a resistance such that a potential difference of one volt produces a current through it of one ampere. If a potential difference P volts between the ends of a wire gives a current C amperes, the resistance R of the wire in ohms is given by $R=P/C$. It is found that the resistance of a wire is proportional to its length and inversely proportional to its cross section. Thus the resistance R of a wire of length l and cross section a is given by $R=\rho l/a$, where ρ is a constant which depends on the nature and physical state of the material of the wire. This constant ρ is called the specific resistance of the material. (*See* ELECTRICITY, CONDUCTION OF.) The methods of measuring resistances are described in the article ELECTRICAL INSTRUMENTS.

Energy Dissipated by a Current.—When a current is passed through a wire, heat is generated in it. The electrical energy used up in driving the current through the wire is converted into heat; this energy, in ergs, is equal to the quantity of electricity E, in electromagnetic units, which flows through the wire

multiplied by the potential difference P, in electromagnetic units, between the ends of the wire. Thus, if W denotes the energy used up, we have $W=EP$ ergs. If H denotes the heat produced, in calories, and J the number of ergs in one calorie, then $H=EP/J$. The quantity of electricity E is equal to the current C multiplied by the time t during which it flows, so that $H=CtP/J$. We have also $P=CR$, where R is the resistance of the wire, so that $H=C^2Rt/J$. If C and P are expressed in amperes and volts respectively, then $H=10^7CtP/J$, since an ampere is one-tenth of an electromagnetic unit of current and a volt is 10^8 electromagnetic units of potential difference. J is nearly equal to $4{\cdot}2\times10^7$, so that $H=CtP/4{\cdot}2$ calories, approximately.

A unit of power frequently used in electrical engineering is the *watt*, which is equal to ten million ergs per second. Thus, since the electrical energy of a current of C amperes flowing across a potential difference of P volts is $CP\times10^7$ ergs per sec., we see that the product CP is equal to the electrical power in watts. A *kilowatt* is a power of one thousand watts.

Thermoelectricity.—If a circuit is made by joining the ends of two wires of different metals, *e.g.*, iron and copper, it is found that, if one of the junctions is kept at a higher temperature than the other, a current flows round the circuit. In the case of iron and copper, the direction of the current is from copper to iron at the hotter junction, provided the average temperature of the two junctions is less than about 600° C. Currents so obtained are called thermoelectric currents, and the branch of electricity dealing with such phenomena is called *thermoelectricity*.

If a current from a battery is passed through a wire consisting of two different metals, it is found that there is an evolution of heat at the junction between the two metals when the current is in one direction, and an absorption of heat when the current is in the other direction. The heat absorbed when a current C is passed for a time t is equal to πCt, where π is a constant depending on the metals used and on the temperature of the junction. With iron and copper at the ordinary temperature, heat is absorbed when the current flows from copper to iron across the junction. This effect is called the *Peltier effect* after its discoverer. The constant π is called the Peltier coefficient. Comparatively large thermoelectric effects are obtained in several cases with two metals having very similar properties; *e.g.*, bismuth and antimony, or iron and nickel, give large thermoelectric currents. Large effects are also obtained in many cases with a metal and one of its alloys with a small amount of some other metal.

Another thermoelectric effect was discovered by William Thomson (Lord Kelvin). He found that there is a reversible heat effect in a wire when a current flows between two points in the wire which are at different temperatures. If one point A is at a temperature T_1, and the other point B at a temperature T_2, and a current C flows in the wire from A to B, then the reversible heat H developed in the wire in a time t is given by $H=\sigma Ct(T_1-T_2)$, where σ is a constant depending on the nature of the wire. This constant σ is called the specific heat of the electricity in the wire, and the effect is called the *Thomson effect*. This heat effect is said to be reversible, because it changes from an absorption of heat to an evolution when the current is reversed. In this way it can be distinguished from the ordinary heating effect of a current in a wire, which, as we have seen, varies as the square of the current and is always an evolution of heat. The specific heat of electricity is positive in some substances and negative in others. The Thomson effect can be demonstrated easily by passing a current through a **U**-shaped piece of platinum wire so that it is heated to a red heat. If then the lower end of the **U** is dipped into water, one side of it becomes visibly hotter than the other. On one side the current is flowing down from the hot end to the cold end, and on the other side the current is flowing up from the cold end to the hot end. The specific heat of electricity is negative in platinum, so the side on which the current is going up is the hotter.

If a circuit is made up by joining together several pieces of wire of different materials, and if all the junctions are kept at the same temperature, there is no current. If the temperature of one only of the junctions is raised, then the current is the same as that which would be obtained in a circuit of the same resistance, composed of the two metals at the heated junction. It is supposed that there is a potential difference between two metals at a junction between them, and that this potential difference varies with the temperature of the junction. If we have a circuit consisting of three metals A, B and C, and if V_{AB} denotes the potential difference between A and B, then, if all three junctions are at the same temperature we have, since there is no current, $V_{AB}+V_{BC}+V_{CA}=0$, or $V_{AB}=V_{AC}-V_{BC}$. This is known as the law of intermediate metals. The theory of the thermocouple, and its use for measuring temperature, are described under THERMOMETRY.

The Thermodynamical Theory of Thermoelectricity, due to Lord Kelvin, is based on the assumption that the electrical energy developed is derived from the reversible heat effects in the circuit. The ordinary non-reversible heat effect is proportional to the square of the current, and so becomes negligible compared with the reversible effects when the current is very small. We may suppose an electromotive force applied to the circuit nearly equal and opposite to the thermoelectromotive force, so that the current is kept very small and can be reversed by changing slightly the applied electromotive force.

Consider a circuit of two metals A and B, and let the two junctions be kept at nearly equal absolute temperatures T and $T+dT$. Suppose a quantity of electricity Q is allowed to flow round the circuit, the current being kept indefinitely small by means of an applied electromotive force dE. The electrical energy developed in the circuit is equal to QdE, so that, if π is the Peltier coefficient at the junction at T, and $\pi+d\pi$ that at the other junction, then

$$QdE=Q(\pi+d\pi-\pi)+Q(\sigma_A-\sigma_B)dT,$$

where σ_A and σ_B are the specific heats of electricity in the metals A and B. The electromotive force E is proportional to dT, so that we may put $dE=PdT$, hence $P=\dfrac{d\pi}{dT}+\sigma_A-\sigma_B$. The quantity P is called the thermoelectric power of the circuit at the temperature T.

According to the second law of thermodynamics the sum of the amounts of heat absorbed, each divided by the temperature at which it is absorbed, is equal to zero, hence

$$Q\left(\frac{\pi+d\pi}{T+dT}-\frac{\pi}{T}\right)+\frac{Q(\sigma_A-\sigma_B)dT}{T}=0,$$

or

$$d\left(\frac{\pi}{T}\right)+(\sigma_A-\sigma_B)dT/T=0.$$

This, with $P=d\pi/dT+\sigma_A-\sigma_B$, gives $\pi=PT$ and $TdP/dT=-(\sigma_A-\sigma_B)$. It is found experimentally that σ for lead is practically zero, so that, in the case of a circuit consisting of a wire of lead and a wire of the metal B, we have $TdP/dT=\sigma_B$. It was shown by P. G. Tait, that, with circuits of any metal, or any alloy, and lead, the thermoelectric power P is a linear function of the temperature T, so that $P=a+bT$, where a and b are constants depending on the nature of the metal or alloy. Hence $\sigma=bT$.

If the electromotive force of a circuit of any two metals with the junctions at T_0 and T_1 is E_1, and with the junctions at T_1 and T_2 is E_2, then, with the junctions at T_0 and T_2, it is found to be E_1+E_2. It follows from this that the electromotive force E of a circuit with junctions at temperatures T_1 and T_2 is given by the equation $E=\int_{T_1}^{T_2}PdT$, because $PdT=dE$. If $P=a+bT$, then $P=0$ at $T=-a/b$. Let $-a/b=T_0$, so that $P=b(T-T_0)$. Hence

$$E=b\int_{T_1}^{T_2}(T-T_0)dT=b\{\tfrac{1}{2}(T_2^2-T_1^2)-T_0(T_2-T_1)\},$$

or

$$E=b(T_2-T_1)\{\tfrac{1}{2}(T_2+T_1)-T_0\}.$$

Tait found that his experimental values of E could be represented quite accurately by this parabolic expression. If the mean temperature of the two junctions is equal to T_0 then $E=0$.

The temperature T_0 is called the neutral point. With $P=a+bT$, we get

$$E=\int_{T_1}^{T_2}(a+bT)dT=a(T_2-T_1)+\tfrac{1}{2}b(T_2^2-T_1^2)$$

If $P=a+bT$ is the thermoelectric power of one metal A and lead, and $P=a'+b'T$ is that of another metal B and lead, then we have

$$E=a\,(T_2-T_1)+\tfrac{1}{2}b\,(T_2^2-T_1^2),$$

and

$$E'=a'(T_2-T_1)+\tfrac{1}{2}b'(T_2^2-T_1^2).$$

The electromotive force of a circuit of the two metals A and B is equal, as we have seen, to $E-E'$, or to $(a-a')(T_2-T_1)+\tfrac{1}{2}(b-b')(T_2^2-T_1^2)$. The thermoelectric power of the circuit $d(E-E')/dT$ is therefore equal to $a-a'+(b-b')T$, or to $P-P'$. It appears that, if we know the values of a and b for circuits of different metals and lead, we can easily calculate the electromotive forces, thermoelectric powers, Peltier coefficients and specific heats of electricity for circuits containing any of the metals. If θ denotes the temperature on the centigrade scale, so that $T=\theta+273$, then $P=a+bT=a+273b+b\theta$; or if $\alpha=a+273b$, then $P=\alpha+b\theta$.

The following table gives the values of α and b for several metals and lead. These values give P in micro-volts per degree C. The neutral point is equal to $-(\alpha/b)$°C.

Metal	α	b	*Metal*	α	b
Sodium	−4·4	−0·021	Bismuth	−86	−0·65
Copper	2·8	0·008	Iron	13·4	−0·032
Magnesium	−0·12	0·002	Nickel	−23·3	−0·030
Zinc	2·5	0·016	Cobalt	−16	−0·070
Mercury	−3·17	−0·0173	Platinum	−3·0	−0·021
Antimony	24	..	Constantan	−34·3	−0·060

The values of these constants depend on the state of purity and physical condition of the metal.

For the applications of the thermoelectric effect to temperature measurement *see* THERMOMETRY.

DIELECTRIC DISPLACEMENT CURRENT

Electromagnetic Induction.—Faraday found that, when a magnet is moved near a circuit so as to change the number of unit tubes of magnetic force passing through the circuit, a current is induced in the circuit. In fig. 20 let ABC be a wire circuit, and let there be a magnetic pole of strength m at a point P. Suppose the pole to be moving towards the circuit along any path QPO, and let the motion be adjusted so that a constant current C is induced in the circuit. If the solid angle subtended by the circuit at P is denoted by ω, then the power, or work per unit time, required to keep the pole moving is equal to $mCd\omega/dt$, where t denotes the time, because the work required to bring up a unit pole from a great distance to P is equal to $C\omega$, when the current C is constant. The electrical power developed in the circuit is equal to EC, where E is the electromotive force induced in the circuit. Hence we have $EC=mCd\omega/dt$, or $E=md\omega/dt$. If the magnetic permeability of the medium is μ, then the field strength F due to the pole is $m/\mu r^2$ at a distance r from the pole. The number of unit tubes of magnetic force coming out of the pole is equal to $4\pi m$, since the cross section of a unit tube is equal to $1/\mu F$ and $4\pi r^2\div(1/\mu F)=4\pi r^2\mu F=4\pi m$. The number of unit tubes from the pole passing through the circuit is therefore $4\pi m\times\omega/4\pi$, or $m\omega$; so that if $N=-m\omega$, then $md\omega/dt=-dN/dt$. The electromotive force induced in the circuit is therefore equal to $-dN/dt$. We conclude that whenever the number N of unit tubes of magnetic force passing through a circuit is changing, there is an induced electromotive force in the circuit equal to $-dN/dt$.

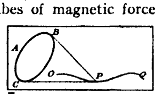


FIG. 20.—MOVING MAGNETIC POLE IN THE NEIGHBOURHOOD OF AN ELECTRIC CURRENT

When a current C is flowing round a circuit the tubes of force of the field due to the current pass through the circuit. The strength of the field is proportional to the current, so that the number N of unit tubes passing through the circuit due to the current is proportional to the current. If then S denotes the number of unit tubes passing through the circuit due to unit current in it we have $N=SC$. The constant S is called the *self-induction* or the *inductance* of the circuit. When the current C varies, there is an induced electromotive force in the circuit equal to $-dN/dt$ or to $-Sdc/dt$. If an electromotive force E is applied to the circuit, by means of a battery or otherwise, the current will be given by the equation $C=(E-SdC/dt)/R$, where R is the resistance of the circuit. The induced electromotive force in a circuit is taken equal to $-dN/dt$, instead of $+dN/dt$, because the induced electromotive force of self-induction opposes the variations of the current; *i.e.*, when an electromotive force E is applied to a circuit in which the current is zero, the current increases with the time and the induced electromotive force is in the opposite direction to the applied electromotive force E. The solution of the equation $E-SdC/dt-CR=0$, when E is constant and $C=0$ at $t=0$, is $C=\dfrac{E}{R}(1-e^{-Rt/S})$. The current therefore increases with the time at a diminishing rate, and finally becomes equal to E/R. dC/dt is equal to $\dfrac{Ee^{-Rt/S}}{S}$, and so at the start is equal to E/S. If, while the steady current E/R is flowing, the electromotive force E is suddenly reduced to zero, we have $SdC/dt+CR=0$. The solution of this equation is $C=(E/R)e^{-Rt/S}$, where t is reckoned from the instant at which E is reduced to zero. In this case the current dies away and finally becomes zero.

The practical unit of self-induction is called a henry, after the American physicist Joseph Henry (*q.v.*), and is a self induction such that the induced electromotive force is equal to one volt when the current is changing at the rate of one ampere per second. Since the volt is equal to 10^8 electromagnetic units of potential difference and the ampere to 10^{-1} electromagnetic units of current, it follows that the henry is equal to 10^9 electromagnetic units of self-induction. If one volt is applied to a circuit of one Ohm resistance and one henry inductance, then $C=1-e^{-t}$, so that after one second $C=0{\cdot}6321$ amperes, and after 10 seconds $C=0{\cdot}9999546$ amperes.

ALTERNATING CURRENTS

If the potential difference applied to a circuit is a periodic function of the time, the current in the circuit is also a periodic function of the time. If the time average of the current is zero, the current is called an alternating current. For example if the current I is equal to $A\cos pt$, where t denotes the time, and A and p are constants, then the current is an alternating current. In fig. 21 let APB be a circle with centre at O, and let AOB be a diameter. Suppose that the radius OP moves round the circle with uniform angular velocity p, so that the angle POB is equal to pt. Let PN be a perpendicular from P on to the diameter AOB. If AOB remains fixed while P goes round, we have

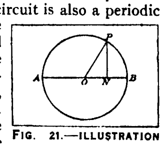


FIG. 21.—ILLUSTRATION OF THE VARIATION OF THE AMPLITUDE OF AN ALTERNATING CURRENT WITH TIME

$$ON=OP\cos P\hat{O}B,$$

or $ON=OB\cos pt$. Thus ON may be taken to represent the alternating current $A\cos pt$, if $OB=A$. The current is positive when N is between O and B, and negative when N is between O and A. The time average of the current is clearly zero for times which are multiples of the time of one revolution of P, or of $2\pi/p$. The number of revolutions per second made by P or $p/2\pi$ is called the frequency of the alternating current. Each complete revolution of P corresponds to a cycle of the current, and the frequency is equal to the number of cycles per second. If n denotes the frequency, then $p=2\pi n$.

The average value of the square of the current which we may denote by $\overline{I^2}$ is given by $\overline{I^2}=(p/2\pi)\int_0^{2\pi/p}A^2\cos^2 pt\,dt=A^2/2$; for, since $\cos^2x+\sin^2x=1$, and the average value of $\cos^2x$ is clearly equal to that of $\sin^2x$ we see that the average value of either is equal to $\tfrac{1}{2}$. The instruments which are used for measuring

alternating currents are so constructed that they indicate the square root of $\overline{I^2}$, which is called the *root mean square current* or simply the alternating current. Thus if an alternating ammeter indicates 25 amperes, this means that $\sqrt{\overline{I^2}}$ is equal to 25 when I is in amperes (*see* ELECTRICAL INSTRUMENTS). In general, if the current I in a circuit is given by $I=f(t)$, where $f(t)$ denotes a function of the time t, and if $f(t)=f(nT+t)$, where n is an integer and T a constant, and if $\frac{1}{T}\int_t^{t+T} f(t)dt=0$, then the current is an alternating current of period T and frequency $1/T$. Also $\overline{I^2}=\frac{1}{T}\int_t^{t+T}(f(t))^2dt$, and an alternating ammeter will give the value of $\sqrt{\overline{I^2}}$. Any alternating current of frequency $n=1/T$ can be regarded as the sum of currents $A_1\cos(2\pi nt+\alpha_1)$, $A_2\cos(4\pi nt+\alpha_2)$, $A_3\cos(6\pi nt+\alpha_3)$, ..., where the A's and α's are constants; that is to say, as the sum of currents with frequencies n, $2n$, $3n$, ..., each of which is a simple harmonic function of the time. The components with frequencies which are multiples of the fundamental frequency n are called the harmonics of the alternating current. In what follows we shall consider only alternating currents which are represented by the simple formula $I=A\cos pt$; *i.e.*, currents without harmonics.

Suppose an alternating potential difference $P=B\cos pt$ is applied to a circuit of resistance R and self induction S. The current I will be given by the equation $IR=B\cos pt-SdI/dt$. If the alternating potential difference has been acting for some time, the current will be an alternating current given by $I=A\cos(pt-\alpha)$, where A and α are constants. By substituting this value of I in the differential equation, we find that $A=B/\sqrt{(R^2+S^2p^2}$ and $\tan\alpha=Sp/R$, so that $I=B\cos(pt-\alpha)/\sqrt{(R^2+S^2p^2)}$. This solution of the equation $B\cos pt=IR+SdI/dt$ may be obtained graphically as follows: Assuming $I=A\cos(pt-\alpha)$, we get

$$B\cos pt=AR\cos(pt-\alpha)-ASp\sin(pt-\alpha).$$

In fig. 22 let the angle BOE be made equal to pt and $OB=B$, also let the angle BOA be made equal to α; from B drop a perpendicular BA to OA; draw BD and AE perpendicular to OE, and draw AC perpendicular to BD; then we have

$$OD=OE-DE=OE-CA;$$

the angle CBA is equal to the angle $AOD=pt-\alpha$; hence

$$OB\cos pt=OA\cos(pt-\alpha)-AB\sin(pt-\alpha).$$

But $OB=B$, so that, comparing this with the equation

$$B\cos pt=AR\cos(pt-\alpha)-ASp\sin(pt-\alpha),$$

we see that $OA=AR$ and $AB=ASp$. Hence $\tan\alpha=BA/OA$, and $AB=ASp$ and $B^2=OA^2+AB^2=A^2R^2+A^2S^2p^2$; so that

$$B=A\sqrt{(R^2+S^2p^2)},$$

as before.

If the resistance R is small compared with Sp, the current is approximately equal to $B\sin pt/Sp$, since $\cos(pt-\frac{\pi}{2})=\sin pt$.

It appears that the current due to the potential difference $B\cos pt$ lags behind the potential difference. The angle of lag, α, is called the phase difference between the potential difference and the current.

Discharge of Condenser.—The capacity of a condenser in electromagnetic units is defined, as in electrostatics, to be the ratio of the charge on one of the plates to the potential difference between the plates. The practical unit of capacity of a condenser is called a *farad*, and is a capacity such that, when the charge on one of the plates is one coulomb, the potential difference between the plates is one volt. Since one coulomb is one tenth of an electromagnetic unit of quantity and one volt is 10^8 electromagnetic units of potential difference, it follows that one farad is equal to 10^{-9} of an electromagnetic unit of capacity. The *microfarad* is one millionth part of a farad and so is 10^{-15} of an electromagnetic unit.

Suppose now that a condenser of capacity C is charged, and that then the plates are connected together by a wire of resistance R and self-induction S. If P denotes the potential difference between the plates and I the current in the wire, after a time t, we have $I=(P-SdI/dt)/R$, or $SdI/dt+RI-P=0$. If E is the charge on one of the plates, then $E=PC$ and $I=-dE/dt$ so that $Sd^2E/dt^2+RdE/dt+E/C=0$. Putting $E=Ae^{\alpha t}$, we get $S\alpha^2+R\alpha+C^{-1}=0$. Denoting the two roots of this equation by α and β, we see that the solution of the differential equation is $E=Ae^{\alpha t}+Be^{\beta t}$ where A and B are constants. When $t=0$ we have $I=-dE/dt=0$, so that $A\alpha+B\beta=0$, and if E_0 denotes the value of E at $t=0$, then $E_0=A+B$. Hence $A=E_0\beta/(\beta-\alpha)$, and $B=-E_0\alpha/(\beta-\alpha)$, so that $E=\frac{E_0}{\beta-\alpha}(\beta e^{\alpha t}-\alpha e^{\beta t})$. The roots of $S\alpha^2+R\alpha+C^{-1}=0$ are given by $\alpha=-\frac{R}{2S}-\sqrt{\left(\frac{R^2}{4S^2}-\frac{1}{SC}\right)}$ and $\beta=-\frac{R}{2S}+\sqrt{\left(\frac{R^2}{4S^2}-\frac{1}{SC}\right)}$. If $R^2/4S^2$ is greater than $1/SC$, both roots are real and negative, so that the charge E gradually diminishes and finally becomes zero. The current

$$I=-dE/dt=\frac{E_0\alpha\beta}{\beta-\alpha}(e^{\beta t}-e^{\alpha t})$$

is given by $I=\frac{E_0e^{-Rt/2S}}{\sqrt{(R^2C^2-4SC)}}(e^{t\sqrt{(R^2/4S^2-1/SC)}}-e^{-t\sqrt{(R^2/4S^2-1/SC)}})$,

so that if $R^2/4S^2$ is less than $1/SC$, we get

$$I=\frac{E_0e^{-Rt/2S}}{\sqrt{-1}\sqrt{(4SC-R^2C^2)}}(e^{\sqrt{(-1)}t\sqrt{(1/SC-R^2/4S^2)}}-e^{-\sqrt{(-1)}t\sqrt{(1/SC-R^2/4S^2)}}),$$

or $$I=\frac{2E_0e^{-Rt/2S}}{\sqrt{(4SC-R^2C^2)}}\sin\left[\sqrt{\left(\frac{1}{SC}-\frac{R^2}{4S^2}\right)}\right]t$$

since $e^{\sqrt{(-1)}x}-e^{-\sqrt{(-1)}x}=2\sqrt{(-1)}\sin x$. It appears therefore that when $R^2/4S^2$ is less than $1/SC$ the current from the condenser is an alternating current which gradually diminishes. The frequency, or number of oscillations per second, is given by $n=\frac{1}{2\pi}\sqrt{\left(\frac{1}{SC}-\frac{R^2}{4S^2}\right)}$. If R/S is very small, n is approximately equal to $1/(2\pi\sqrt{SC})$, so that the time of one oscillation is $2\pi\sqrt{SC}$. In this case $I=\frac{E_0}{\sqrt{SC}}\sin(t/\sqrt{SC})$, so that, since $I=-dE/dt$, we have $E=E_0\cos(t/\sqrt{SC})$. The charge E is therefore alternately positive and negative, or we may say that the electricity oscillates backwards and forwards from one plate of the condenser to the other through the wire. The number of oscillations per second, when an ordinary Leyden jar is discharged through a short wire, is very large. For example, if the capacity of the jar is 2,000 electrostatic units, or $2{,}222\times10^{-12}$ farads, and the self-induction of the wire used is $1/222{,}200$ henry, then $T=2\pi\sqrt{(10^{-14})}=6{\cdot}28\times10^{-7}$ sec., so that $n=T^{-1}=1{\cdot}59\times10^6$ oscillations per second.

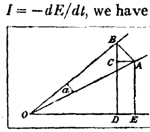


FIG. 22.—GRAPHICAL SOLUTION OF THE DIFFERENTIAL EQUATION FOR AN ALTERNATING CURRENT

Alternating Electromotive Force Acting on a Circuit Containing a Condenser.—Now consider the case of a condenser of capacity C, with its plates connected by a wire of self-induction S and resistance R, when an alternating electromotive force $B\cos pt$ acts in the wire. If E is the charge on one of the plates of the condenser, it is easy to show that

$$S\frac{d^2E}{dt^2}+R\frac{dE}{dt}+\frac{E}{C}=B\cos pt.$$

The solution of this equation is $E=\frac{B\sin(pt-\alpha)}{p\{(S-1/Cp^2)^2p^2+R^2\}^{1/2}}$,

so that $$\frac{dE}{dt}=\frac{B\cos(pt-\alpha)}{\{(S-1/Cp^2)^2p^2+R^2\}^{1/2}},$$

where $$\tan\alpha=p(S-1/Cp^2)/R.$$

It appears that if $p=1/\sqrt{SC}$, the current dE/dt is equal to

$B\cos pt/R$, which is the same as the current due to an electromotive force $B\cos pt$ in a wire of resistance R and zero self-induction. The effect of the self-induction in the circuit can therefore be eliminated by the introduction of a condenser. If the frequency $p/2\pi$ of the applied electromotive force is varied, the current obtained is comparatively small until the frequency approaches $1/(2\pi\sqrt{SC})$, at which value the current is a maximum. The oscillations of electricity in circuits containing a condenser may be compared with the oscillations of a body hung on a spiral spring. If x denotes the displacement of the body from its equilibrium position then we have $m\dfrac{d^2x}{dt^2} + r\dfrac{dx}{dt} + \mu x = F$, where m is the mass of the body, r the viscous resistance to its motion per unit velocity, μ the restoring force for unit displacement and F the external applied force (*see* MECHANICS). If we put $x=E$, $m=S$, $r=R$, and $\mu=1/C$ this equation becomes the same as that for the condenser and circuit, with F standing for the applied electromotive force. The maximum current obtained when the frequency $n=1/(2\pi\sqrt{SC})$ is thus analogous to resonance in dynamics. When the applied force F has the frequency $1/(2\pi\sqrt{m/\mu})$, with which the body oscillates freely when F and r are zero, the amplitude of the vibration set up is a maximum.

Power of Alternating Currents.—If an alternating potential difference $P=B\cos pt$ is applied to any circuit, and the current I produced is equal to $A\cos(pt-\alpha)$, the electrical work done in time dt is equal to $PIdt$. The rate of doing work, or the power, is therefore, at any instant, $W=PI=BA\cos pt\cos(pt-\alpha)$. We have $\cos pt\cos(pt-\alpha)=\cos^2 pt\cos\alpha+\frac{1}{2}\sin 2pt\sin\alpha$. The average values of $\cos^2 pt$ is $1/2$, and that of $\sin 2pt$ is zero, so that we see that the average value of W is equal to $\frac{1}{2}BA\cos\alpha$. If the root mean square values of the potential difference and current are denoted by P' and I', then $P'=B/\sqrt{2}$ and $I'=A/\sqrt{2}$; so that $P'I'=AB/2$ and the average value of the power is $P'I'\cos\alpha$; $\cos\alpha$ is called the *power factor*.

In the case of a potential difference, $B\cos pt$, sending a current $I=B\cos(pt-\alpha)/\sqrt{(R^2+S^2p^2)}$ through a wire, we have $P'=B/\sqrt{2}$, $I'=B/\sqrt{2}\sqrt{(R^2+S^2p^2)}$; and, since $\tan\alpha=Sp/R$, $\cos\alpha=R/\sqrt{(R^2+S^2p^2)}$, so that $P'I'\cos\alpha=B^2R/2(R^2+S^2p^2)$, which is equal I'^2R. In this case all the energy expended is converted into heat, which is equal per unit time to the mean square of the current times the resistance, just as in the case of a steady current C it is equal to C^2R per unit time.

In the case of a potential difference $B\cos pt$ acting on a circuit of inductance S, connected to a condenser of capacity C, if the resistance of the circuit is negligible, we have for the current $I=B\cos(pt-\alpha)/p(S-1/Cp^2)$, where $\tan\alpha=\infty$, so that $\alpha=\pi/2$. The power $P'I'\cos\alpha$ is therefore zero, since $\cos(\pi/2)=0$. The work done in charging the condenser is given out again when the condenser is discharged, so that no energy is used up. In the transmission of power by means of alternating currents, it is important that the power factor should be nearly equal to unity since, if it is small, large currents are required to transmit a small amount of power.

Energy of the Magnetic Field of Currents.—When a constant potential difference P acts on a circuit of resistance R and inductance S then as we have seen above $P-SdI/dt=IR$, where I denotes the current. The electrical energy expended in a time dt is $PIdt$, so that denoting this by dW, we have

$$dW=RI^2dt+SI\frac{dI}{dt}dt.$$

Now $RI^2\,dt$ is the heat energy produced, so that $SIdI$ must represent energy stored up in some form. The current produces a magnetic field, and the electromotive force SdI/dt is due to the increase of this field, so that it is natural to suppose that the energy $SIdI$ is the energy of the magnetic field. If the current increases from zero to I, then the energy stored up is

$$\int_0^I SIdI=\tfrac{1}{2}SI^2,$$

which we therefore suppose to be the energy of the magnetic field of the current I. In fig. 23 let ABC be the circuit, and let PQR represent a unit tube of force of the magnetic field of the circuit. Along this tube $\mu Fa=1$, where F is the field strength in the tube, a the cross section of the tube and μ the magnetic permeability of the medium. If s is the length of a short element of the tube, then the work required to take a unit pole once round the tube is equal to the sum of the products Fs, one for each element of the tube. This work is equal to $4\pi I$, so that, denoting the sum of all the products Fs by ΣFs, we have $\Sigma Fs=4\pi I$.

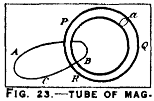


FIG. 23.—TUBE OF MAGNETIC FORCE (P Q R) THREADING CIRCUIT CARRYING ELECTRIC CURRENT (A B C)

The number N of unit tubes which pass through the circuit is equal to SI, so that, if we take the sum of the products Fs for all the unit tubes, we get $\Sigma Fs=4\pi SI^2$, where ΣFs now denotes the sum of the products Fs for all the elements of all the unit tubes in the field. The energy $W=\frac{1}{2}SI^2$ is therefore given by $W=\dfrac{1}{8\pi}\Sigma Fs$. Since $\mu Fa=1$ at any section of any unit tube, we may multiply each of the products Fs by μFa, F and a being the values at the element in question and so obtain $W=\dfrac{1}{8\pi}\Sigma\mu F^2 sa$. But sa is the volume of the element of the unit tube, so that it appears that the energy W can be regarded as distributed throughout the magnetic field with energy density $\mu F^2/8\pi$. This result may be compared with the analogous result in electrostatics, that the electrostatic energy may be regarded as distributed throughout the electric field with energy density $KE^2/8\pi$, where K is the specific inductive capacity and E the electric field strength.

Induced Electromotive Force in Conductors Moving in Magnetic Field.—If the number N of unit tubes of magnetic force passing through a circuit is altered by moving the circuit, or part of it, an induced electromotive force equal to $-dN/dt$ is produced, just as when the circuit is kept fixed and the magnetic field altered. Suppose part of a circuit consists of a straight wire, and that it is in a magnetic field of strength F perpendicular to the wire. If the wire is moved in a direction perpendicular to itself and to the field with a velocity v, the number of unit tubes it crosses per second is $v\mu F$ per centimetre length of the wire. There will therefore be an electromotive force per centimetre in the wire equal to $v\mu F$. The existence of this electromotive force in the moving wire may also be deduced from the force on a current in a magnetic field. We may suppose that the current consists of electricity moving along the wire. If E is the amount of electricity per centimetre which moves in the wire, and v its velocity, the current I is given by $I=Ev$. The force on the wire per centimetre due to a magnetic field F at right angles to the wire is $\mu FI=\mu FEv$. The force on unit charge in the wire is therefore μFv. If then the wire is made to move across the magnetic field with velocity v, there will be a force on unit charge in it equal to μFv along the length of the wire. The induced electromotive force per centimetre in the wire is therefore equal to μFv.

Absolute Determination of Resistance and Potential Difference.—The resistance of a conductor in electromagnetic units may be found by means of a method due to L. Lorenz (1873). A circular metal disc is mounted on a shaft, so that it can be made to rotate about an axis through its centre and perpendicular to its plane. A magnetic field, perpendicular to the plane of the disc and symmetrical about the axis of rotation, is produced by means of a circular coil of wire, concentric with the disc, through which a current is passed. The current is also passed through the resistance to be determined, and the ends of the resistance are connected to two brushes, one making contact with the circumference of the disc and the other with the shaft close to the disc. If R is the resistance and I the current, both in electromagnetic units, then the potential difference between the ends of the resistance is equal to IR. When the disc is rotating in the magnetic field there is an induced electromotive force in it which tends to produce a potential difference between the two

brushes. If the induced electromotive force is equal to the potential difference IR between the ends of the resistance, there will be no current in the wires connecting the resistance to the brushes. The speed of rotation of the disc is adjusted until the deflection of a galvanometer, in series with the resistance and one of the brushes, is zero.

Let H_r denote the strength of the magnetic field at a distance r from the centre of the disc, a the radius of the shaft and b that of the disc. The induced electromotive force between distances r and $r+dr$ from the centre of the disc is equal to $\omega r H_r dr$, where ω is the angular velocity of the disc, for ωr is the velocity of the disc at the radial distance r. The potential difference between the brushes, when no current is flowing through them is therefore $\omega\int_a^b H_r r dr$, and this is equal to IR. Now H_r is proportional to I, so that if H'_r is the value of H_r when $I=1$, then $H_r=IH'_r$. Also, if n is the number of revolutions per second made by the disc, $\omega=2\pi n$, so that $IR=2\pi nI\int_a^b H'_r r dr$,

or
$$R=n\int_a^b H_r 2\pi r dr.$$

The number N' of unit tubes of magnetic force passing through the disc due to unit current in the coil is equal to $\int_a^b H'_r 2\pi r dr$, so that we have $R=nN'$. N' can be calculated from the dimensions of the coil and disc, so that R can be found in this way. This method is only suitable for the determination of very small resistances. For example, suppose $b=20$ cm., $a=1$ cm., and that the average value of H'_r is 200. Then, if n is 100 revolutions per second, we have $R=100\times 200\times\pi(400-1)$, or $R=2\cdot 51\times 10^7$ electromagnetic units of resistance, or 0·0251 ohm, since one ohm is equal to 10^9 electromagnetic units of resistance. When a resistance has been found accurately in this way, other resistances can be found by comparing them with it, and so standards of resistance can be made.

The value of a potential difference, in electromagnetic units of potential difference, can be found by comparing it with the potential difference between the ends of a wire of known resistance, through which a known current is passing. The current can be measured in electromagnetic units by means of an electrodynamometer. In this way it has been found that the potential difference due to one normal Weston cell is equal to 1·0183 volts at 20° C. For practical purposes, the ampere is often defined as a current which deposits 1·1180 milligrams of silver in one second. This definition is based on experimental measurements of the amount of silver deposited by currents measured with an electrodynamometer.

Mutual Induction.—Consider the case of two circuits A and B near together. If some of the unit tubes of magnetic force due to the circuit A pass through the circuit B, when the current in A is changing there will be an induced electromotive force in B. For example, suppose a battery and key included in the circuit A; then, on closing the key, the current in A rises rapidly from zero to a constant value. While the current in A is rising, there is an induced current in B, in the opposite direction to that in A. This current in B stops when the current in A becomes constant. If the key in A is now opened, the current in A very suddenly stops, and there is a momentary current in B in the same direction as that in A.

The mutual induction between two circuits A and B is defined to be the number of unit tubes of magnetic force which pass through A due to a unit current in B. It can be shown that the number of unit tubes which pass through A, due to unit current in B, is equal to the number which pass through B due to unit current in A. To show this, consider the work required to start the currents, and let the current in A be I_1 and that in B be I_2. The work done against the electromotive force of self-induction, when a current I_1 is started in A with the circuit B open, so that $I_2=0$, is equal to $\frac{1}{2}S_1I_1^2$, where S_1 is the self-induction of A. If we suppose that a current I_2 is started in B, while the current I_1 in A is kept constant, the work required will be $\frac{1}{2}S_2I_2^2$, together with the work required to keep the current in A constant. If M is the number of unit tubes through A due to unit current in B, this work is $\int_0^t M\frac{dI_2}{dt}I_1dt=MI_1I_2$, since I_1 is supposed kept constant. Thus the work required to start I_1 in A, and then I_2 in B is $\frac{1}{2}S_1I_1^2+\frac{1}{2}S_2I_2^2+MI_1I_2$. If now we suppose the current I_2 started with $I_1=0$, and then I_1 started with I_2 constant, we get, for the work to start the currents, $\frac{1}{2}S_1I_1^2+\frac{1}{2}S_2I_2^2+M'I_1I_2$, where M' is the number of unit tubes through B due to unit current in A. The two results for the work must be equal so that $M=M'$. The work required to start the currents is supposed to be the energy of the magnetic field as in the case of a single circuit. If the electromotive force applied to the circuit A is denoted by E, we have

$$I_1R_1=E-S_1\frac{dI_1}{dt}-M\frac{dI_2}{dt},$$

and
$$I_2R_2=-S_2\frac{dI_2}{dt}-M\frac{dI_2}{dt},$$

where R_1 and R_2 are the resistances of the two circuits.

Suppose that, at $t=0$, the currents I_1 and I_2 are both zero, and that a constant electromotive force E is applied to the circuit A. At the start I_1 and I_2 are zero, so that, when $t=0$,

$$E=S_1\frac{dI_1}{dt}+M\frac{dI_2}{dt},$$

$$0=S_2\frac{dI_2}{dt}+M\frac{dI_1}{dt};$$

and therefore $\frac{dI_1}{dt}=E/(S_1-M^2/S_2)$, when $t=0$. Thus, the presence of the second circuit causes the current in A to increase more rapidly at the start, as though the self-induction of A were reduced from S_1 to S_1-M^2/S_2. If $M^2=S_1S_2$, the initial value of dI_1/dt is infinite, as if S were zero. The initial value of dI_2/dt is $-ME/(S_1S_2-M^2)$. The current in the primary circuit A will become equal to E/R_1 after a time, and then the current in the other or secondary circuit will be zero. The quantity of electricity Q_1, which flows past any point in the primary circuit in a long time t, is $\int_0^t I_1dt$ so that

$$R_1\int_0^t I_1dt=E\int_0^t dt-S_1\int_0^t\frac{dI_1}{dt}dt-M\int_0^t\frac{dI_2}{dt}dt,$$

or $R_1Q_1=Et-S_1I'_1$; and in the same way $R_2Q_2=-MI'_1$, where Q_2 is the quantity of electricity, flowing past any point in the secondary circuit, and $I'_1=E/R_1$ is the final value of I_1, so that $Q_2=-ME/R_1R_2$. If, when the primary current has attained the constant value E/R_1, it is then rapidly reduced to zero, by breaking the circuit or otherwise, we have

$$R_2Q_2=-S_2\int_0^0 dI_2-M\int_{C_1'}^0 dI_1,$$

or $Q_2=ME/R_1R_2$. Thus, when the primary current is stopped, the flow in the secondary is equal but opposite to that when the primary current is started.

If the number of unit tubes of magnetic force N passing through a circuit, of resistance R and self-induction S due to magnets or currents in other circuits, is changed from N_1 to N_2, we have

$$RC=-\frac{dN}{dt}-S\frac{dI}{dt},$$

so that $R\int_{t_1}^{t_2}Idt=-\int_{N_1}^{N_2}dN-S\int_{t_1}^{t_2}dI$, where t_1 is the time when $N=N_1$, and t_2 that when $N=N_2$. If N is constant and equal to N_1 for some time after t_1, and to N_2 for some time before t_2, then I will be zero at both t_1 and t_2, so that $RQ=N_1-N_2$, where Q is the amount of electricity which flows past any point in the circuit when N is changed from N_1 to N_2. The previous result

$Q_2 = -ME/R_1R_2$ agrees with the equation $Q = (N_1 - N_2)/R$, for, when the primary current changes from o to E/R_1, the number of unit tubes passing through the secondary changes from o to ME/R_1.

If alternating potential differences $E_1\cos pt$ and $E_2\cos pt$ are applied to the primary secondary circuits respectively, we have

$$I_1R_1 = E_1\cos pt - S_1\frac{dI_1}{dt} - M\frac{dI_2}{dt}$$

$$I_2R_2 = E_2\cos pt - S_2\frac{dI_2}{dt} - M\frac{dI_1}{dt}.$$

Let us suppose that the resistances R_1 and R_2 are small, and the frequency $p/2\pi$ large, so that I_1R_1 and I_2R_2 can be neglected. In this case we get

$$\frac{dI_1}{dt} = \frac{S_2E_1 - ME_2}{S_2S_1 - M^2}\cos pt$$

and $$\frac{dI_2}{dt} = \frac{S_1E_2 - ME_1}{S_2S_1 - M^2}\cos pt,$$

so that $$I_1 = (S_2E_1 - ME_2)\sin pt/p(S_2S_1 - M^2)$$

and $$I_2 = (S_1E_2 - ME_1)\sin pt/p(S_2S_1 - M^2).$$

If $E_2 = E_1M/S_1$, the secondary current is zero, so that an electromotive force $E_1\frac{M}{S_1}\cos pt$ in the secondary circuit is just sufficient to stop the induced current in the secondary due to the primary circuit. In the same way if $E_1 = E_2M/S_2$, the primary current is zero. For both primary and secondary currents to be zero, we must have $E_2 = E_1M/S_1$ and $E_1 = E_2M/S_2$, which is only possible when $M^2 = S_1S_2$. If $E_2 = o$ we have $I_1 = \frac{E_1}{S_1 - M^2/S_2}\frac{\sin pt}{p}$ and $I_2 = \frac{ME_1}{M^2 - S_2S_1}\frac{\sin pt}{p}$. Thus the primary current is the same as that due an electromotive force $E_1\cos pt$, acting on a single circuit of small resistance and self-induction $S_1 - M^2/S_2$. The secondary circuit therefore diminishes the apparent inductance of the primary circuit.

Suppose that the primary circuit is a coil of n_1 turns of wire, and the secondary circuit a coil, of n_2 turns, which practically coincides with the primary coil, so that all the unit tubes of force go through both coils. Let N_1 be the number of unit tubes going through the two coils due to unit current flowing round them. Then, if a current I_1 is passed through the primary coil, we have $I_1n_1^2N_1 = I_1S_1$, and in the same way $I_2n_2^2N_1 = I_2S_2$, and also $I_1n_1n_2N_1 = MI_1$, or $I_2n_1n_2N = MI_2$, so that $S_1 = N_1n_1^2$, $S_2 = N_1n_2^2$ and $M = n_1n_2N_1$. Hence $M^2 = S_1S_2$. Also $M/S_1 = n_1n_2/n_1^2 = n_2/n_1$. Thus the electromotive force in the secondary coil, necessary to stop the secondary current, is equal to E_1n_2/n_1, and the electromotive force in the primary coil, necessary to stop the primary current, is E_2n_1/n_2, so that, if $E_1n_2 = E_2n_1$, both currents will be zero, approximately, when all the unit tubes pass through both coils, so that $S_1S_2 = M^2$, and the resistances R_1 and R_2 are small.

DIELECTRIC DISPLACEMENT CURRENTS

In electrostatics, conductors are regarded as substances in which electricity can move more or less freely, and insulators as substances through which electricity cannot pass. An electric field produces a current in a conductor, but not in an insulator. If a condenser, consisting of two parallel metal plates with air or a vacuum between them, is connected to a battery, a current flows through the battery and wires leading to the condenser for a fraction of a second while the condenser is being charged. If the space between the plates is filled with a substance of specific inductive capacity K, the current is increased K times. The charging current flows into one plate and out of the other, just as though there were a flow of electricity right through the insulator between the plates. Such phenomena led Faraday to suggest that there is something analogous to a current in the insulator, or dielectric, between the plates during the charging process. He supposed that the electric field produces a separation of the positive and negative electricities in the atoms of the dielectric, so that the positive electricity is slightly displaced towards the negatively charged plate, and the negative electricity towards the positively charged plate. The separation is proportional to the field strength, so that, while the field is changing, there is a current. Maxwell adopted Faraday's ideas and pointed out that such currents in the dielectric should produce a magnetic field, just as currents in a conductor do. He supposed the dielectric current to be equal to the current in the wires leading from the battery to the condenser. According to this assumption, there is a dielectric current even when the insulator between the plates is a vacuum.

The Deduction of the Electromagnetic Equations.—If the electric intensity between the plates is F, and the charge per square centimetre on the positive plates is S, in electrostatic units, then we have $F = 4\pi S/K$, so that the dielectric current density is equal to $\frac{K}{4\pi}\frac{\partial F}{\partial t}$, since, according to the assumption just mentioned, it is equal to ds/dt. If the substance between the plates is not a perfect insulator, there will be a conduction current in addition to the dielectric current. If σ denotes the conductivity of the substance, the conduction current density is σF, so that the total current is $\sigma F + \frac{K}{4\pi}\frac{\partial F}{\partial t}$, where we may suppose K, F and σ to be all expressed in electrostatic units, so that $K = 1$ for a vacuum, and the unit of conductivity is that of a conductor one centimetre long and one square centimetre cross section through which a potential difference of one electrostatic unit produces a current of one electrostatic unit of charge per second.

The work required to take a magnetic pole of strength m once round a current of strength i, in electromagnetic units of current, is equal to $4\pi mi$ ergs. Hence, if we imagine a small plane closed curve, drawn anywhere in a medium in which there are currents flowing, the work required to take a unit pole once round the closed curve will be equal to 4π times the total current flowing through the curve. This result may be expressed analytically as follows:—Take axes x, y, z, (fig. 24) and consider a small rectangular area $ABCD$ with its sides parallel to the y and z axes. Let $BA = CD = \delta y$ and $DA = CB = \delta z$. Let the components of the magnetic field in the direction of the axes be denoted by H_x, H_y, H_z and the components of the current density by i_x, i_y, i_z. The current through the rectangle $ABCD$ is equal to $i_x\delta y\delta z$, so that the work required to take a unit pole round the rectangle is $4\pi i_x\delta y\delta z$. The work to take a unit pole from B to A along BA, and D to C along DC, will be equal to δy multiplied by the difference between H_y at CD and at AB, or to $-\delta y\frac{\partial H_y}{\partial z}\delta z$. In the same way, the work to take a unit pole along AD and along CD is equal to $\delta z\frac{\partial H_z}{\partial y}\delta y$, so that the work to take the unit pole round the rectangle along $ADCBA$ is equal to $\left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)\delta y\delta z$. Hence we have $4\pi i_x = \frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}$. By considering the currents through small rectangles parallel to the xz and xy planes, we get in the same way

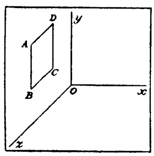


FIG. 24.—SMALL RECTANGULAR AREA, IN A MEDIUM CONTAINING TUBES OF FORCE, USED IN DERIVING MAXWELL'S SIX ELECTROMAGNETIC EQUATIONS

$$4\pi i_y = \frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}$$

$$4\pi i_z = \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}$$

The current density in a medium, of specific inductive capacity K and conductivity σ, is equal to $\sigma\dot{F}+\frac{K}{4\pi}\frac{\partial F}{\partial t}$, so that if we now suppose σ, K and F expressed in electromagnetic units, and denote the components of F by F_x, F_y and F_z we get

$$4\pi\left(\sigma F_x+\frac{K}{4\pi}\frac{\partial F_x}{\partial t}\right)=\frac{\partial H_z}{\partial y}-\frac{\partial H_y}{\partial z} \tag{1}$$

$$4\pi\left(\sigma F_y+\frac{K}{4\pi}\frac{\partial F_y}{\partial t}\right)=\frac{\partial H_x}{\partial z}-\frac{\partial H_z}{\partial x} \tag{2}$$

$$4\pi\left(\sigma F_z+\frac{K}{4\pi}\frac{\partial F_z}{\partial t}\right)=\frac{\partial H_y}{\partial x}-\frac{\partial H_x}{\partial y} \tag{3}$$

In good conductors like metals the conduction current σF is usually very large compared with the dielectric current, $\frac{K}{4\pi}\frac{\partial F}{\partial t}$, which can then be neglected, and in good insulators the conduction current is usually negligible. These equations express a relation between the electric and magnetic fields in a medium of conductivity σ and specific inductive capacity K. They involve the assumption that dielectric currents produce the same magnetic field as ordinary conduction currents, and also that the theory of the magnetic field due to currents in thin wire circuits is applicable to currents in a medium in three dimensions. The latter assumption is easily justifiable, since it is clear that any distribution of currents in a medium can be regarded as made up of currents flowing along thin filaments coinciding in direction with the lines of flow.

Another similar relation between the electric and magnetic fields in a medium can be obtained from the result that the induced electromotive force round any circuit is equal to the rate of diminution of the number of unit tubes of magnetic force passing through the circuit. We assume that this result is true for any small plane curve drawn in the medium, and that the electromotive force is equal to the work required to take a unit charge of electricity round the curve against the forces exerted on it by the electrostatic field. The work to take a unit charge round the rectangle $ABCD$ (fig. 24) along $ADCBA$ is $\left(\frac{\partial F_z}{\partial y}-\frac{\partial F_y}{\partial z}\right)\delta y\delta z$, as in the case of the unit pole; and the number of unit tubes passing through the rectangle is $\mu H_x\delta y\delta z$, since along a unit tube $\mu Ha=1$, where μ is the magnetic permeability of the medium and a the cross section of the tube, so that $a=1/\mu H$. Hence we have

$$-\frac{\partial}{\partial t}(\mu H_x)\delta y\delta z=\left(\frac{\partial F_z}{\partial y}-\frac{\partial F_y}{\partial z}\right)\delta y\delta z$$

or

$$-\mu\frac{\partial H_x}{\partial t}=\frac{\partial F_z}{\partial y}-\frac{\partial F_y}{\partial z} \tag{4}$$

and in the same way

$$-\mu\frac{\partial H_y}{\partial t}=\frac{\partial F_x}{\partial z}-\frac{\partial F_z}{\partial x} \tag{5}$$

$$-\mu\frac{\partial H_z}{\partial t}=\frac{\partial F_y}{\partial x}-\frac{\partial F_x}{\partial y}. \tag{6}$$

If V denotes any vector, and V_x, V_y, V_z its components along the directions of the axes x, y, z, then we may derive another vector, denoted by curl V from it. the components of which are defined by the equations:—

$$(\text{curl } V)_x=\frac{\partial V_z}{\partial y}-\frac{\partial V_y}{\partial z}$$

$$(\text{curl } V)_y=\frac{\partial V_x}{\partial z}-\frac{\partial V_z}{\partial x}$$

$$(\text{curl } V)_z=\frac{\partial V_y}{\partial x}-\frac{\partial V_x}{\partial y}.$$

Introducing this notation we see that the six differential equations we have obtained are equivalent to the vector equations

$$4\pi\left(\sigma\mathbf{F}+\frac{K}{4\pi}\frac{\partial\mathbf{F}}{\partial t}\right)=\text{curl }\mathbf{H} \tag{7}$$

and

$$-\mu\frac{\partial\mathbf{H}}{\partial t}=\text{curl }\mathbf{F}. \tag{8}$$

Thus, the component of the curl of a vector along the normal to a small plane area is equal to the line integral of the vector round the boundary of the area divided by the area. The equations (7) and (8) therefore are merely the mathematical expression of the results that the work to take a unit pole once round a closed curve is equal to 4π times the current through the curve, and that the work to take a unit charge once round a closed curve is equal to the rate of diminution of the number of unit tubes of magnetic force passing through the curve.

The equations (1) to (6), or (7) and (8), were first obtained by Clerk Maxwell, and they form the basis of his electromagnetic theory of light and electric waves. They are of fundamental importance for modern electrical theory. In the case of a perfect insulator, for which $\sigma=0$, we have from (1) $K\frac{\partial F_x}{\partial t}=\frac{\partial H_z}{\partial y}-\frac{\partial H_y}{\partial z}$. Differentiating this with respect to t, and substituting the values of $\frac{\partial H_y}{\partial t}$ and $\frac{\partial H_z}{\partial t}$ given by (5) and (6), we get

$$\mu K\frac{\partial^2F_x}{\partial t^2}=\frac{\partial^2F_x}{\partial x^2}+\frac{\partial^2F_y}{\partial y^2}+\frac{\partial^2F_z}{\partial z^2}-\frac{\partial}{\partial x}\left(\frac{\partial F_x}{\partial x}+\frac{\partial F_y}{\partial y}+\frac{\partial F_z}{\partial z}\right).$$

Similar equations for F_y, F_z, and for the components of H can be obtained in the same way.

These equations show quite clearly that the electro-magnetic disturbances are propagated through the medium with the velocity $1/\sqrt{(\mu K)}$, as can easily be proved by the following simple case. If ρ is the density of charge in the medium, we have

$$\frac{\partial}{\partial x}(KF_x)+\frac{\partial}{\partial y}(KF_y)+\frac{\partial}{\partial z}(KF_z)=4\pi\rho.$$

If $\rho=0$, and K has the same value everywhere, this gives $\frac{\partial F_x}{\partial x}+\frac{\partial F_y}{\partial y}+\frac{\partial F_z}{\partial z}=0$, so that $\mu K\frac{\partial^2F_x}{\partial t^2}=\frac{\partial^2F_x}{\partial x^2}+\frac{\partial^2F_y}{\partial y^2}+\frac{\partial^2F_z}{\partial z^2}$

In the case of an electromagnetic field in which F and H are constant over all planes perpendicular to the x axis, this equation reduces to $\mu K\frac{\partial^2F_x}{\partial t^2}=\frac{\partial^2F_x}{\partial x^2}$. A solution of this equation is $F_x=f(x-vt)$, where $f(x-vt)$ denotes any function of $x-vt$ and $v=1/\sqrt{(\mu K)}$. According to this, such a field travels along x with the velocity $1/\sqrt{(\mu K)}$. For, if x is increased from x_1 to x_2, and t also increased from t_1 to t_2, and if $x_2-x_1=v(t_2-t_1)$, then x_1-vt_1 is equal to x_2-vt_2, so that $f(x_1-vt_1)$ is equal to $f(x_2-vt_2)$.

The equation $v=1/\sqrt{(\mu K)}$ gives the velocity of electric waves in a medium of magnetic permeability μ, and specific inductive capacity K. μ and K must, of course, both be expressed in units of the same system either the electrostatic or the electromagnetic. The force in dynes between two charges e and e' in electrostatic units is equal to ee'/Kr^2, where r is the distance between the charges in centimetres. For a vacuum, $K=1$, in electrostatic units of specific inductive capacity. If one electromagnetic unit of charge is equal to c electrostatic units, then, if E and E' denote the values of e and e' in electromagnetic units, we have $E=e/c$ and $E'=e'/c$. The force between the charges is therefore equal to $EE'c^2/Kr^2$, and this must be equal to $EE'/K'r^2$, where K' is the specific inductive capacity of the medium in electromagnetic units. Hence $K'=K/c^2$, so that for a vacuum $K'=1/c^2$. For a vacuum $\mu=1$ in electromagnetic units. so that the velocity, for a vacuum, is equal to

$$1/\sqrt{(\mu K)}=1/\sqrt{(c^{-2})}=c\text{ cm. per sec.}$$

Thus it appears that the velocity of electric waves in a vacuum in centimetres per second should be equal to the number of electrostatic units of electricity in one electromagnetic unit.

Ratio of Electrostatic to Electromagnetic Units.—The number c can be found by making a measurement of some electrical quantity in electrostatic units and also in electromagnetic units. For example, the capacity of a condenser may be calculated in electrostatic units from its dimensions and then determined in electromagnetic units, by comparison with standards of resistance of known value in electromagnetic units. If a condenser of capacity C in electromagnetic units is charged with charges $+E$ and $-E$ electromagnetic units, then its electrical energy is $\frac{1}{2}E^2/C$ ergs. If the charges and capacity when expressed in electrostatic units are denoted by E' and C', then $\frac{1}{2}E^2/C=\frac{1}{2}E'^2/C'$. But $E=E'/c$ so that $E'^2/C=E^2c^2/C'$ which gives $C'/C=c^2$. In this and other ways it has been shown that c is nearly equal to 3×10^{10}. It follows that the velocity of electromagnetic waves in a vacuum should be equal to 3×10^{10} cm. per sec. The velocity of light *in vacuo* is equal to 3×10^{10} cm. per sec., so that, following Clerk Maxwell, we may conclude that *light consists of electromagnetic waves.* It will be noted that the argument consists in throwing Faraday's ideas into mathematical form, which shows that an electromagnetic disturbance will be propagated as a wave; then finding from the equations the velocity of such a wave, and showing that it equals the velocity of light, as ordinarily determined.

ELECTRON THEORY

For most practical purposes it is sufficient to regard the media, in which electrical phenomena are observed, as continuous media possessing conductivity σ, specific inductive capacity K and magnetic permeability μ, in greater or less degree. These electrical properties of matter are the properties of matter in bulk, or of bodies containing enormous numbers of atoms. They represent average values taken over volumes very large compared with the volume of one atom. For scientific purposes it is desired to explain such properties of matter, and to do so it is necessary to develop a theory of the nature of the ultimate particles composing material bodies. According to the *electron theory*, matter consists of minute particles of negative electricity which are all equal, and are called electrons, together with minute positively charged particles, one in each atom. The positive particles are called positive nuclei, and an electrically neutral atom is supposed to consist of a positive nucleus surrounded by a number of electrons; the charge on the nucleus being equal and opposite to that on the electrons. The electrons and nuclei are supposed to be so small that even in very dense matter, such as platinum, only a very minute fraction of the volume is occupied by them. (*See* NUCLEUS.)

If we imagine a point selected at random inside a piece of matter, then there will almost always be nothing at the point except the electric and magnetic fields excited by the electrons and nuclei. If the point should happen to be inside an electron or a nucleus, we may suppose that there is also a certain density of electricity at it in addition to the electromagnetic field. According to this theory, the electromagnetic equations for the interior of matter are the equations for space containing nothing but electricity and the fields which it excites. The magnetic permeability and the specific inductive capacity are everywhere the same as in a vacuum. If F denotes the electric field strength, and ρ the density of the charge at a point, then we have

$$\frac{\partial F_x}{\partial x}+\frac{\partial F_y}{\partial y}+\frac{\partial F_z}{\partial z}=4\pi\rho,\ \text{or}\ \operatorname{div}\mathbf{F}=4\pi\rho$$

and since on this theory there is no such thing as magnetism we have also $\frac{\partial H_x}{\partial x}+\frac{\partial H_y}{\partial y}+\frac{\partial H_z}{\partial z}=0$, or $\operatorname{div}\mathbf{H}=0$, where H is the magnetic field strength. For, if there is no magnetism, all the unit tubes of magnetic force must be closed so that the number starting in unit volume is zero.

In the electron theory it is customary to express the magnetic field strength in electromagnetic units, and the electric field strength and charge density in electrostatic units. The current density is equal to the dielectric current, $\frac{1}{4\pi}\frac{\partial F}{\partial t}$, together with the current due to the motion of the electricity, which is ρv, where v is the velocity of the electricity.

Maxwell's equations (1), (2), (3) are therefore replaced by

$$\frac{4\pi}{c}\left(\rho v_x+\frac{1}{4\pi}\frac{\partial F_x}{\partial t}\right)=\frac{\partial H_z}{\partial y}-\frac{\partial H_y}{\partial z}$$
$$\frac{4\pi}{c}\left(\rho v_y+\frac{1}{4\pi}\frac{\partial F_y}{\partial t}\right)=\frac{\partial H_x}{\partial z}-\frac{\partial H_z}{\partial x}$$
$$\frac{4\pi}{c}\left(\rho v_z+\frac{1}{4\pi}\frac{\partial F_z}{\partial t}\right)=\frac{\partial H_y}{\partial x}-\frac{\partial H_x}{\partial y},$$

where v_x, v_y, v_z are the components of v. The current components are divided by c, the number of electrostatic units of charge in one electromagnetic unit, because ρ and F are supposed expressed in electrostatic units, while H is in electromagnetic units. The specific inductive capacity K is put equal to unity, its value for a vacuum in electrostatic units. In the same way Maxwell's equations (4), (5), (6) are replaced by

$$-\frac{1}{c}\frac{\partial H_x}{\partial t}=\frac{\partial F_z}{\partial y}-\frac{\partial F_y}{\partial z}$$
$$-\frac{1}{c}\frac{\partial H_y}{\partial t}=\frac{\partial F_x}{\partial z}-\frac{\partial F_z}{\partial x}$$
$$-\frac{1}{c}\frac{\partial H_z}{\partial t}=\frac{\partial F_y}{\partial x}-\frac{\partial F_x}{\partial y}.$$

The magnetic permeability μ is put equal to unity, its value for a vacuum in electromagnetic units, and $\partial H/\partial t$ is divided by c, because the work to take an electrostatic unit of electricity round a closed curve is only $1/c$ of that for an electromagnetic unit. The six equations are equivalent to the vector equations

$$\frac{4\pi}{c}\left(\rho\mathbf{v}+\frac{1}{4\pi}\frac{\partial\mathbf{F}}{\partial t}\right)=\operatorname{curl}\mathbf{H},\ \text{and}\ -\frac{1}{c}\frac{\partial\mathbf{H}}{\partial t}=\operatorname{curl}\mathbf{F};$$

these with $\operatorname{div}\mathbf{F}=4\pi\rho$, $\operatorname{div}\mathbf{H}=0$, and the equation for the force on a moving charge are the fundamental equations of the electron theory. The force, per unit charge, on a charge moving with velocity $\mathbf{v}$ is equal to $\mathbf{F}+\frac{1}{c}[\mathbf{v}\,.\,\mathbf{H}]$ where $[\mathbf{v}\,.\,\mathbf{H}]$ denotes the vector product of $\mathbf{v}$ and $\mathbf{H}$, and is defined to be a vector, perpendicular to the plane containing $\mathbf{v}$ and $\mathbf{H}$, equal to $vH\sin\theta$, where θ is the angle between v and H. The factor $1/c$ is introduced because $vH\sin\theta$ is the force on one electromagnetic unit of charge moving with velocity v in a magnetic field H.

The fundamental equations can be simplified by expressing F and H in terms of units $\sqrt{(4\pi)}$ times larger than the ordinary units, and ρ in terms of a unit $\sqrt{(4\pi)}$ times smaller than the ordinary unit. If this is done, the equations become

$$\frac{1}{c}\left(c\mathbf{v}+\frac{\partial\mathbf{F}}{\partial t}\right)=\operatorname{curl}\mathbf{H},\quad -\frac{1}{c}\frac{\partial\mathbf{H}}{\partial t}=\operatorname{curl}\mathbf{F},\ \operatorname{div}\mathbf{F}=\rho,\ \operatorname{div}\mathbf{H}=0$$

The force in dynes on a charge per unit charge is still equal to $\mathbf{F}+\frac{1}{c}[\mathbf{v}\,.\,\mathbf{H}]$, because the unit of charge is $\sqrt{(4\pi)}$ times smaller, and the unit of field strength $\sqrt{(4\pi)}$ times larger than before. In what follows we shall use this simplified form of the electromagnetic equations.

Calculation of H and F at Any Point.—These general equations enable H and F to be calculated at any point when ρ and $\mathbf{v}$ are known throughout space as functions of the time t. As with

Maxwell's equations, we can eliminate all the components of F and H, except one, and obtain equations like

$$\frac{\partial^2 F_x}{\partial x^2}+\frac{\partial^2 F_x}{\partial y^2}+\frac{\partial^2 F_x}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2 F_x}{\partial t^2}=\omega,$$

where ω is a function of ρ and $\mathbf{v}$. The solution of this equation is $F_x=-\frac{1}{4\pi}\int\frac{[\omega]dS}{r}$, where dS is an element of volume at a distance r from the point at which F_x is to be calculated, and $[\omega]$ denotes the value of ω in the element dS at a time r/c earlier than the instant at which F_x is to be calculated. This solution shows that the effect due to the element of volume dS travels out from it with the velocity c of light. The integral is to be taken over all the parts of space where ω at the times in question differs from zero.

As a simple example, suppose an electron with charge e has been at rest at the origin from $t=-\infty$ to a time t_1, and that, between t_1 and t_2, it moves a small distance away from the origin and then back again, and then remains at rest. Up to t_1 the field will be $e/4\pi r^2$ along r, but when the electron begins to move, the field will change and the change will move out from it with velocity c. If we describe two spheres with centres at the origin and radii $c(t-t_1)$ and $c(t-t_2)$, then outside the larger sphere the disturbance due to the motion will not have arrived, and inside the smaller sphere the disturbance will have passed by, so that the field will be $e/4\pi r^2$ along r, except in the space between the two spheres. Inside this space there will be a magnetic field due to the motion as well as the electric field. Thus the motion of the electron produces a wave in the field, which moves out from it with the velocity c.

Poynting's Theorem.—A very important theorem due to Poynting, to which reference has been made in the historical section, deals with the flow of energy in an electromagnetic field. Let P denote the energy flowing per square centimetre per second through a surface drawn perpendicular to the direction of the stream of energy. Then it can be shown that P is in a direction perpendicular to the plane containing F and H, and equal to c times the product of F and the component of H perpendicular to F. As an example, consider the case of two long, thin-walled, concentric, conducting, hollow cylinders of radii a and b, with a current i flowing along the inner cylinder and returning along the outer one. Let the potential difference between the cylinders be V, and the space between them vacuum. The magnetic field between the cylinders is equal to $i/2\pi cr$, in the units we are now using, and the electric field is equal to $V/r\log(b/a)$, where r is the distance from the axis of the two cylinders, so that the flow of energy between the cylinders parallel to the axis is, by Poynting's theorem, equal to

$$c\int_a^b 2\pi r\,\frac{i}{2\pi cr}\,\frac{V}{r\log(b/a)}\,dr=\frac{iV}{\log(b/a)}\int_a^b dr/r=iV.$$

This is equal to the power required to drive a current i against a potential difference V, so that it appears that, when power is transmitted through an electric circuit, it flows in the insulator between the conductors.

Electromagnetic Momentum.—As we have seen, there is a force on a current in a magnetic field. This force is due to the action of the field on the magnetic field of the current. Since we suppose that a dielectric current produces a magnetic field like a current in a wire, we should expect that there would be a force on a dielectric current in a magnetic field. In the case of a dielectric current in a vacuum, there is no material body present on which the force can act, so that we must suppose that the force acts on the field and gives it momentum. In this way we see that there must be momentum in the electromagnetic field. A varying magnetic field produces an electric field round it like the magnetic field of a dielectric current, but in the opposite direction. We should therefore expect there to be a force on a varying magnetic field in an electric field. The rate of increase of the electromagnetic momentum in the field must therefore be equal to the resultant of these two forces. The x component of the force, on unit volume of the field, due to the y component of the dielectric current, is equal to $\frac{1}{c}H_z\frac{\partial F_y}{\partial t}$, and that due to the y component of the variation of the magnetic field is $-\frac{1}{c}F_z\frac{\partial H_y}{\partial t}$. The x component, due to the z components, is $-\frac{1}{c}H_y\frac{\partial F_z}{\partial t}+\frac{1}{c}F_y\frac{\partial H_z}{\partial t}$. Thus the total x component of the force on the field per cubic centimetre is

$$\frac{1}{c}\left(F_y\frac{\partial H_z}{\partial t}+H_z\frac{\partial F_y}{\partial t}-F_z\frac{\partial H_y}{\partial t}-H_y\frac{\partial F_z}{\partial t}\right)$$

which is equal to $\frac{1}{c}\frac{\partial}{\partial t}(F_yH_z-F_zH_y)$. But this is equal to $\frac{1}{c^2}\frac{\partial P_x}{\partial t}$, since $P_x=c(F_yH_z-F_zH_y)$. In the same way it is easy to see that the y and z components of the force on the field are equal to $\frac{1}{c^2}\frac{\partial P_y}{\partial t}$ and $\frac{1}{c^2}\frac{\partial P_z}{\partial t}$. Since force is equal to rate of increase of momentum, we conclude that the electromagnetic momentum of the field is equal to P/c^2 per cubic centimetre. But P is the energy flowing through unit area in unit time, so that it is natural to conclude that the electromagnetic momentum P/c^2, is the momentum of the stream of energy.

If the energy density is E, and we suppose that the energy is moving along with velocity v, then we have $P=Ev$, and the momentum density, P/c^2, is Ev/c^2. We infer that energy has mass, equal to the energy divided by the square of the velocity of light, since momentum is equal to mass times velocity. Since one form of energy can be converted into any other form, it is natural to conclude that any form has this amount of mass. Since the electromagnetic field has energy, mass and momentum, and can move through space, it has all the essential characteristics of material bodies, and so may be regarded as a material substance. It moves through space by a process of growing in front and fading away behind, *i.e.*, by wave motion, and differs from material bodies, as usually conceived, in this respect, but it may be that material bodies, such as electrons, also move through space by means of some sort of wave motion.

Variation of Mass with Velocity.—For a small particle of any kind, we have $M=Ev/c^2$, where M is the momentum, E the energy and v the velocity of the particle. If a force f acts on the particle in the direction in which it is moving, and if there is no loss of energy by radiation or otherwise, then $f\delta t=\delta M$, and $f\delta x=\delta E$. But $\delta x=v\delta t$, so that $v\delta M=\delta E$. The equation $M=Ev/c^2$ gives $c^2\delta M=E\delta v+v\delta E$ so that $c^2\delta E=Ev\delta v+v^2\delta E$ or $\delta E/E=v\delta v/(c^2-v^2)$. Integrating this gives

$$\log E=-\tfrac{1}{2}\log(c^2-v^2)+\log E_0+\tfrac{1}{2}\log c^2,$$

where E_0 is the value of E when $v=0$. Hence $E=E_0/\sqrt{(1-v^2/c^2)}$. Since the momentum is equal to Ev/c^2, we have

$$M=E_0v/c^2\sqrt{(1-v^2/c^2)}.$$

Now consider the mass of the particle. We may define the mass, so that, when a mass m has velocity v, its momentum is mv. Hence $m=m_0/\sqrt{(1-v^2/c^2)}$, where $m_0=E_0/c^2$. The kinetic energy of the particle is $E-E_0$, or $E_0\left\{\frac{1}{\sqrt{(1-v^2/c^2)}}-1\right\}$, when v/c is very small this gives $E-E_0=E_0v^2/2c^2=m_0v^2/2$.

If the particle considered is an electron, m will be the mass of the field, which it excites and which moves along with it, together with any additional mass which it may have. If the electron is merely an electric charge, it may have no additional mass, but

in any case its mass will vary with its velocity, in accordance with the equation $m = m_0/\sqrt{(1 - v^2/c^2)}$. The experiments of Kaufmann, Bucherer and others on the variation of the mass of electrons with their velocity have shown that the mass does vary approximately in accordance with this equation. These experiments confirm that momentum is due to flux of energy, but give no information as to the constitution of electrons. (*See* ELECTRON· and ELECTRICITY, CONDUCTION OF: *in Gases*.

Properties of Matter in Bulk.—The electromagnetic equations of the electron theory give the field due to any distribution of charges. From the microscopic standpoint, the field at any point inside a material body is the field due to all the electrons and positive nuclei in the body; it varies rapidly from point to point, being very large near to electrons or nuclei. The field at a point in a material body cannot be determined experimentally. Experimental results on the electrical properties of material bodies only give average values over volumes containing enormous numbers of electrons and nuclei. For example, if the potential difference between the plates of a condenser, with an insulator of specific inductive capacity K between them, is equal to P, and the distance between the plates is d, then we say that the electric field in the insulator between the plates is equal to P/d, and we ignore the microscopic variations of the field in between the electrons and nuclei. In an electrically neutral piece of matter, in which there is no measurable electric or magnetic field, it is supposed that the average fields are zero, although there are intense fields between the electrons and nuclei. The average field over any small volume containing an enormous number of electrons and nuclei is zero, and the total charge in any such small volume is also zero.

It is supposed that some of the electrons in conductors are free to move about, and that an electric field causes these free electrons to move along in the direction of the field with an average velocity proportional to the field. If k denotes the average velocity due to unit field, and n the number of free electrons per cubic centimetre, then the conduction current density, i, is given by $i = nekF$, where e is the electronic charge and F the electric field strength. The conductivity σ is equal to i/F, so that $\sigma = nek$. If ρ denotes the density of the electricity at any point in the substance, and V its velocity, then the conduction current is easily seen to be equal to the average value of the part of ρV due to the motion of the free electrons, the average being taken over a small volume large enough to contain a very great number of free electrons.

It is supposed that some of the electrons are not free to move about, but are acted on by restoring forces proportional to the distances of the electrons from their equilibrium positions. In an electrically neutral piece of matter the average field due to the electrons and nuclei is zero, but, when an electric field acts on the matter, the electrons are displaced from their equilibrium positions, and so produce a field. Consider a small volume S containing n electrons per cubic centimetre, and suppose these electrons are displaced from their equilibrium positions through an average distance ξ. It is easy to see that the small volume will then produce the same field as two charges neS and $-neS$ at a distance ξ apart; for when the electrons are not displaced, the positive and negative charges, on the average, neutralize each other, so that, when the negative charges are displaced, the positive and negative charges are separated and no longer neutralize each other. The electric moment of the volume S is equal to $ne\xi S$. The moment per unit volume is called the polarization, so that, denoting this P, we have $P = ne\xi$. The polarization P is a vector quantity, and we may draw lines in the medium in the direction of the polarization. If we draw lines of polarization through the boundary of a small area, we get a tube of polarization. Consider a short length l of such a tube, and let its cross section be α, so that its volume is $l\alpha$ and its electric moment $Pl\alpha$. This moment is the same as that of a charge $+P\alpha$

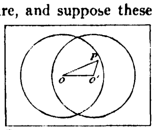


FIG. 25.—DISPLACEMENT OF AN ELECTRON, WHICH PRODUCES AN ELECTRIC FIELD

and a charge $-P\alpha$ separated by a distance l. Thus we see that a tube of polarization starts from a charge $-P\alpha$ and ends on a charge $+P\alpha$. A unit tube of polarization may be defined as one which ends on a unit charge, so that $P\alpha = 1$ for a unit tube. The number of unit tubes of polarization starting in a unit volume is therefore equal to $-\rho_P$, where ρ_P denotes the density of charge due to the variation of the polarization. We have therefore $\operatorname{div}P = -\rho_P$. If then ρ_E denotes the average density of charge in the medium due to electricity in the medium, not due to variations in the polarization, and $\bar{\rho}$ the total average charge density over the small volume S, we have $\bar{\rho} = \rho_E + \rho_P$. The charge ρ_P disappears when the polarization is reduced to zero, but the charge ρ_E does not. The equation $\operatorname{div}F = \rho$ of the electron theory, when averaged over the small volume S, gives $\operatorname{div}\bar{F} = \bar{\rho}$, where $\bar{F}$ denotes the average value of F. $\bar{F}$ is the value of the electric field which would be given by experimental methods. We have therefore $\operatorname{div}\bar{F} = \rho_E + \rho_P$ or $\operatorname{div}\bar{F} + \operatorname{div}P = \rho_E$. If we now denote $\bar{F} + P$ by D, we get $\operatorname{div}D = \rho_E$. D is called the total polarization, or the electric induction. Also it is sometimes called the electric displacement.

When the polarization changes, there is a current due to the motion of the electrons. The current density is equal to $ne\dfrac{d\xi}{dt}$ or dP/dt. Thus we see that the total average current in a material medium at rest, is equal to $\sigma\bar{F} + dP/dt + d\bar{F}/dt$. $\sigma\bar{F}$ is the conduction current, dP/dt the polarization current, and $d\bar{F}/dt$ the displacement current of the variation of the electric field. The equation $\operatorname{curl} H = \frac{1}{c}\left(\frac{\partial F}{\partial t} + \rho V\right)$ of the electron theory, when averaged over the small volume S, gives

$$\operatorname{curl}\bar{H} = \frac{1}{c}\left(\frac{\partial\bar{F}}{\partial t} + \overline{\rho V}\right),$$

so that, for a medium at rest, since $\overline{\rho V} = \sigma\bar{F} + \partial P/\partial t$, we get $\operatorname{curl}\bar{H} = \frac{1}{c}\left(\sigma\bar{F} + \frac{\partial P}{\partial t} + \frac{\partial\bar{F}}{\partial t}\right)$, or, since $D = P + \bar{F}$ we have $\operatorname{curl}\bar{H} = \frac{1}{c}(\sigma\bar{F} + \partial D/\partial t)$. For an insulator $\sigma = 0$ and

$$\operatorname{curl}\bar{H} = \frac{1}{c}\,\frac{\partial D}{\partial t}.$$

In a non-magnetic substance the motion of the electrons and nuclei is such that it produces no magnetic field except that due to the conduction and polarization currents. The magnetic moment is zero everywhere. In such a substance the average value of H, or $\bar{H}$, will be equal to the experimentally determined value of H, so that the equation $\operatorname{curl}F = -\frac{1}{c}\,\frac{\partial H}{\partial t}$ gives $\operatorname{curl}\bar{F} = -\frac{1}{c}\,\frac{\partial\bar{H}}{\partial t}$. The equation $\operatorname{div}H = 0$ also gives $\operatorname{div}\bar{H} = 0$.

The equations for a non-magnetic material medium at rest are therefore

$$\operatorname{div}D = \rho_E, \qquad \operatorname{div}\bar{H} = 0$$

$$\operatorname{curl}\bar{H} = \frac{1}{c}(\sigma\bar{F} + \partial D/\partial t), \qquad \operatorname{curl}\bar{F} = -\frac{1}{c}\,\frac{\partial\bar{H}}{\partial t}.$$

In a magnetized medium, according to the electron theory, the motion of the electrons is such that it produces an observable magnetic field, even when the average current $\sigma\bar{F} + \partial D/\partial t$ is zero. It is supposed that some of the electrons move round orbits in the atoms, so that the atoms have a magnetic moment. These atomic currents do not contribute anything to the average current over the small volume S containing many atoms, because as many electrons are moving in one direction as another, but they nevertheless produce a magnetic field and the medium

is said to be magnetized. The average, or observable, current therefore does not correspond to the observable magnetic field, so that the equations for a non-magnetic substance are not applicable to a magnetic one. The total magnetic field, averaged over the small volume S, is called the magnetic induction and denoted by B, while the part of the magnetic field which is not due to the atomic currents in S is called the magnetic field strength, and denoted by H (*see* MAGNETISM). The equations for a magnetic substance at rest are then $\text{div}D=\rho_E$, $\text{div}B=0$, $\text{curl}\,\overline{H}=\frac{1}{c}\,(\sigma\overline{F}+\partial D/\partial t)$, $\text{curl}\,\overline{F}=-\frac{1}{c}\,\frac{\partial B}{\partial t}$. The specific inductive capacity K is equal to $D/\overline{F}$, and the magnetic permeability μ is equal to B/H, so that the equations may be written $\text{div}K\overline{F}=\rho_E$, $\text{div}\mu H=0$,

$$\text{curl}\,\overline{H}=\frac{1}{c}\left(\sigma\overline{F}+K\,\frac{\partial\overline{F}}{\partial t}\right),\ \text{curl}\,\overline{F}=-\frac{\mu}{c}\,\frac{\partial\overline{H}}{\partial t}.$$

These are equivalent to the equations of Maxwell's theory.

Theory of Specific Inductive Capacity.—The specific inductive capacity K of a medium is equal to $D/\overline{F}$, or to $(\overline{F}+P)/\overline{F}$, and so to $1+ne\xi/\overline{F}$, since, as we have seen, $P=ne\xi$. The average displacement of the electrons from their normal positions in which they neutralize the positive charges may be calculated as follows:—The force on the n electrons in unit volume is not equal to $ne\overline{F}$, because the displacement of the electrons produces a microscopic field at each electron, which does not appear in the average field $\overline{F}$. An approximate value for this field may be obtained by supposing that each electron is inside a small spherical cavity, in the medium, of radius about equal to the distance from one electron to the next. For the purpose of calculating the field in a spherical cavity, we may suppose the medium to consist of positive electricity of uniform density ne and negative electricity of equal density. When the negative electricity is displaced a distance ξ, we get a layer of free positive electricity over half the surface of the cavity, and of free negative electricity over the other half. These layers are the same as would be obtained on the surface of a solid sphere of the medium, equal to the cavity, if the negative electricity in the sphere were displaced a distance $-\xi$. The field in the cavity due to the layer is thus equal to the field due to two equal solid spheres of electricity, one of density $+ne$ and the other of density $-ne$, with their centres at a distance ξ apart. The field inside a solid sphere of density ne, at a distance r from its centre, is equal to the charge inside a sphere of radius r divided by $4\pi r^2$, or to $\frac{4}{3}\pi r^3ne/4\pi r^2=\frac{1}{3}ner$, and so is proportional to r and directed away from the centre of the sphere. In the same way the field due to the negative sphere is equal to $\frac{1}{3}ner$ but directed towards the centre. In fig. 25 let O and O' be the centres of the two spheres, so that $OO'=-\xi$. The field at any point P is therefore the resultant of a field, along PO, proportional to PO, and a field, along $O'P$, proportional to $O'P$, and so is proportional to $O'O$, and therefore equal to $\frac{1}{3}ne\xi$, so to $P/3$. The field in the spherical cavity is therefore equal to $\overline{F}+P/3$.

Now suppose that the average restoring force on an electron in the medium is equal to $-\alpha\xi$ where α is a constant. The resultant force on an electron is therefore equal to $-\alpha\xi+e(\overline{F}+P/3)$. In a steady field this will be equal to zero, so that $\xi=e(\overline{F}+P/3)/\alpha$. This equation, with $K=1+P/\overline{F}$ and $P=ne\xi$, gives

$$K=1+\frac{ne^2/\alpha}{1-ne^2/3\alpha},\ \text{or}\ \frac{K-1}{K+2}=\frac{1}{3}\,\frac{ne^2}{\alpha}.$$

If the electric field is not steady, then it is necessary to take into account the inertia of the electrons. If m denotes the mass of an electron, we have $nm\ddot{\xi}=-n\alpha\xi+ne(\overline{F}+P/3)$, or, since $P=ne\xi$ so that $\ddot{P}=ne\ddot{\xi}$, this gives $m\ddot{P}=-\alpha P+ne^2(\overline{F}+P/3)$. If we suppose that $\overline{F}=\overline{F}_0\cos pt$, we find that $K=1+P/\overline{F}$ is given by

$$K=1+\frac{ne^2}{\alpha-mp^2-ne^2/3},\ \text{or}\ \frac{K-1}{K+2}=\frac{1}{3}\frac{ne^2}{(\alpha-mp^2)}.$$

Thus the specific inductive capacity, and so the refractive index, which is equal to $\sqrt{K}$ for a non-magnetic medium, vary with the frequency $p/2\pi$. In this way an explanation of the phenomena of dispersion can be obtained from the electron theory. By introducing a frictional force on the electrons proportional to the velocity $\dot{\xi}$, absorption can also be explained (*see* LIGHT). The theory of magnetic permeability is discussed in the article on MAGNETISM.

Electron Theory of Metallic Conduction.—On the electron theory, some of the electrons in metallic conductors are supposed to be free to move about inside the material of the conductor. These free electrons are set in motion by an electric field, so producing a current. According to the classical electron theory, the free electrons were supposed to move about in the conductor like the molecules of a gas and to have the same average kinetic energy as gas molecules at the same temperature. This theory is no longer regarded as tenable. The question of metallic conduction is discussed under ELECTRICITY, CONDUCTION OF: *Solids*.

Hall Effect.—When a metal plate carrying a current is put in a transverse magnetic field (H), it is found that a small electric field (F) is produced in the plate along the direction perpendicular to the current and to the magnetic field. This is known as the Hall effect. According to the electron theory, we should expect the transverse electric field to be given by the equation $He\bar{u}+Fe=0$, or $F=-H\bar{u}$, where $\bar{u}$ is the average velocity of the electrons along the direction of the current. For $He\bar{u}$ is the sideways force on the electrons due to their motion in the magnetic field and the transverse electric field must be such as to prevent any sideways motion. According to this the Hall effect should be in the same direction in all metals, whereas in fact it is in one direction in some and in the other direction in other metals. It is also usually very small and appears to be entirely absent in liquid metals. The classical electron theory therefore fails to explain the Hall effect.

It is found that the electric conductivity of metals is slightly diminished by a magnetic field. The change is nearly proportional to the square of the field strength. No satisfactory explanation of this effect is offered by the electron theory (*see* ELECTRICITY, CONDUCTION OF). In recent years modifications of the classical electron theory of metallic conduction have been developed which seem to agree with more of the facts than the classical theory. These modifications depend upon the principles of the theory of quanta (*see* QUANTUM THEORY, and THERMIONICS).

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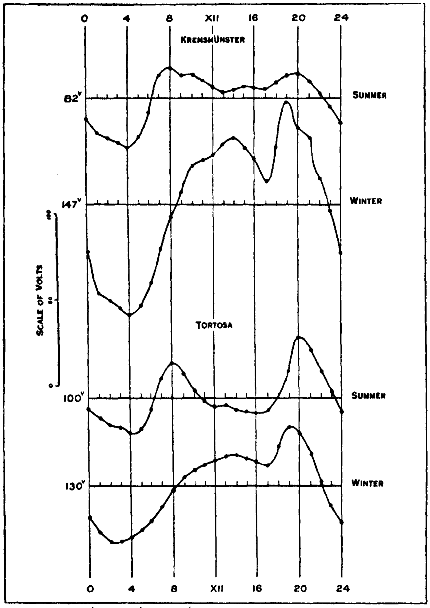
ELECTRICITY, ATMOSPHERIC. Atmospheric-electric phenomena divide themselves into two main classes: those which we shall call Normal Phenomena—phenomena which prevail at all times, even in the absence of abnormal meteorological conditions—and those more particularly associated with thunderstorms, which we shall class as Thunderstorm Phenomena. A class of phenomena associated with the motion of electricity in the upper atmosphere and capable of investigation only by indirect means is becoming more and more important in view of the part they play in wireless telegraphy.

NORMAL ATMOSPHERIC ELECTRIC PHENOMENA

General Survey.—The earth is not an electrically neutral body, but its surface is negatively charged to such an extent that the increase of potential per metre increase of altitude at its surface, the ***potential gradient*** as it is called, amounts to about 150 volts per metre. The potential gradient varies throughout the day and throughout the year in a more or less systematic manner, the variations amounting at 50% or more of its total value. During abnormal weather conditions the sign of the potential gradient may be reversed.

If the atmosphere were neutral, and if the negative charge on the earth's surface were approximately uniform in density, the potential gradient would be constant with increase of altitude for all altitudes which were small compared with the earth's radius. However, the atmosphere is charged positively, so that successively increasing spheres drawn in the atmosphere about the earth's centre contain, on the whole, correspondingly less and less amounts



FROM CHAUVEAU, "ÉLECTRICITÉ ATMOSPHÉRIQUE"

FIG. 1.—COMPARATIVE GRAPHS OF DAILY VARIATION OF MEAN VALUE OF THE POTENTIAL-GRADIENT AT KREMSMÜNSTER, GERMANY (ABOVE) AND AT TORTOSA, SPAIN (BELOW)

of negative charge, with the result that the potential gradient diminishes with altitude until at an altitude of about 10km. it attains a value negligible compared with its value at the earth's surface. A sphere drawn through a point at this altitude and concentric with the earth contains as much positive electricity in the atmosphere as it contains negative electricity on the earth's surface.

The atmosphere is a conductor of electricity. The conductivity is so small that a column of air one inch long offers as much resistance to the flow of the electric current as would a copper cable of the same cross-section extending from here to the star Arcturus and back, twenty times over. Yet this conductivity, small as it is, would be sufficient to ensure that 90% of the earth's charges would disappear in ten minutes if there were no means of replenishing the loss. The source of this replenishment constitutes the great mystery of atmospheric electricity.

Atmospheric Conductivity.—The electrical conductivity of the atmosphere arises from the presence of positive and negative ions. These are primarily of two kinds, ordinary ions, sometimes called "small ions" which move in an electric field with a "mobility" of about 1·3cm. per second per volt per centimetre, and "heavy ions," which are probably small ions attached to dust nuclei, and which have mobilities of the order $\frac{1}{1,000}$ of that of the small ions. Other classes of ions having mobilities of the order of 1% of the mobilities of the small ions have been cited by several observers. The ratio of the number of large ions to the number of small ions per cu.cm. varies enormously with the locality, so that it is undesirable to give more than a few representative values. For this ratio, P. Langevin (1905) found 50 in Paris, A. Göckel (1917) found between two and three in the Swiss Alps and in Freiburg, while J. A. McClelland and H. Kennedy (1912) found 200 in Dublin.

While the heavy ions affect the vertical distribution of the potential gradient, their small mobility prevents them from contributing in an important degree to the electrical conductivity of the atmosphere, and it is customary to neglect their effects in this connection. On this basis, if n_+ and n_- are the numbers per cu.cm. of the positive and negative small ions, v_+ and v_- the corresponding mobilities, and e the charge on an ion, the atmospheric electric conductivity λ may be written as $\lambda = n_+ ev_+ + n_- ev_-$. It is customary to denote n_+ev_+ by λ_+ and n_-ev_- by λ_-.

TABLE I. *Numbers of Small Ions per Cu. cm. in Various Localities*

Place	Latitude degrees.	Longitude E. of Greenwich	$\frac{n_+ + n_-}{2}$	$\frac{n_+}{n_-}$
Kew	51·5 N.	359·7	330	1·40
Munich	48·1 N.	11·6	904	1·24
Karasjok	69·3 N.	25·6	750	1·17
Freiburg	50·9 N.	16·3	624	1·36
Barcelona harbour	41·4 N.	2·2	541	1·30
Jachenau	47·6 N.	11·4	915	2·16
Aibling	47·9 N.	12·0	950	1·25
Buenos Aires	34·6 S.	301·6	1,980	1·04
Atlantic ocean			504	1·04
Pacific ocean			549	1·25
Southern ocean			558	1·18

TABLE II. *Atmospheric Conductivity* $\lambda = \lambda_+ + \lambda_-$, *in Various Localities and Air-earth Current Density*

Place	Latitude Degrees	Longitude E. of Greenwich	$\lambda_+ + \lambda_-$ e.s.ū. $\times 10^{-4}$	$\frac{\lambda_+}{\lambda_-}$	s.u. $\times 10^{-7}$
Göttingen	51·5 N.	9·9	2·22	0·98	8
Potsdam	52·4 N.	13·1	0·95	1·16	7·1
Davos	46·8 N.	9·8	2·68	1·13	5·2
Samoa	13·8 S.	188·2	4·5	1·04	7·0
Petermann I.	65·2 S.	295·8	4·16	1·62	22·6
Seeham	48·0 N.	346·9	2·64	1·02	6·9
Buenos Aires	34·6 S.	301·6	1·32	1·02	5·7
Atlantic ocean			2·34	1·18	11·2
Pacific ocean			2·51	1·25	11·5
Southern ocean			2·14	1·22	11·5

The principal sources of ionization in the lower atmosphere are:

(1) The Radioactive material in the atmosphere.
(2) Radioactive material in the soil.
(3) The Penetrating radiation.

Radioactive substances emit three types of radiation, alpha-rays which are positively charged atoms of helium travelling with a velocity of the order of 10^9cm. per second, beta-rays which are ordinary electrons travelling with a velocity of the order of 3×10^{10}cm. per second, and gamma-rays, which partake of the nature of X-rays or light rays of extremely short wave-length. The penetrating radiation is usually regarded as a radiation of gamma-ray type, but of wave-length still shorter than that of the gamma-rays from radioactive substances.

The number of pairs of ions which combine per cu.cm. per second is $\alpha n_+ n_-$ according to the elementary theory dealing with only one kind of positive and one kind of negative ion. The constant α, which is known as the coefficient of recombination, has been determined for ions produced artificially in the laboratory, and has been found to have the value $1{\cdot}6\times10^{-6}$.

When the numbers n_+ and n_- are approximately equal we have, for the case of equilibrium in a space where the field is zero or sensibly uniform

$$q = \alpha n^2$$

where q is the number of ions produced per cu.cm. per second.

This expression seems totally inadequate to represent the conditions in the atmosphere, where dust nuclei and the like play such an important part, and it appears that the state of equilibrium obeys more nearly an expression of the type

$$q = an^2 + \beta n \qquad (1)$$

where, as a matter of fact, over land the term an^2 is negligible compared with βn.

The air over the land contains about 130×10^{-18} curies of radium emanation per cu.cm., and the radium content of the soil amounts to about 2×10^{-12} gram per cubic centimetre. The soil and atmosphere also contain a certain amount of thorium and its products. The radioactive materials in the air are capable of accounting for a rate of production of about 5 ions per cu.cm. per second. The beta and gamma radiation for the radioactive materials in the soil account for a rate of production of about 3 ions per cu.cm. per second, while it has been customary to attribute about 1·5 ions per cu.cm. per second to the penetrating radiation. Thus, in all, we can account for about 9·6 ions per cu.cm. per second over land.

Values of β obtained from different localities vary from about 6×10^{-3} to 20×10^{-3}. Even the smaller value makes the βn atom of (1) outweigh the an^2 term, and, with $q = 9{\cdot}5$ as above accounted for, the smaller value of β would give $n = 1{,}600$ and the larger value would give $n = 480$.

In view of the variability of the data, the agreement of these values with the land value quoted in Table I. is sufficiently close to warrant the assumption that the essential features of the ionization over land call for no new sources other than those we have invoked.

Over the ocean, the radioactive material in the air and in the seawater is negligible as regards its power to contribute appreciably to the ionization observed, and we are left with only the 1·5 ions per cu.cm. due to the penetrating radiation. We are at a loss to know what value to assume for β. The appropriate value would be much lower than that of land, so that it is not unthinkable that on the ocean the an^2 term of (1) may play an important, if not the principal rôle. If we assume $q = 1{\cdot}5, a = 1{\cdot}6 \times 10^{-6}$, and if we take $n = 540$ as the average value for the ocean, the value of β necessary to satisfy (1) is $\beta = 1{\cdot}9 \times 10^{-3}$. In view of the greater purity of the ocean air, this value seems not inappropriate in comparison with the values of β quoted above for the land.

Variation of Conductivity with Altitude.—The conductivity increases with altitude, so that at an altitude of 9km. its value is about 30 times that at the earth's surface. Thus, as corresponding to an average surface value of about $1{\cdot}5 \times 10^{-4}$ e.s.u. for $\lambda_+ + \lambda_-$, A. Wigand (1919) found:

Altitude (metres)	5,300	5,385	8,345	8,865
$(\lambda_+ + \lambda_-) \times 10^4$	16·5	18·8	23·2	37·3

The conductivity of the atmosphere at altitudes above 10km. is not known from direct observation, but values for it have been inferred on the basis of assigning to it values sufficient to account for such conditions in the upper atmosphere as would be responsible for the diurnal variations of terrestrial magnetism, and on the basis of data obtained from the transmission of radio waves between different parts of the earth's surface.

The conclusions which may be drawn from the evidence of terrestrial magnetism are as follows: There are two independent regions of high conductivity ionized by independent solar agencies. One of these extends over the whole earth. It probably owes its origin to the sun, and the intensity of the ionization at any part is a function of the sun's zenith distance. The average total conductivity of this layer is equivalent to that of a layer of copper ·005cm. thick. The conductivity of the layer increases by 40 or 50% from sunspot minimum to sunspot maximum. The other ionized regions are the auroral zones around each pole, and the polar caps within these zones. Here we have ionization due to the charged particles which enter our atmosphere from the sun and are deflected to the polar and auroral regions by the earth's magnetic field. Measurements of the height of the aurora indicate that these particles penetrate our atmosphere down to about 90km. from the ground. Their effects at higher altitudes are demonstrated by the extension of the aurora to altitudes of several hundred kilometres.

The phenomena concerned with the reflection of wireless waves around the earth lead to information as to the number of free electrons per cu.cm. rather than to the total numbers of pairs of ions. They suggest that the density of free electrons in the atmosphere increases with altitude and attains a value of about

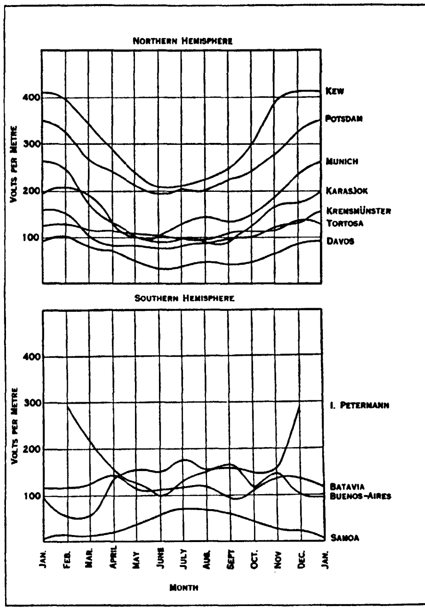


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FIG. 2.—COMPARATIVE GRAPHS OF ANNUAL VARIATION OF POTENTIAL-GRADIENT AT STATIONS IN NORTHERN HEMISPHERE (ABOVE) AND IN SOUTHERN HEMISPHERE (BELOW)

10^5 electrons per cu.cm. at an altitude between 70 and 150 miles. (*See* WIRELESS TELEGRAPHY.)

The Potential Gradient.—An idea of the daily mean values of the potential gradient at various places on the earth's surface will be gained from Table III. The daily variation of the mean value of the potential gradient at different times of the year is

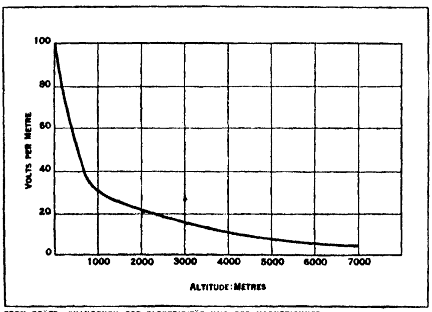
TABLE III. *Potential Gradient. Land Values*
Mean Values Taken Throughout One or More Years

Place	Latitude Degrees	Longitude E. of Greenwich	Pot. Grad. volts–meter
Kew	51·5 N.	359·7	304
Potsdam	52·4 N.	13·1	245
Tortosa	40·8 N.	0·5	114
Kremsmunster	48·0 N.	14·1	107
Munich	48·1 N.	11·6	168
Davos	46·8 N.	9·8	64
Trieste	45·6 N.	13·8	73
Karasjok	69·3 N.	25·6	139
Petermann I.	65·2 S.	295·8	176
Buenos Aires	34·6 S.	301·6	126
Perpignan	42·7 N.	357·1	55
Seeham	48·0 N.	13·1	84
Upsala	59·9 N.	15·2	70
Atlantic ocean			146
Pacific ocean			141
Southern ocean			160

illustrated by fig. 1, the diurnal and the annual variation by fig. 2. Thus the annual variation presents, in most cases, a maximum in winter and a minimum in summer. The diurnal variation presents rather complicated characteristics. In the simplest, the winter type there is a minimum in the early morning (4hr.–6hr.) and a maximum in the late afternoon. The summer usually presents a secondary minimum at about 14 hours. At some places, as at Kew, the secondary minimum is very marked even in winter. It is customary to analyse diurnal variation measurements by a Fourier series with a 24hr. fundamental. The afternoon minimum is then characteristic of the 12hr. wave. This wave is usually regarded as of less fundamental cosmical significance than the 24hr. wave, on account of such facts as are illustrated by measurements at Paris, where at the top of the Eiffel tower the 12hr. wave is absent throughout the year, whereas it is present in the summer at the level of the base of the tower. It seems reasonable to suppose that the 12hr. wave is the symbol of secondary and local phenomena, such as the influence of charged nuclei and currents of air in the vicinity of the earth. Over the ocean, the diurnal variation seems to partake principally of the 24hr. type; and, by a careful analysis of the data, S. J. Mauchly (1923) has reached the conclusion that this wave progresses according to universal rather than to local time. This conclusion, if extended to the land observatory measurements on the basis of which the foregoing statements have been made, would of course modify to some extent the universality of the conclusion as to the occurrence of the principal minimum in the early morning, and the principal maximum in the late afternoon, *local time.*

Variation of Potential Gradient with Altitude.—Fig. 3 represents the variation of potential gradient with altitude. The mere fact that the potential gradient diminishes with altitude carries with it the necessary conclusion that the atmosphere carries a positive charge, and the existence of a potential gradient at 10km. altitude relatively insignificant compared with its value at the earth's surface, necessitates the conclusion that the atmosphere below that altitude carries a positive charge practically equal to the negative charge on the earth's surface.

For an explanation of the decrease of potential gradient with altitude, we need no cause further than the known fact that the



FROM GRATZ, "HANDBUCH DER ELEKTRIZITÄT UND DES MAGNETISMUS"

FIG. 3.—GRAPH OF VARIATION OF POTENTIAL-GRADIENT WITH ALTITUDE
Mean of results of various observers has been reduced to correspond to 25 volts per metre at 1500 metres' altitude

atmospheric conductivity increases with altitude to a value which, at 10km. for example, is great compared with its value at the earth's surface. For, even though the atmosphere carried no positive charge initially, so that the potential gradient was independent of altitude, the existence of a higher conductivity at the altitude $h+dh$ than at the altitude h would cause more positive electricity to flow into the layer between h and $h+dh$ through the plane at $h+dh$ than flowed out of it through the plane at h. This would cause the field to become smaller at $h+dh$ than at h; and the process would continue until finally a steady state would be attained in which the conduction current density, or the product of the field X and the total conductivity λ was independent of altitude.

COSMIC RADIATION

Penetrating Radiations.—As early as 1903, several investigators, among whom were J. McLennan, E. F. Burton (1903), E. Rutherford, and H. L. Cooke (1903), made investigations of the residual ionization in closed vessels with and without absorbing screens of lead. Under ordinary conditions over land, about 10 ions are produced per cu.cm. per second in a closed unshielded metal vessel freed as far as possible from radioactive contamination. That a portion of this ionization is due to the earth itself and to radioactive emanations in the atmosphere is borne out by the fact that, over the ocean, the residual ionization falls to about 4 ions per cu.cm. per second. Moreover, measurements in a vessel of ice made over Lake Ontario by J. McLennan and his collaborators gave a value as low as 2·6 ions per cu.cm. per second. In 1911, V. F. Hess in Austria and W. Kolhörster (in 1913–14) in Germany published results of balloon ascents, and the net result of this work was the conclusion that the residual ionization diminished with altitude up to an altitude of about 1,000m. and then increased with further increase of altitude until at 9,000m. it was about seven times as great as at the earth's surface. The diminution up to 1,000m. was attributed to the diminution of the gamma-ray radiation from the earth.

In 1921 and 1922, R. A. Millikan and I. S. Bowen sent pilot balloons fitted with electroscope measuring systems up to altitudes of ten miles. One of these balloons survived accidents sufficiently to permit an interpretation of its records, and from this Millikan and Bowen concluded that the absorption coefficient of the radiation was much less than that found by Kolhörster. Happily the divergence between the values of different observers for the absorption coefficient of the more penetrating part of the radiation is not so great as to prevent agreement on the conclusion that it is much greater than that for ordinary gamma-rays, so that it is possible by suitable shielding of the apparatus to diminish to relative insignificance the true gamma-ray part and so disentangle it from the more penetrating part. In 1923 W. Kolhörster made absorption measurements of the radiation on Alpine glaciers, while R. A. Millikan and R. M. Otis made absorption measurements on lead at the summit of Pike's Peak. Kolhörster's data gave an absorption coefficient of 0·25 per metre of water. On the other hand, R. A. Millikan and R. M. Otis (1926) concluded that if there existed any rays of cosmic origin they must be more penetrating than Kolhörster found, or the intensity at sea-level must be less than corresponding to the value of 2 ions per cu.cm. per second which he regarded as the most probable value.

In 1925, R. A. Millikan and G. H. Cameron, by sinking apparatus to various depths in snow-fed lakes at high altitudes arrived at the conclusion that there existed a radiation of cosmic origin such as would produce 1·4 ions per cu.cm. per second in the ionization chamber at sea-level. Moreover, they concluded that this radiation was of a non-homogeneous type, varying in absorption coefficient from 0·18 to 0·3 per metre of water. Still further measurement experiments have led them to extend the range of absorption coefficient from 0·1 to 0·25; and in their most recent publication (June 1928) they have analyzed the radiation into three parts corresponding to the coefficients of absorption, per metre of water, 0·35, 0·08, 0·04. On the other hand, G. Hoffmann (1927), on the basis of Kolhörster's results, found 0·29 ions per cu.cm. for the ionization at sea-level.

Measurements of the residuary ionization as a function of the pressure in the ionization chamber lead to the conclusion that the increase of ionization per atmosphere increase diminishes with pressure increase. Such measurements are of interest because the increase of ionization per atmospheric increase at high pressures is independent of the effects of *soft* radiation emitted from the walls of the vessel as a result of radioactive contamination or even as a result of the action of the primary radiation. While the increase in ionization per atmosphere is not the same thing as the ionization produced in a vessel at one atmosphere, it is closely related to it; and it appears (W. F. G. Swann, 1922), on the basis of plausible assumptions, that the least value of the

increase of ionization per atmosphere for the whole ionization pressure curve is greater than, or at least equal to, the ionization which would be produced by the direct and secondary actions of the penetrating radiation *in the gas itself*. Experiments on the variation of residual ionization with pressure have been made by W. Wilson (1909), by J. C. McLennan and E. F. Buxton (1903), and in more recent times (1920) by W. F. G. Swann and his collaborators, K. Melvin Downey, H. F. Fruth and J. W. Broxon. In 1926 W. F. G. Swann made measurements at the summit of Pike's Peak (14,100ft.), at Colorado Springs (6,000ft.) and at New Haven (sea-level). The increase of ions per cu.cm. per atmosphere was measured in a vessel of iron 1in. thick surrounded by 2in. of lead, and, at the highest pressures, was 0·23 ions per cu.cm. per atmosphere at sea-level. As regards the absorption coefficient, observers previous to Millikan have used the expression $I=I_0e^{-\mu H}$ for the intensity I in terms of the intensity I_0 outside of the region of atmospheric absorption. Here μ is the absorption coefficient, and H the altitude of the top of the atmosphere above the point if the atmosphere were rendered homogeneous and corresponding in density to the density at sea-level. The above formula does not take into account the fact that the radiation comes in from all directions. A formula taking this into account is $I=I_0\int^{\infty}\frac{e^{-\mu H_x}}{x^2}dx$, and such a formula was used by Millikan and Cameron. These two formulae give decidedly different values of μ for the same experimental data, a fact which must be taken into account in comparing the actual content of the results of different observers. Thus, when reduced to a value corresponding to a unit of absorption of one metre of water, Swann's results given by the first formula are, μ (Pike's Peak–Colorado Springs) = 0·390; μ (Colorado Springs–New Haven) = 0·172. The corresponding data as calculated by the more complicated and more appropriate formula are 0·120 and 0·305. These latter values are comparable with those found by Millikan.

Origin of the Cosmic Radiation.—If the results of the low coefficient of absorption be accepted, then that origin of the cosmic rays as ordinary gamma radiation from radioactive material in the higher regions of the atmosphere, or elsewhere, becomes ruled out. The most natural assumption as to the nature of the rays is to regard them as gamma-rays of a very high penetration produced by encounters between the nuclei of atoms and electrons of very high energy. Rays having an absorption coefficient of 0·18 per metre of water would be expected to have a wave-length of 38×10^{-13}cm.; and to produce them would require an electronic energy corresponding to a fall of the electronic charge through about 33×10^6 volts. It has been suggested by W. F. G. Swann (1919) that the origin of the penetrating radiation may be found in the X-rays produced by the electrons from the sun which Birkeland supposed responsible for the aurora. Birkeland's calculations assign to these electrons a velocity of only 45m. per second less than the velocity of light. Such electrons would have energies corresponding to $1{,}000\times10^6$ volts which would be more than is required for the purpose, so that the softer rays which would be too soft to correspond to the aurora except in very high altitudes would, as far as energy considerations are concerned, serve for the cosmic rays.

In weighing such a hypothesis in the light of experiments concerned with the direction of the radiation in relation to the sun, one must remember that the magnetic field of the earth prevents anything like a rectilinear approach of the electrons towards the earth. Even electrons of velocity corresponding to $1{,}000\times10^6$ volts could not approach the earth in the equatorial plane nearer than eight times the earth's radius before being turned back into space, and many electronic orbits circle the earth several times. C. T. R. Wilson (1925) has suggested that electrons with many millions of volts velocity may be produced in lightning flashes. On the other hand, Millikan inclines to the view that the cosmic rays owe their existence to neither the sun nor lightning flashes, but that they represent energy radiated during the actual creation of such atoms as helium, oxygen and silicon out of electrons and protons in interstellar space. (*See* RADIATION.)

METHODS OF MEASUREMENT

Potential Gradient.—One type of device for measuring relative values of the potential gradient is illustrated by the water dropper, which comprises primarily an insulated pipe connected at one end to a quadrant electrometer or to an electroscope, and with the other end projecting through a window and exposed to the earth's electric field. To this exterior end is fastened a nozzle through which water flows in a fine stream, breaking into drops, the supply of water being maintained by an insulated tank. The theory of the action of such an appliance may be regarded as follows: if the water were not flowing, and the pipe were connected to earth, the nozzle, or for example a stationary drop on it, would acquire a charge induced by the electric field in the vicinity of the building, which field owes its origin ultimately to the potential gradient. When the drop falls, this charge falls off with it and so, if the pipe is insulated, its potential is raised. A new charge is produced on the next drop as it forms, and in turn falls off with that drop. The process goes on, and the potential of the pipe continues to rise with the result that the charges induced on the successive drops get less and less until finally a potential is reached at which the drops cease to acquire any charge as they form. The apparatus may thus be regarded as a means of securing a condition by which a conductor exposed to an electric field is raised to a potential such that the surface density of the induced charge on some point of it is zero, although it is by no means zero at other points on the conductor. The potential finally attained by the insulated conductor is proportional to the potential gradient which is ultimately responsible for the electric field in the vicinity of the insulated conductor.

If we could limit our considerations to cases where there were no irregularities of surface such as are caused by houses, trees, etc., and if we could confine our attention entirely to a perfectly flat surface of infinite extent, the potential gradient would have a perfectly definite significance as the electric field in volts per cm. (or volts per metre) at the earth's surface. The presence of buildings, etc., is responsible for irregularities and renders it desirable that we crystallize in our minds a reasonably exact meaning to the potential gradient under such conditions.

Let us picture a problem in which the potential is specified as zero over an irregular contour of sensibly infinite extent, such as the surface of the earth with its buildings and irregularities, and in which the electric field is specified as vertical, constant and equal to X over some plane at an altitude large compared with the dimensions of the irregularities considered. Then, the equation of Laplace ($\Delta V^2=0$), which governs the variation of the field in the space considered, has a unique solution for the problem assigned. The surface density σ, which is determined at the surface of a conductor by the relation field$=4\pi\sigma$, becoming also uniquely determined. We may define the potential gradient corresponding to an undisturbed earth's surface at the place considered as the value of X necessary to secure, in a problem of the above kind, the distribution of surface density actually existing over the surface of the earth, houses, trees, etc.; or if one so prefers, the value of X necessary to ensure the field intensities actually measured at the various places.

Suppose that now, in the above problem, we should include an insulated conductor. In general it would have induced charges on it. If, for example, it were a vertical rod with zero total charge it would have a negative charge at the top end and a positive charge at the bottom end. Whatever the body might be, it would always be possible to assign to it a potential so high in relation to the arbitrary zero of the earth that the surface density on any specified point P of it was positive, or a potential so low that the surface density at P was negative, and consequently it would be possible to assign to it one, and, in general, only one potential V which would make the surface density at P zero. The potential V necessary to assign to the conductor to secure zero surface density at P is obviously proportional to X, since multiplying the potential at each point by a constant η secures a new solution uniquely determined throughout all space, and corresponding therefore to zero field at P, to a field η X at infinity, and to a potential η V for the insulated conductor.

Another method which has been used to secure a condition of zero surface density at some point of an insulated conductor is to attach there a small plate, called a collector, covered with a radioactive preparation which imparts conductivity to the air in the vicinity of the point and enables the plate to acquire a charge from its surroundings until the field at its surface and so the surface density there, is zero. If there were two collectors on different parts of the insulated system, each would make an effort to reduce to zero the surface density in its vicinity, but a situation with the surface density zero in two places could not, in general, be realized by any potential which the insulated system could acquire. A compromise would be reached depending upon the relative conductivities imparted to the air in the vicinities of the two collectors. A somewhat similar situation arises with a single collector when the range of ionization of its rays is large, since then a variable conductivity of the air is to be found over a relatively large portion of the collector support. Under such conditions the final potential attained by the insulated system depends upon the distribution of air conductivity about the conductor and so depends upon the wind velocity. In order to avoid these complications it is customary to use a radioactive preparation emitting only alpha-rays whose range in air is confined to a few centimetres. Polonium and ionium are frequently used. Occasionally a flame takes the place of the collector for the purpose of rendering the air conducting over a restricted region.

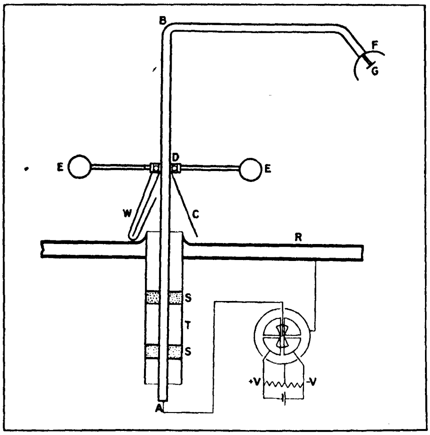


FIG. 4.—PERMANENT APPARATUS FOR MEASURING RELATIVE VALUES OF THE POTENTIAL-GRADIENT

An apparatus suitable for continuous use is shown in fig. 4.

The sulphur plugs S, fastened on the tube T which is fixed into the roof R of the observation house serve to insulate the rod AB and its various attachments C, D, E, F, W, and the radioactive plate G. The cap F serves to protect the radioactive plate, and the cone C, the hole in the roof, from rain. The wire W is mounted on a ball-bearing D and is kept in rotation by the wind vanes E. In this manner spider threads are prevented from forming in such a way as to connect the insulated system to ground. The insulated system is connected to the needle of a quadrant electrometer whose quadrants are kept at such potentials $+V$ and $-V$ in relation to the case as will ensure a convenient sensitivity. By means of a beam of light reflected from a mirror on the electrometer needle to a revolving drum covered with photographic paper, the motion of the needle is recorded.

In order to obtain the absolute value of the potential gradient, it is necessary to secure a horizontal surface of large extent. One may then suspend a horizontal wire by two insulators from two vertical posts at a distance of 10m. or possibly more, the wire being one or two meters above the ground. A collector is attached to the centre of the wire and the insulated system of an electroscope is attached to one end, the case of the electroscope being earthed. Under these conditions, when the equilibrium potential is attained and the collector carries no surface density of charge, the wire also carries no surface density of charge, since it is at the altitude of the collector, and consequently the potential of the wire is simply that which the horizontal plane containing it would have in its absence. The potential recorded by the electroscope divided by the altitude of the wire gives the absolute value of the potential gradient, and the apparatus serves to determine for any other apparatus situated at not too great a distance, a reduction factor by which the readings of the second apparatus may be reduced to absolute value.

Methods other than the water dropper and the radioactive collector have been devised for obtaining relative values of potential gradient. These utilize, as a rule, the fact that the potential gradient induces a charge on an earthed conductor. In C. T. R. Wilson's universal electrometer, a disc connected to an electroscope is exposed to the atmosphere and, together with the electroscope case, is earthed. Under these conditions the electroscope shows no deflection. A cover is then placed over the disc. The charge on the disc now distributes itself throughout the electroscope and the leaves diverge to a potential which is proportional to the potential gradient. In actual use the deflection of the leaves is compensated by means of a variable condenser with one armature attached to the insulated system, the other being kept at a known potential V. By altering the capacity of this condenser it is possible to throw a charge on to the electroscope from the condenser and so compensate the deflection produced by other causes. This charge is VC; where C is the change of capacity of the condenser (or more precisely, the change of coefficient of induction between the insulated system and the outer member of the condenser), and the quantity VC is thus proportional to the potential gradient.

Measurements of Conductivity and Ionic Density.—Measurements of conductivity depend upon a theorem, which is fundamental in many calculations in atmospheric electricity, to the effect that if a body with a charge Q is exposed to a current of air of sufficient velocity, the rate of loss of charge is given by the expression

$$\frac{-dQ}{dt} = 4\pi n evQ = 4\pi\lambda' Q$$

where n, v and λ' refer to the ions of sign opposite to that on the charged body, n is the ionic density, e the electronic charge, and v the mobility.

The foregoing theorem was first developed by E. Riecke (1903) for the case of charged sphere, and it was applied to the case of infinite concentric cylinders by H. Gerdien (1905), in both cases the air flow being supposed to occur in parallel lines with constant velocity. It was developed by W. F. G. Swann (1914) for a general air motion of arbitrary type, and for a body of any shape, as follows.

Confining our attention for the moment to ions of one particular sign, if N is the total number of ions within any volume at some instant, then the rate of increase of N with time is given by

$$\frac{dN}{dt} = -\int\int(w_n+E_n vn)dS$$

where w_n and E_n are respectively the components of the *air* velocity and of the electric field in the direction of the outwardly drawn normal from the surface, n is the ionic density of the ions, and v the mobility, regarded as negative if the ions are negative. Since the rate of increase of *air* within any volume is zero

$$\frac{dN}{dt} = -v\int\int E_n n\, dS \qquad (2)$$

If n is constant over the surface

$$\frac{dN}{dt} = -vn\int\int E\, dS = -4\pi nvq \qquad (3)$$

where q is the charge contained within the boundary of the volume.

Now in all calculations concerned with the theory of atmospheric electric instruments, and having to do with the motion of ions to charged conductors, it has been customary to neglect the field caused by any space density of electricity in the space around the conductor, compared with that due to the charge on the conductor itself. This amounts to neglecting q in (3) when the surface does not surround the conductor, and (3) then leads to

$$\frac{dN}{dt} = 0.$$

We can readily ascertain the limitations of the conclusion on which the foregoing result rests, viz., the conclusion that n is constant over the boundary of the volume considered. The stream lines of the ions are completely determined by the velocity of the air and by the electric field. Let us consider any tube of stream lines of ions and let the volume referred to above be the volume at P enclosed by the walls of the stream tube and two surfaces drawn across it at R and S, fig. 5A. Then, if the density is the same at R and S before the application of the field, dN/dt will be zero immediately after the application of the field, so that the ionic density within our volume will not change in the time dt. The same argument applies to all the elements of volume into which the tube may be divided, and if this tube extends back to infinity it continues to apply at P for each successive element of time dt. In other words, the ionic density remains constant with the time all along the tube. In general, the ions increase in speed in going from a place of small to a place of large field, but any thinning out of the density which might at first sight be supposed to occur as a consequence is compensated by a drawing together of the stream line in regions where the field is high.

Suppose that now as we produce the stream lines of the ions back, we encounter an obstacle D, as in fig. 5B. Then while it is still true that dN/dt is zero at the initial instant at P, it will not be zero, initially, for the element of volume adjacent to the surface of D. The part of the stream tube in the immediate vicinity of D will have all its ions removed and the boundary between the part of the tube where the ionic density has its original amount and the part where it is zero will move down the tube until it eventually reaches the boundary of P, and at that instant the ionic density in the element at P will change. In fact, neglecting re-formation of ions and diffusion, any stream tube which, on projection back, encounters an obstacle will become completely denuded of ions. The simple theory which neglects diffusion and the field due to space density of charge in the air permits only two possible situations in the steady state. Considering the ions of any one sign, either their density at a point remains constant with time and equal to the value undisturbed by the field, or it falls to zero. The sorts of situations which arise are represented in fig. 6. Suppose the sphere is positively charged, and that the air current is from right to left. Then, in general, the space around the sphere divides itself into two portions separated by the heavy line, fig. 6A. In the region outside of this space, the paths of the positive ions are of the general nature shown by the arrows, and the density is constant and equal to its value at infinity. Within the heavy lines the positive ionic density is zero, and the paths by which the ions have been cleared out are dotted. On the other hand, fig. 6B shows the general paths of the negative ions. Here again the density is constant, but the stream lines divide themselves into two groups, those which go to the sphere and those which escape it.

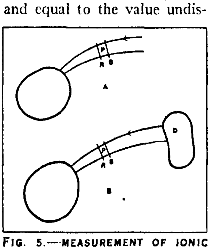


FIG. 5.—MEASUREMENT OF IONIC DENSITY

Returning to our conductor of general shape, let us suppose it to have a positive charge, Q. Then, provided that all the stream lines of the negative ions flowing to it can be produced back to infinity without encountering obstacles, equation (2) may be applied to the surface immediately surrounding the conductor and n may be taken outside the integral sign and allotted its value at infinity. Equation (3) follows, but the quantity q now refers to the charge Q on the conductor, so that multiplying throughout by e, the charge on an ion, dNe/dt becomes dQ/dt, and

$$\frac{dQ}{dt} = -4\pi Q nev = -4\pi Q \lambda' \qquad (4)$$

As a matter of fact, these results, which have been proved for the conductor as a whole, may be extended to any part of it with Q referring simply to the charge on that part, provided always that the stream lines from the part when produced back go to infinity without encountering obstacles. In case obstacles are encountered, the absolute value of dQ/dt is less than that calculated above.

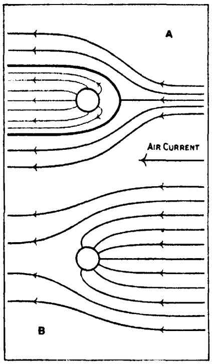


FIG. 6.—PATHS OF POSITIVE IONS (A) IN SPACE AROUND SPHERE, AND OF NEGATIVE IONS (B)

The foregoing principles have been utilized in an apparatus designed by H. Gerdien (1905), in which air is drawn by a fan between two concentric cylinders, the inside member of which is insulated, charged and connected to an electroscope. The smaller the potential of the central cylinder, or the higher the velocity of flow, the narrower the cylindrical stream of air from which the central cylinder draws ions. Provided the outer cylinder is wide enough to accommodate this cylindrical stream, so that the ionic stream lines can be traced back from the central cylinder and out through the opening of the outer cylinder without encountering the wall of the latter, we may apply (4). If C_1 is the capacity of the part of the insulated system exposed to the air current, C, the capacity of the whole insulated system, and V its potential, (4) gives

$$\frac{CdV}{dt} = -4\pi C_1 V \lambda' \qquad (5)$$

$$\lambda' = \frac{C}{4\pi C_1 t} \log \frac{V_1}{V_2} \qquad (6)$$

which gives λ' in terms of the initial and final potentials, and the time to pass between them.

If, in the Gerdien conductivity apparatus, the potential is raised to such a point that the cylindrical boundary of the ionic stream lines which go to the central conductor swells out so as to touch the outer cylinder, then for this and for all higher potentials the "saturation current" obtainable with the given rate of flow of air will be obtained; and above this potential the rate of charging of the central conductor will be independent of the potential difference between the cylinders. It will, in fact, be given by

$$\frac{-dQ}{dt} = Wne$$

where W is the number of cu.cm. of air passing through the system per second. If C is the capacity of the entire insulated system

$$-C\frac{dV}{dt} = Wne$$

which serves to determine n in terms of measurable quantities.

If the conductivity, say for negative ions, $\lambda_- = n_- e v_-$ is known, and if also the value of n_- is known, the mobility v_- may of course be obtained by division.

It is customary to use for the determination of the ionic density a pair of cylinders of much smaller diameter than those used for the conductivity measurements, so that a saturation current may be the more readily secured. In this form the apparatus is

usually known as Ebert's ion counter. In the modern form, the axis of the concentric cylinders is vertical, and, in spite of the fact that the upper end of the cylinders where the ions enter is shielded by a cap, the negative charge induced by the potential gradient on the region of entry produces serious errors in the case of the measurements for negative ions, although no error exists for positive ions.

Another method, that of Schering (1908), which has been used for measuring the unipolar conductivities, involves the use of a long wire stretched parallel to the ground, and surrounded by a wide cylindrical wire netting connected to earth. The wire is charged and connected to an electrometer. It proceeds to lose its charge according to the law expressed by (4), provided that a breeze of air blows through the netting, and the conductivity may be calculated, as in the Gerdien apparatus, from a knowledge of the ratio of the capacity of the wire (surrounded by its netting) to the whole capacity of the insulated system, of the potential, and of the rate of fall of potential. This apparatus, and also the aspiration apparatus, has been adapted to the purposes of continuous registration of conductivity. Another method of measuring atmospheric conductivity is afforded by C. T. R. Wilson's portable electrometer. If the plate of that instrument is earthed and exposed to the atmosphere it acquires a negative charge. If it is now insulated, it starts to lose that charge at a rate determined by (4). By means of the compensator the electroscope may be kept undeflected, and the value of dQ/dt may be deduced from the rate of change of the compensator reading. The total value of Q at the initial instant may be obtained by shielding the test plate with the cap, and adjusting the compensator to reduce to zero the deflection caused thereby, in the manner already described in connection with the use of the instrument for measurement of the potential gradient. The data thus obtained serve to yield λ' by the aid of (4).

The air-earth conduction current density may be obtained by multiplying $\lambda_+ + \lambda_-$ by the potential gradient. If it should be true that the emission of negative ions from the ground were insufficient to contribute appreciably to the air-earth current density then the latter could be obtained directly by compensating the loss of charge per second from an insulated plate in the manner adopted in C. T. R. Wilson's electrometer, but with the apparatus arranged so that the test plate was level with the ground. This method has occasionally been utilized for measurements of the air-earth current density. The relation of the quantity so measured to that obtained by multiplying $\lambda_+ + \lambda_-$ by the potential gradient is rather a complicated one, involving as it does the emission of ions from the pores of the soil, and the convectional effects of the air motion.

Measurement of the Radium Emanation Content of the Air.—F. Satterly (1910) and others have made absolute determination of the emanation content of the atmosphere by passing air through a liquid air-cooled tube which condensed the emanation and thus permitted its subsequent determination. Coconut charcoal has also been used to retain the emanation.

In an apparatus used on the American yacht "Carnegie," air was drawn at a measured rate and for a fixed time between two concentric cylinders with a potential difference between them of such sign and amount as to cause all the radium A, B and C to deposit on the central cylinder, or rather on a copper foil wrapped around it. The foil was reversed at the end of the assigned time and caused to line another vessel, its outside being now turned towards the inside. This vessel was provided with an insulated rod which was connected to an electroscope, so that by placing a potential difference between the vessel and the rod the saturation current due to the ions formed by the radioactive material could be measured and plotted against the time. From the data thus obtained it was possible to work back and deduce the radium emanation content of the atmosphere.

Measurement of the Penetrating Radiation.—Most measurements of the penetrating radiation have been made by a method illustrated by the following. A thin metal vessel of about 30 litres capacity is provided with a central rod insulated from it and connected to one quadrant of an electrometer, the other quadrant being connected to the electrometer case. A potential of 100 volts between the wall of the vessel and the rod serves to maintain a saturation current to the electrometer, the current being determined by the rate of production of ions in the vessel. This current may be deduced from measurements of the rate of deflection of the electrometer, or preferably by compensating that deflection by a variable potential applied to the outer member of a subsidiary condenser whose inner member is connected to the rod associated with the ionization vessel. Several important precautions are necessary to secure a reliable result.

The rate of production of ions per cu.cm. resulting from such measurements as the above depends on more than one cause, as already explained.

THE ORIGIN AND MAINTENANCE OF THE EARTH'S CHARGE

It is obvious that, if negative electricity is leaving our earth and positive electricity entering it in virtue of the potential gradient operating in a conducting atmosphere, any compensating stream must take place in opposition to the forces of the electric field. The theories which have been proposed divide themselves mainly into two classes, those in which gravity is the primary agent instrumental in moving the charges against the field, and those in which the flux of negative corpuscles towards the earth is brought about in opposition to the field through the agency of a very high velocity produced in them by some means or other.

Theories Invoking Gravitation.—As an example of the former class we have the theory of C. T. R. Wilson (1897–1900) to the effect that the replenishment takes place through the agency of rain. Theoretical considerations have been thought to suggest that the raindrops should form on the atmospheric ions, and more copiously on the negative than on the positive ions, so that rain might be expected to be, on the whole, negatively charged. The charged drops, falling to earth under gravity, would do so in opposition to the electric field, and would constitute the replenishment. This theory is open to two primary objections. In the first place, while rain is charged, and to a degree probably sufficient to account for the necessary replenishment, it is found that 90% of the rain which falls is *positively* charged. Again, it appears that there are grave theoretical difficulties concerned with the possibility of condensation of water upon atmospheric ions, in the form of drops of appreciable size, so that this theory is now generally regarded as inadequate to account for the facts.

A theory which came near to being successful, and which undoubtedly plays a part in the origin of the earth's charge, is one due to H. Ebert (1904). Ebert's theory, which constitutes a modification of an earlier theory due to Elster and Geitel, invokes the fact that if ionized air be passed through a fine tube the negative ions diffuse to the walls of the tube more rapidly than do the positive ions, so that the air which emerges from the tube is positively charged. Ebert applies this to the atmospheric electric problem, by supposing that the air which is to be found in the interstices of the soil, and which is ionized by the radioactive material therein, is drawn out during the periods of falling barometric pressure, leaving an excess of negative charge on the walls of the interstices. The positive charge which emerges would be held in the immediate vicinity of the ground by the negative charge, but here Ebert invokes the aid of upward air currents which carry it, against the field, into the higher regions of the atmosphere. The theory has been criticized on the basis that the emission of ions from the ground would be insufficient, and the upward currents too feeble. One of the most serious objections is to be found in a conclusion, which, however, follows comparatively simply from theoretical considerations, to the effect that, on such a theory, it would result that, before the ascending positive charge had risen to an altitude of a kilometre or so, it would have disappeared almost completely, devoured, as it were, by the negative charge continually fed into it from the earth below, through the medium of the conducting atmosphere. We should obtain a positive charge in the atmosphere, a negative charge on the earth's surface, a conduction current and a potential gradient; but all of

these phenomena would be confined to a layer of the atmosphere about a kilometre or so in thickness. The whole of the positive charge in the atmosphere would be found in this layer, and, being equal to the negative charge on the earth's surface, since that was formerly its partner in neutrality, it would annul the field at all greater altitudes.

Both C. T. R. Wilson's theory and also that of Ebert's suffers from the fact that the positive charge in the atmosphere, which is the counterpart of the negative left on the earth, holds that negative to the spot immediately beneath it, and so fails to provide for the existence of a potential gradient where the primary phenomenon, falling barometric pressure or precipitation, is not going on. Difficulties of these kinds become greatly minimized by the assumption, justified by considerations from other sources, as to the existence of a region of very high conductivity, a conducting layer in the upper atmosphere. For, under such conditions the combined actions of even an isolated positive charge in the atmosphere and its counterpart of negative on the earth would be to set up between the earth and the conducting layer a potential difference which would be handed around more or less uniformly all over the earth.

Corpuscular Theories.—Turning now to theories in which the replenishment of the charge comes about by the agency of high-speed electrified corpuscles shot into the earth, the first of these was proposed by G. C. Simpson (1904). In this theory it was supposed that the sun emitted negative and positive corpuscles of high penetrating power. The former were supposed to pass right through our atmosphere and charge the earth, while the latter were of less penetrating power and were caught in the atmosphere. In this way the earth would continually receive negative, and the atmosphere positive, charge. The ordinary processes of atmospheric conduction would, moreover, cause a continual conduction of electricity between atmosphere and earth, so that a steady state would be reached when the amount of neutralization of charge by this latter process just balanced the charging effect due to the influx of the corpuscles. This theory requires that we suppose the existence of corpuscles of penetrating power so great that they could pass through the whole of the earth's atmosphere, which is comparable in absorbing power with a column of mercury about 76cm. high. The greatest range which has been observed in air, for the β-rays of radium, is about 7 or 8 metres. Electrons having a velocity 99% of that of light can travel through only 1·3cm. of aluminium, which is equivalent in absorbing power to about 10m. of air at atmospheric pressure.

Although, according to electromagnetic theory, the velocity of light represents the maximum velocity which a corpuscle can attain, one must guard against the supposition that, because corpuscles with velocity 99% of that of light have ranges of only 10m. in air, no corpuscles can have ranges much greater than this. For electromagnetic theory shows that corpuscles with velocity even 99% of that of light are very far removed in their properties from those which approach that limit much more closely. As a matter of fact, the mass of a corpuscle increases with its velocity in such a way that the corpuscle must have infinite energy in order to attain the velocity of light.

We may, however, avoid the assumption of exceptionally long ranges by a device in which the penetrating radiation becomes invoked as the primary cause responsible for the earth's charge (W. F. G. Swann, 1917; E. v. Schweidler, 1918). The penetrating radiation is probably of the nature of a gamma-ray radiation. Now gamma-rays possess the power of ionizing, *i.e.*, of ejecting electrons from a gas through which they pass, and the nature of their action is such that the ejected electron is sent out almost entirely in the direction of the gamma-ray. (*See* COMPTON EFFECT.)

We may thus expect that such a radiation coming from above will eject electrons from the air, and these will travel certain distances in a downward direction before coming to rest. Those electrons which are shot out within striking distance of the earth will reach it and charge it. Their places will be taken by other electrons, which have been shot out from layers above and have become absorbed before reaching the earth. One advantage possessed by this type of corpuscular theory is that it invokes, for the production of the corpuscles, an agency which is already recognized for other reasons, and another advantage lies in the fact that no artificial adjustments of the theory are necessary in order to provide for a conduction current which is practically independent of altitude.

Further, on submitting the theory to calculation, we arrive at magnitudes for the quantities involved which are by no means unreasonable. Thus, if we assume that only three high-speed corpuscles are emitted per cu.cm. per second, a number comparable with that which the penetrating radiation is supposed to eject, it is only necessary to assume that these corpuscles have a range of 9m. in air in order to account for the replenishment of the earth's charge. We shall presently see that, for reasons concerned with the ionization which would be produced by the corpuscles, it is desirable to endow them with a range greater than 9m.; but for the mere requirements of the replenishment of the earth's charge an average range of 9m. is sufficient.

Objections to Corpuscular Theories.—Two main objections may be raised against all forms of corpuscular theories. The first of these comes from failure to detect any charging effect on an insulated body exposed to the corpuscles (E. v. Schweidler, 1918; W. F. G. Swann, 1917). If corpuscles are being shot into the earth from above, an insulated mass of metal should gradually acquire a charge from the corpuscles which enter it, unless, indeed, the corpuscles are so penetrating as to pass right through it. Experiments of this kind have failed to reveal any corpuscular current of amount sufficient to correspond to the requirements. The difficulty it not insurmountable, however, if one adopts the last of the views referred to above, *i.e.*, that the ejection of the corpuscles from the molecules of air is brought about by exceptionally hard gamma-rays from above. For, on this view, if the *gamma-rays* are sufficiently penetrating to pass right through the metal, they will eject corpuscles from the bottom of the mass as well as inject them at the top. A simple calculation shows that, provided the intensity of the gamma radiation does not alter in passing through the metal, all that is necessary in order to conclude that as many electrons would be shot out of the bottom of the mass as were shot in at the top is the assumption that the ratio of the numbers of corpuscles shot out per cu.cm. of air and metal is equal to the inverse of the ratio of the average ranges of a corpuscle in air and in the metal. This assumption is entirely consistent with our knowledge of the laws pertaining to the action of gamma-rays and the passage of corpuscles through matter.

The second great objection, and perhaps the most serious objection, at first sight, to any corpuscular theory is the fact that we might expect the passage of high-speed corpuscles through the atmosphere, on their way to the earth, to be accompanied by a much greater ionization than is observed. The situation is this: The corpuscular current necessary to balance the atmospheric electric current amounts to an influx of 1,500 corpuscles per sq.cm. per second. We know that an electron approximating in velocity to that of light produces about 40 ions per cm. of its path, so that in each cu.cm. we might expect ions to be produced to the extent of about 60,000 per cu.cm. per second, whereas experiment shows that they are only produced to the extent of one ten-thousandth of this amount. In order to see how we may escape this difficulty it may be of interest to probe a little more closely the mechanism of the ionization.

Absence of Ionization by Corpuscles with Velocities Approximating That of Light.—Consider an electron in an atom, and suppose that another electron which we shall distinguish by calling it a corpuscle, approaches the atom. The corpuscle will start to repel the electron as it approaches, and will continue to do so as it recedes, with the result that the electron receives energy, the momentum which it acquires being more or less in a direction perpendicular to the line of flight of the corpuscle. The greater the velocity of the corpuscle the shorter the time during which the electron has opportunity to receive momentum from it. The efficiency of the corpuscle as regards its power to hurl the electron out of the atom thus diminishes with increase of its velocity, and would, as a matter of fact, become zero if the corpuscle could attain an infinite velocity. The velocity of the corpuscle cannot

attain a value greater than that of light, however, and, as regards the above effect, there is not very much reduction in ionizing efficiency for an increase of velocity from, say, 95% of that of light, where the ionization has been measured, to the velocity of light itself. As the velocity of light is approached, however, another phenomenon comes in. The field of the corpuscle does not remain uniformly distributed. According to known electromagnetic laws, its lines of force close up more and more into its equatorial plane. The time which the corpuscle has for acting effectively on the electron is therefore reduced still further on this account; but the intensity of the action during that time is increased; and, it turns out that, if we take nothing else into consideration, the energy communicated to the electron by the passage of the corpuscle will be unaffected by this concentration of the lines of force. There is one other very important consideration which we must take into account, however. If an electron receives even a small velocity in a very short time, it is known that it will radiate a large amount of energy. Its sudden start results in a violent jerk in the aether. On submitting this matter to calculation it turns out that, even if we should wish to give to an electron but a small amount of energy, in an infinitesimal time, it would be necessary to pay a sort of tax, of an infinite amount of energy, in the shape of radiation. Now the more nearly the corpuscle approaches the velocity of light the more suddenly does it communicate to the electron such energy as it imparts. Without entering too greatly into details, we may describe the situation as follows: In the case of a corpuscle moving with a velocity approximating that of light (say 95% of the velocity of light) it turns out that the corpuscle must approach an electron of an oxygen atom within $0{\cdot}7 \times 10^{-10}$cm. in order that it shall be able to eject that electron from the atom. If the minimum distance of approach is less than this amount the energy imparted to the electron will be greater, if it is more the energy imparted will be less. It is, however, possible to assign to the corpuscle a velocity so high that, irrespective of the distance of approach, if we should suppose it to transmit to the electron an amount of energy corresponding to the ionization potential of oxygen (15·5 volts), we should lead ourselves to the impossible conclusion that the electron's acceleration would be so large that the energy radiated by it in acquiring its velocity would be greater than the work done on it by the corpuscle. Thus corpuscles having the velocity in question, or any higher velocity, would be unable to eject an electron from an atom of oxygen, the more easily ionizable of the two main constituents of the atmosphere. When we work out this velocity, we find that it comes out as only 45 metres per sec. less than the velocity of light. In spite of the very close approximation of the velocity to the velocity of light, the value found happens to be exactly the velocity which Birkeland has found it necessary to assign to solar corpuscles if the bending which these corpuscles suffer in the earth's magnetic field is to be consistent with their accounting for the aurora. Corpuscles of lower speeds would suffer too large deviations in the field to permit of their accounting for the facts. The diminution of bending, resulting from approximation of the velocity to that of light, results not so much from the direct influence of high speed as from the increase in the mass of the corpuscle which approximation to the velocity of light implies. It is, of course, a fact that, if the present theory were true, it would lead to difficulty as regards Birkeland's corpuscles being responsible for the aurora, since they could not ionize. This difficulty may be of a secondary nature, however. It may perhaps be worth while pointing out that closeness of approximation to the conditions pertaining to the velocity of light is not well symbolized by closeness of approximation of v to c; for, as regards the energy of a corpuscle, for example, there is an infinite range from that corresponding to v less than c by 45 metres per second and $v=c$.

As a special aspect of the above comparison with Birkeland's data, it is of interest that, if an electron were shot from infinity into our atmosphere—in the equatorial plane, for example—it would not reach the earth, but would be turned back into space by the earth's magnetic field, unless it had a velocity nearer to that of light than the velocity which we have calculated as sufficiently great to ensure absence of ionization. Indeed, with this velocity (45m. per second below the velocity of light) the corpuscle would not succeed in approaching nearer the earth than about eight times the earth's radius before being turned back by the earth's magnetic field.

The Possibility of Spontaneous Generation of Charge.—The possibility of a spontaneous generation of charge within the earth was first tentatively suggested by G. C. Simpson (1916). This possibility has been elaborated by W. F. G. Swann (1927) into a theory in which a modification of the ordinary laws of electromagnetism is made in a form consistent with the theory of relativity and of such a type as to secure a slow death of positive charge as a result of the earth's rotation. The surplus negative electricity accumulates until it has built up a potential gradient adequate to drive negative electricity away from the earth at a rate sufficient to balance the rate of death of positive electricity. The necessary rate of death of positive electricity is very small. It amounts to only one proton per cu.cm. per *day*, or, in other words, it corresponds to a diminution of only 0·5% of the earth's mass in 10^{20} years. The modification in the electrodynamic scheme is also made to provide for the origin of the earth's magnetism and gravitation.

THUNDERSTORMS AND RELATED PHENOMENA

The first observations on the charge carried down by rain were made by Elster and Geitel (1899) and by H. Gerdien (1903), and led to the conclusion that more negative than positive electricity was precipitated by this cause. However, G. C. Simpson (1909), in a long series of measurements made at Simla, India, concluded that a much larger precipitation of positive than of negative occurs, and his conclusions have been supported by many observers in various parts of the world. The currents carried to ground by rain are usually of the order 10^{-12} amperes per sq.cm., and the amount of electricity per cu.cm. of the precipitated water is usually less than one electrostatic unit.

Thunderstorms.—It is a universally accepted belief that thunderstorms and lightning are a secondary phenomena brought about by the abnormal meteorological conditions we always find associated with them, and nearly all theories of thunderstorms invoke some mechanism by which falling rain drops, snow or hail become charged in some manner with one sign of electricity, while the air and smaller drops capable of being carried up by the rising columns of air associated with the storm are charged in the opposite sense. The separation of electricity proceeds until differences of potential are produced sufficient to result in a lightning flash.

According to one of the earliest theories, that of Elster and Geitel (1885, 1913), the rain drops were polarized by the potential gradient, so that they became positively charged below and negatively charged above. The smaller spray associated with the rain, and which is carried up in the rising air currents, was supposed to strike the larger descending drops on the underside and remove from them some of the positive charge, so that they fell to earth negatively charged, while the smaller drops were carried upwards with the positive charge. On this view the electrical separation would act to increase the electric field formerly existing, a result not in harmony with the usual facts. There is a certain amount of evidence that the smaller drops may rebound from the larger drops in such a way as to part from them at the top; and on such a view the possibility of positive precipitation becomes realized. However, the theory has suffered criticism in connection with the possibility of the existence of the necessary contact between drops at the moment of rebound to secure a separation of charge without a coalescence of the drops.

G. C. Simpson's theory rests upon the experimental fact that, when falling water drops are caused to break on a rising stream of air, the water drops become positively charged while the air or lighter spray becomes negatively charged. In the period immediately preceding the thunderstorm we picture a sort of hourglass structure to the air motion, in the vicinity of the thundercloud, the air feeding in towards the axis of the hour-glass below, then rising vertically and finally fanning out at the top. As the

air rises into colder regions precipitation forms and the drops grow as they fall. However, it is contended that drops large enough to fall in air which is rising with a velocity up to 8 metres per second become unstable and break up into fine drops. In this process they become positively charged while the air around them is negatively charged. It is thus contended that when the drops in their fall reach the narrowest part of the hour-glass where the velocity is high, they break up and become positively charged. Having been reduced in size by the disruption, they start to rise in the air current, but not as fast as the negatively charged air. As they rise they start to coalesce on account of their charge, and eventually attain such a size that they once more start to descend. The process continues, and as it does so the rain becomes charged more and more positively at each successive descent, while the rising air carries negative electricity to the top of the thundercloud. Eventually the potentials attained become sufficiently high to result in a flash between the top and bottom of the cloud, or occasionally between one part of the cloud and another. On Simpson's views, the rain which falls in the centre of the thundercloud should be positively charged, while a negative charge should appear on the rain which falls from the more remote regions and has received its charge from the negatively charged air which has risen to the top of the cloud and fanned out at the sides.

Simpson's theory does not lead immediately in its details to an explanation of the origin of lightning flashes in cases where all the water concerned is in the form of ice. However, H. Norinder has shown that large separations of charges may be produced by the impact of ice particles with each other, the small particles becoming charged with a sign opposite to that which the larger particles acquire. Again, a separation of the two comes about through the greater supporting power of the rising currents for the smaller as compared with the larger particles.

The Electron Currents and Fields Developed in Lightning Flashes and Thunderstorms.—By measuring the changes of electrical potential of an exposed insulated conductor, C. T. R. Wilson (1920), H. Norinder and others have made estimates of the electric fields associated with thunderstorms, and from these have deduced the orders of magnitude of the charges on thunderclouds, and the amount of electricity transferred when a lightning flash takes place. Estimates of the last named quantity have also been made in a novel manner by W. J. Humphreys from an estimation of the pinch effect produced in a lightning rod which had been struck and crushed by the attraction of the current elements on each other during the discharge.

The fields developed at the earth's surface in the vicinity of thunderclouds are of the order of 100,000 volts per metre, and an average lightning flash may discharge about 20 coulombs through a length of two kilometres.

Data collected by the British Meteorological Office show that at any one time about 1,800 thunderstorms are in progress in different parts of the world, and that the average frequency of lightning flashes during a storm is about 200 per hour. This gives about 100 flashes per second as representative of the average frequency of lightning discharges for the whole earth.

Special Forms of Lightning.—It has been supposed by W. J. Humphreys that a lightning flash progresses by a sort of burrowing action rather than by a simultaneous breakdown of the whole lightning part. Humphreys supposes that at any instant during the formation of the flash the field at the end of the lightning streak ionizes the air immediately around it, permitting of its further extension, and so on until the flash is completed. While there is some doubt as to the universality of this origin of the flash, the process undoubtedly occurs in certain instances, and to special forms of this type of development Humphreys has attributed the occurrence of *rocket lightning* and *ball lightning*. The former is seen as a progressive burrowing of the flash through the sky and is to be attributed to conditions in which the flash grows at a slow rather than at its customary rapid rate. *Ball lightning*, in which a ball of fire may be seen to hang in the sky, may be regarded as a form of rocket lightning in which the progress of the flash is very slow and the conditions are such that the ionization at the end of the discharge is just able to maintain itself. *Sheet lightning* is merely the reflection of ordinary lightning from the clouds. Some observers have reported the appearance of discontinuous or beaded streaks of lightning. It has been suggested that they arise from successive discharges and that each bead may represent the end-on view of the irregular portions of the lightning path; these remain luminous during the subsequent lesser discharges, while the intermediate sections become non-luminous because viewed from the side. *St. Elmo's fire* is simply a brush discharge from objects projecting from the earth's surface and it is caused by intense fields resulting from the presence of thunderclouds.

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(W. F. G. S.)

ELECTRICITY, CONDUCTION OF. The mechanism of the conduction of electricity is markedly different in solids, liquids and gases, which are accordingly dealt with separately.

CONDUCTION IN SOLIDS

The electric conductivity of a substance is that property in which electricity is transferred through the substance if an electric potential difference is applied to two parts thereof. A substance in which unit quantity of electricity is transferred through unit cross-section under the influence of unit potential gradient is said to have unit conductivity. The reciprocal quantity is the electric resistance which may be defined in a similar way. A priori the quantity of electricity transferred for a given potential gradient might well depend upon how long the current had been flowing. The concepts, electrical conductivity and electrical resistance, would probably never have been formed were it not that there is a large class of substances for which the conductivity is determined completely by the conditions of the moment and is independent of the previous history of the conductor. Strictly speaking, it is for these only that the terms conductivity and resistance have any validity. All substances conduct electricity to a greater or smaller degree. For the purpose of description, it is convenient to divide solids into three classes, namely, metallic conductors, non-metallic conductors and dielectrics although there are no precise lines of demarcation.

Metallic Conductors.—The main characteristics of a metal are its high electric conductivity and consequent opacity, its good heat conductivity, its tendency to form positive ions in solution and its inability to form a simple solution in non-metals. All these properties are consequences of the ease with which the atoms of a metal can lose or dissociate electrons. When in the vapour phase the atoms are far apart and electrons dissociate appreciably only at comparatively high temperatures such as the surface of the sun or stars. But when the atoms are packed close together as in solid metals, polarization comes into play so that it is easier for an electron to escape from its parent atom. That the current is carried through a metal by these free electrons has been proved. That they can also transfer heat is an extremely important phenomenon, the explanation of which is not so apparent.

Resistivity of Metallic Conductors.—The resistance of a

conductor depends of course upon its shape as well as upon the material of which it is composed. The effect of shape can be eliminated and the specific resistance of the material, *i.e.*, the resistance of unit cube, can be obtained provided Ohm's Law, that the current is proportional to the applied voltage, and inversely proportional to the resistance, is satisfied. In metals, Ohm's Law is fulfilled to a very high degree of accuracy; slight deviations have, however, been found at excessively high current densities. If a current of the order five million amperes per square centimetre is made to flow through a thin film of silver or gold, the departure from Ohm's Law may amount to something of the order of one per cent. Strictly speaking therefore, the definition of the specific resistance should include the current density, but in metals at any rate, Ohm's Law is valid over such an enormous range that this can be omitted. If a conductor is of uniform cross-section and of homogeneous material, the potential gradient must be uniform, since the current flowing through every cross-section must clearly be the same. It has been shown that the resistance of such conductors is inversely proportional to their cross-sections. Hence, in this simple case, it is easy to derive the specific resistance from the resistance of the conductor. It is obviously the observed resistance divided by the length in centimetres and multiplied by the cross-section in square centimetres. Thus, a wire one metre long and of a cross-section of one square millimetre, will have a resistance 10,000 times greater than the specific resistance of the material of which it is composed, or inversely, the specific resistance of the material is one ten-thousandth of the observed resistance of such a wire. If the shape is not so simple, the transition from observed resistance to specific resistance is, of course, much more complicated, since the potential gradient will vary along the conductor. The resistance of a metallic conductor is within wide limits independent of the time. It has been shown that the reflection coefficient of metals for infra-red rays may be calculated from the resistance if one treats the incident radiation as an alternating field as postulated by the electro-magnetic theory. That this relation breaks down at frequences of the order 10^{14}, *i.e.*, for currents which change their direction in 10^{-14} seconds, is scarcely surprising. It indicates merely, that the resistance to the motion of the electrons is composed of a number of elementary processes at intervals which are not short compared to 10^{-14} seconds.

International Ohm.—The practical unit of electrical resistance was legally defined in Great Britain by the authority of the Queen in council in 1894, as the "resistance offered to an invariable electric current by a column of mercury at the temperature of melting ice, 14·4521 grammes in mass, of a constant cross-sectional area, and a length 106·3 centimetres." The same unit has been also legalized as a standard in France, Germany, and the United States and is denominated the "International or Standard Ohm." It is intended to represent as nearly as possible a resistance equal to 10^9 absolute C.G.S. units of electrical resistance. Convenient sub-divisions and multiples of the Ohm, are the microhm and the megohm, the former being a millionth part of an Ohm, and the latter a million Ohms. The resistivity of substances is then numerically expressed by stating the resistance of one cubic centimetre of the substance taken between opposed faces, and expressed in Ohms, microhms or megohms, as may be most convenient. The reciprocal of the Ohm is called the Mho, which is the unit of conductivity, and is defined as the conductivity of a substance whose resistance is one Ohm. The absolute unit of conductivity is the conductivity of a substance whose resistivity is one absolute C.G.S. unit, or one-thousandth-millionth part of an Ohm.

Besides this so-called volume-resistivity, a quantity is sometimes employed, called the mass-resistivity, defined as the resistance in ohms of a wire of the material in question of uniform cross-section one metre in length, and one gramme in weight. This quantity is of small scientific interest, though convenient in some cases for technical purposes when the weight of a conductor, capable of carrying a given current at a given voltage, is of importance. The mass-resistivity so defined, is the volume-resistivity multiplied by the density times 10^4.

A quantity of far greater importance, for the understanding of the cause of metallic resistance, may be described as the atomic-resistivity. Since one is only concerned with comparative quantities the units are of course immaterial, but it might be conveniently described as the resistance for unit potential difference of a cube containing Avogadro's number of atoms. This quantity refers to the electrical characteristics of the metal in comparable circumstances, *i.e.*, there are the same number of atoms in cross-section in each case, and the potential drop per atom is the same. It may be obtained from the usual volume-resistivity, by multiplying by the third root of the density and dividing by the third root of the atomic weight. Table I. gives a list of the commoner metals with their volume-resistivity, mass-resistivity and atomic-resistivity at 18° C. The values are given in ohms: they can be translated into absolute C.G.S. units by multiplying by 10^9.

TABLE I.

Metals	Volume resistivity at 18° C $\times 10^{-6}$ ohms	Temp. coeff. of volume resistivity 0°–100° C $\times 10^{-4}$	Mass resistivity at 18° C ohms	Atomic resistivity at 18° C $\times 10^{-6}$ ohms	Atomic resistivity at corresponding temperatures $\times 10^{-6}$ ohms
Aluminium	2·94	38	0·079	1·36	1·8
Antimony	40·4	47	2·67	15·3	..
Bismuth	119·0	44	11·7	42·9	..
Cadmium	7·54	40	0·65	3·21	..
Copper	1·78	43	0·159	0·93	1·0
Gold	2·42	40	0·46	1·12	0·73
Iron	10·0	62	0·7	5·2	7·3
Lead	20·8	43	2·36	7·9	2·4
Magnesium	4·7	40	0·082	1·95	1·8
Mercury	95·7	9*	13·0	39·0	..
Molybdenum	4·0	50	0·40	1·88	2·5
Nickel	11·8	62	1·05	6·29	8·0
Platinum	11·0	38	2·33	5·28	4·0
Potassium	7·3	57†	0·063	2·05	0·71
Silver	1·63	40	0·171	0·75	0·54
Sodium	5·07	50†	0·049	1·77	0·97
Tin	11·3	45	0·82	4·45	2·1
Tungsten	4·8	51	0·90	2·25	2·4
Zinc	6·1	37	0·43	2·91	..
Alloys					
Brass	6·6	10	0·56	..	..
Constantan	49·0	$\left\{\begin{matrix} -0·4 \text{ to} \\ +0·1 \end{matrix}\right\}$	4·35	..	..
German silver	27·0	2·7	2·30	..	..
Manganin	44·5	0·0 to 0·5	3·78	..	..
Nichrome	110·0	1·7	..	..	..

NOTE: The resistance of a metal varies according to its previous history, *i.e.*, whether it has been rolled, drawn, cast, etc., and also according to its purity, a small trace of impurity in many cases increasing the resistance by 20%. Therefore in actual practice variations of 10% in the above values may be expected.

*0°–24° C. †0° C—melting point.

The figures of course refer to normal polycrystalline metals. Single crystals may have a higher conductivity, *e.g.*, in copper there is a difference of about 8%. In non-cubic crystals the conductivity also varies with the orientation, as will be seen a most important and suggestive phenomenon. It will be noted that the volume-resistivity of the metals in the first group of the periodic table, is lower than that of any of the others. The transition elements, like bismuth and antimony, have an abnormally high resistance, but no clear connection between the resistivity and the other characteristics of the metals is immediately discoverable. This can scarcely cause surprise, since the metals are not in comparable condition as regards temperature. Comparable temperatures, according to modern theories of specific heat, would be those in which the amplitudes of oscillation of the atoms, were in all cases an equal fraction of the distance between them. If the atomic-resistivity is reduced to corresponding temperatures, as exhibited in the last column of the table, one sees a certain regularity emerge.

So far attention has been directed exclusively to pure metals. The resistance of alloys is a very complicated matter. In the case of those alloys, which do not form solid solutions and which consist really simply of a mixture of two or more metals, the specific conductivity, as might be expected, is proportional to the volume composition of the alloy. The conductor is merely an aggregate of small conductors consisting of pure metals. The resistivity is a much more complicated matter in those cases, in which one metal is in solid solution, in the other, *i.e.*, in which the crystal structure is retained, and the atoms of one metal are replaced by atoms of the other in the space-lattice. The admixture of the second component raises the resistivity, and if the two metals form a continuous solid solution, one finds in general in a binary alloy a continuous curve rising fairly sharply at either end of the scale with a flat maximum between the two pure metals. The effect of different metals upon the electrical resistance is very varied. Thus the addition of 1% of silver to copper, changes its resistivity by an amount variously estimated at 7 to 12 per cent, whereas one percent of zinc changes it by 15 to 17, tin 145, chromium 220 and antimony 310 to 420 per cent. In general it would seem that the effect is greater the further the solvent and solute metals are apart in the periodic table, but this can only be regarded as an empirical rule which may have a certain technical interest when the effect of impurities is at issue.

Temperature.—One of the most important factors affecting the electrical resistance is the temperature. If one plots the resistance of a pure metal as a function of the temperature, it may be represented roughly as a straight line pointed at the origin, in other words, the resistance may be represented as a very rough approximation, by the expression const. T. This significant fact is only the first which emerges. A closer examination reveals that this expression is only a first approximation and represented more accurately by the expression const.U,U representing the internal energy of the metal. The internal energy is the integral of the atomic heat, so that if this formula were accurate the temperature coefficient of the resistance should be proportional to the atomic heat. It has been shown that the atomic heats of the elements, which according to Dulong and Petit's law, should be constant and equal to about six calories, may in reality be represented with much more accuracy by a complicated, but general function of the temperature divided by a characteristic temperature pertaining to each individual metal. (*See* QUANTUM THEORY.) At high temperatures this function approaches asymptotically the value 3 R demanded by Dulong and Petit. At temperatures of the order of the characteristic temperature, the atomic heat falls well below 3 R and approaches zero as the absolute zero of temperature is reached. Metals with a high melting point, *i.e.*, strong inter-atomic forces and low atomic weights, such as aluminium or copper, have comparatively high characteristic temperatures, whilst metals with a low melting point and large atomic weights, such as lead or mercury have low characteristic temperatures. Thus in the first class, the atomic heat falls considerably below 3 R at comparatively high temperatures (100° to 200° absolute) whilst in the latter class the atomic heat remains constant down to much lower temperatures (20° to 40° absolute). The temperature coefficient of the resistance shows the same characteristics. Constant, in the case of copper and aluminium down to 100° to 200° absolute, at these temperatures it commences to fall whereas, in the case of lead or mercury it remains constant down to 20 or 40 degrees of the absolute zero. This very striking fact is often masked by the presence of slight impurities. As was pointed out above, these usually have the effect of increasing the resistance. The added resistance due to the impurity, is not subject in the same way to the effect of temperature. As a first approximation, it may be treated as a constant so that the resistance of a metal may be represented roughly as composed of two terms, one small and constant, probably due to the presence of impurities, and the other rising according to the universal function of the temperature, which presents the internal energy of the metal.

The fact that the added resistance due to the alloying metals does not vary greatly with the temperature, has been made use of by employing alloys of special composition for standards of resistance and other similar purposes. When the main resistance is the alloy resistance, as for instance occurs when the metals which conduct well individually, are dissolved in one another, the constant term is large compared to the term which represents the resistance as a function to the temperature and the total resistance may be almost independent of temperature.

A very remarkable phenomenon has been observed in the case of some metals whose resistance has been measured at extremely low temperatures. Observed to be normal down to the vicinity of about 5° absolute, the resistance already small, but easily measurable, diminishes suddenly to an imperceptible quantity. In the case of lead for instance, it has been shown that the resistance below the critical temperature is less than 10^{-12} of its value at zero centigrade. So small is the resistance in this state, that a current started in a ring, induced say by removing a magnet from the centre, will continue to flow for months without appreciable diminution. This so-called supra-conductivity is a quite distinct phenomenon which has only been observed in the case of certain metals. At first sight, it might appear that its absence in the case of other metals might be due to some small impurity, which gives the metal a small alloy resistance unaffected by temperature. This does not seem to be the true explanation, for supra-conductivity has been looked for in vain in gold which can be obtained relatively pure, whilst it has been found in such metals as tin and lead which are much more likely to contain traces of impurities. Table II. gives a list of those metals in which supra-conductivity has been observed and the temperatures at which it appears.

TABLE II.

Substance	Temperature at which supra-conductivity appears
Indium	3·40° Abs.
Tin	3·72° ,,
Mercury	4·16° ,,
Thallium	2·47° ,,
Lead	7·20° ,,

A most important fact that emerges is that supra-conductivity sets in at an extremely well marked and definite temperature. It can be destroyed by the application of an external magnetic field to reappear as the temperature is lowered; this is not altogether surprising seeing that an electrical current must be due to the motion of electric charges, when one considers the curvature of the path of a moving charge produced by a magnetic field.

Pressure.—The effect of pressure upon the electrical resistance of metals is usually slight. In a great majority of cases it diminishes the resistance, but in a few, namely, Lithium, Caesium, Calcium, Strontium, Antimony and Bismuth, the resistance increases as the pressure is raised. Caesium occupies a special position as the only metal in which the resistance first increases and afterwards decreases with rising pressure, a condition which has been sought, but not found in any other metal. At first sight it might seem surprising that an increase of pressure which corresponds to a decrease in volume, should facilitate the flow of electrons through the metal. Even taking into account that the specific resistance is the resistance of unit volume, so that the increase of pressure with the accompanying contraction corresponds to an increase in the number of atoms and therefore, of electrons in unit volume, the conductivity often increases. Since one has an effect compounded of the variation in the permeability of the metal for electricity and the change in the number of electrons in unit volume owing to the increase in density, simple results can scarcely be expected. The effects are in all cases small, being of the order of the change in volume, *i.e.*, the fractional change of resistance is of the order 10^{-12} or 10^{-11} per dyne.

Stress.—Still more complicated are the effects of stress and deformation on the electrical resistance. These are of a similar order of magnitude to those due to pressure as long as the

deformations are within the elastic limit. When greater deformations are produced, considerably greater changes are caused and variations up to as much as 8% have been observed on working some of the pure metals. The same applies to the temperature coefficients, but all these effects may be annulled by annealing the metal, when recrystallization takes place and it returns to its original unstrained condition.

Magnetic Field.—The effect of a magnetic field upon the conductivity of a metal shows itself in various ways. The so-called longitudinal Hall effect, is the name given to the change in the resistance which occurs in the magnetic field. For all except magnetic metals (iron, nickel and cobalt) the resistance increases, the amount however, being of the order of ·01% for a field of ten thousand C.G.S. units. In bismuth a comparatively enormous effect is observed, so much so, that the resistance of spirals of thin metal bismuth wire is used for measuring magnetic fields. The order of magnitude of the effect is shown in table III., and it will be noted that it increases very much at low temperatures. It is probable that this effect is a secondary one, due to the presence of microscopic cracks which expand under the influence of the field.

TABLE III.

Field strength	Resistance of bismuth in magnetic field	
	Temp. 19° C	Temp. 185° C
0	116,200	41,000
8,800	149,200	738,000
21,800	257,000	6,190,000

Allied Effects.—Four lateral effects caused by the magnetic field correspond to the lateral displacement of a moving electrical charge. The *Hall* effect may be described as the potential difference produced on the two edges of an elongated metallic plate through which a current is flowing when placed in a magnetic field at right angles to it. The magnitude varies from metal to metal, and is in general small, but no relation has as yet been discovered which enables one to predict either its magnitude or even its sign.

The *Ettinghausen* effect is the name given to the temperature difference produced on the two edges on an elongated metal plate through which a current is flowing by the application of a magnetic field at right angles to it. It analogizes to the Hall effect, except that a temperature difference is observed in place of a potential difference.

The two other transverse effects correspond to the above, except that a current of heat replaces the electric current. The *Nernst* effect expresses the fact that a potential difference is observed between the edges of an elongated plate down which heat is flowing when it is placed in a magnetic field. The *Righi-Leduc* effect corresponds to the temperature difference observed on the edges in similar circumstances. All these effects are very slight in the case of the normal metals, but are much greater in the case of elements such as antimony and bismuth, in which non-metallic properties begin to appear.

Thermo-electric (or Seebeck) Effect, Peltier Effect and Thompson Effect.—One cannot consider the electric conductivity of metal without taking into account secondary effects connected with the mechanism by which electricity is transported from one part to another. The best known of these, is the thermo-electric effect, also well known as the Seebeck effect. If two different metals are brought into electrical contact at two points, thus forming a circuit, and the two junctions are kept at different temperatures, a current flows round the circuit. The voltage difference for any given pair of metals, depends solely upon the two temperatures, the current of course being determined by this voltage difference and the resistance of the circuit. At any given temperature the metals may be arranged in a definite order according to the potential difference, which is produced with a given temperature difference between each metal and any one of them arbitrarily chosen as the zero. The potential difference produced by forming a circuit between any two of them is then simply the difference between the voltages produced against the standard metal. Table IV. gives a list of the commoner metals and the potential differences produced against platinum for a temperature difference of one degree centigrade at 0° C. It is evident that these thermo-electric constants are small, usually less than 10^{-4} volts per degree. Their magnitude depends upon the temperature, becoming smaller as the absolute zero is approached. Small though they are the thermo-electric effect forms the basis of a large class of instruments for measuring temperature. It is evident from what has been said, that all that is required is to solder or weld wires of two metals together and measure the voltage difference between the two other ends when the junction is brought to the temperature it is desired to measure.

TABLE IV.

Metal	Thermo-electric effect against platinum at 0° C for 1° diff. in temp.$\times 10^{-6}$ volts
Aluminium	3·8
Antimony	47·0
Bismuth	−65·0
Copper	7·4
Iron	16·0
Palladium	− 5·6
Silver	7·1
Constantan	−34·4

An inversion of the thermo-electric effect is the *Peltier effect.* If two dissimilar metals are brought into electrical contact and a current is passed through the junction this is heated or cooled according to the direction of the current The amount of heating or cooling for a given current at a given temperature depends solely upon the metals used.

The Thompson effect is of somewhat similar character. If a current is passed through a metal, parts of which are at different temperatures, a certain transport of heat takes place, whose amount depends upon the strength of the current. A very important property possessed by all good electrical conductors is the faculty of transmitting heat. Thermal conductivity is possessed in a greater or less degree by all substances. It is measured by the quantity of heat transferred across unit cross-section in unit time for unit temperature gradient. In solids we may distinguish three different types of thermal conductivity. Amorphous solids such as glass possess a conductivity, usually small, which does not vary greatly with temperature. Crystals such as rock salt or rock crystal possess a conductivity roughly inversely proportional to the temperature. At ordinary temperatures it is usually of the same order as the amorphous conductivity of a glass, but at low temperatures clearly it may and does become large. The expression low and high temperatures refers of course to the characteristic temperature of the substance, familiar from the theory of the specific heats.

Electrical conductors possess in addition a thermal conductivity, which would in a non-conductor be considered large and which does not vary greatly with temperature. The mechanism which enables heat to be transported in conductors is certainly closely allied to that which comes into play in electrical conduction. This is shown by the fact that there is a very distinct proportionality between the electrical and the thermal conductivity of the metals. The so-called Wiedemann-Franz constant is the ratio of thermal to electrical conductivity. As shown by table V. it is approximately constant for a large number of metals, whose conductivities diverge by a factor of no less than 27. It will be noted that there is a steady increase in the constant as the conductivity decreases. This is in part due to the fact that the metals possess, in addition to electronic conductivity, the ordinary atomic conductivity of every solid. It is clear that this will become more important as the electronic conductivity diminishes. Its amount may be estimated in the case of single crystals, where it is known that the atomic conductivity varies inversely as the temperature and a corrected Wiedemann-Franz constant can be obtained by subtracting the atomic conductivity from the total conductivity and dividing the electronic conductivity, thus

TABLE V.

	Heat Conductivity / Electric Conductivity at 18 cent. $\times 10^{-8}$ e.m.u.	Temperature coefficient of Heat Conductivity / Electric Conductivity $\times 10^{-4}$
Theoretical	517	36·6
Aluminium	637	42
Cadmium	707	38
Copper	668	40
Gold	710	..
Iron	802	43
Lead	715	40
Nickel	698	40
Silver	686	38
Tin	735	34
Zinc	670	38
Manganine	912	25
Steel	890	36

obtained by the electrical conductivity. This is found, in the cases examined, to give a result even more constant than that obtained in the table. In the last column of the table may be found the temperature coefficient of the ratio of the conductivities. As will be seen, this is approximately ·36 per cent, *i.e.*, the Wiedemann constant appears to be proportional to the absolute temperature. This fact, which is usually regarded as of great importance in any theory of electrical conduction, is of course only another way of stating that the electrical conductivity is roughly inversely proportional to the temperature, whilst the thermal-conductivity is approximately constant. For any theory of electrical conductivity, an important factor is the specific heat of the substance. It has been shown that monatomic substance have atomic heats at constant volume, which may be represented with considerable accuracy by one and the same function of the temperature over a characteristic temperature. Measurements have shown that, at any rate at ordinary temperatures and at low temperatures, the metals possess atomic heats conforming accurately to this function. Reduced to corresponding temperatures, there is no perceptible difference between the atomic heat curve of a conductor and a simple non-conductor. The conclusion seems inevitable that the mechanism which transmits electricity and heat, and which distinguishes electrical conductors from non-conductors, possesses no appreciable heat capacity of its own. Such are the main characteristics of electrical conductors. It remains to consider the theories which have been advanced to account for them.

Theories of Electric Conduction in Metals.—Various attempts have been made to account for the properties of metallic conductors. The first, which for a time was widely accepted, may be described as the electron gas theory (Drude, Riecke, H. A. Lorentz). It was assumed that electrons dissociate from the metal atoms and exist in the interstices between them in much the same state as the atoms of a perfect gas would exist, say, in a heap of shot. According to the classical Kinetic Theory of Gases, the law of equipartition of energy would be fulfilled so that if m is the mass of the electron, k is Boltzmann's constant, and t the absolute temperature: its mean velocity v would be given by the equation $\frac{mv^2}{2}=\frac{3}{2}kT$. At ordinary temperatures, owing to the small mass of the electron, v is very large, of the order of 10^7 cm/sec. Any velocity which can be superposed by extraneous means, such as an electrical field, is negligible compared to this. Hence one may consider, according to this theory, the electrons to be flying about at high speeds until checked by collision with the atoms, their paths being slightly modified but not materially altered in length by any outside influence. If a field X be applied, the electron will suffer an acceleration $X\cdot\frac{e}{m}$, e being the charge. If t is the time between one collision and the next, the electron will acquire an extra velocity $\frac{Xe}{m}\cdot t$ during one free path. If there are n electrons in unit volume the field X will therefore cause a current $\frac{Xne^2}{2m}t$ to flow, in other words, the specific conductivity will be $\frac{ne^2}{2m}t$. In itself, this value is reasonably plausible. If the known figures for e and m are inserted and n is taken of the same order as the number of atoms per cubic centimetre t is of the order 10^{-15} which corresponds to a free path of 10^{-8} cm., the order of distance between the atoms. Without supplementary hypotheses however, it is not clear why the conductivity should vary inversely as the absolute temperature.

The thermal conductivity, according to this theory may, of course, be attributed to the same mechanism which causes a gas to transmit heat. It is merely the diffusion of the hotter and therefore swifter particles, into the more slowly moving ones and the transfer of heat from one group to the other. If ΔT is the temperature gradient, the amount of heat transferred according to the ordinary kinetic theory is $\frac{nv^2k}{2}t\cdot\Delta T$. Hence the conductivity is $\frac{nv^2k}{2}t$, $\frac{3k}{2}$ of course representing the heat capacity of the electron. This expression again gives rise to reasonable values.

The real triumph of the theory is manifest when the Wiedemann-Franz constant, the ratio of thermal to electric conductivity is formed. Inserting the two expressions, it is clear that the quantities n and t, *i.e.*, the number of electrons per cubic centimetre and the time between collisions (those quantities which might well be expected to vary from metal to metal), cancel out, leaving for the ratio of thermal to electrical conductivity $\frac{3k^2}{e^2}T$. Hence the theory explains why the ratio of thermal to electrical conductivity is the same in all conductors and also predicts that it should be proportional to the absolute temperature, as was found empirically. Not only does it give a qualitative explanation, but it gives a very fair approximation to the absolute value, if the known values of k and e are inserted.

The theory of course gives a qualitative explanation of the effect of a magnetic field, since this would cause the deflection of moving electrical particles, though the inverse magnetic effects require supplementary hypotheses; it also explains qualitatively the thermo-electrical, Peltier and Thompson effects, since the electron gases in two different metals would not in general have equal pressures, and, as in the case of osmotic cells (see *Solution*), one would always have a balance between the tendency to diffuse under the influence of thermal agitation and the potential differences set up as soon as movement of the electric charges take place.

The difficulty which proved fatal to this theory, is that it involves the assumption that the electrons have the atomic heat of a monatomic gas. Without this, one cannot obtain the Wiedemann-Franz constant, but if one makes this assumption then the metals should possess atomic heats considerably greater than the non-metals. Of this there is no trace. One cannot escape the dilemma by assuming that only a very small fraction of the atoms dissociate, for in this case thermodynamics shows that the number of electrons would vary rapidly with temperature becoming negligible at low temperatures just where the conductivity is greatest. Thus this theory, great as was the advance which it marked upon the previous attempts to explain the nature of metallic conduction, has had to be abandoned.

Numerous other theories have been put forward to account for the phenomena whilst avoiding this difficulty. One of the first (J. J. Thompson) endeavoured to resuscitate something akin to the Grotthus chain theory of electrolytes. The atoms were considered as dipoles and electric conduction was attributed to the transfer of electrons from one atom to the next. Under the influence of the field the dipoles would tend to arrange themselves, and the probability of an electron being pulled out of the negative part of one dipole into the positive part of the next, would be increased. If the dipoles are distributed at random, there will be no tendency for the electrons to flow in any definite direction,

it is only the polarisation on this theory which gives rise to the current. If one supposes that the kinetic energy of the electron in the doublet is proportional to the kinetic energy of the doublet, then of course a transfer of particles will involve the transfer of energy from hot to cold parts of the metal and give rise to heat conduction. This theory is incompatible with modern views and has scarcely more than historical interest. The mechanism of dissociation, the assumption that the kinetic energy of the electron equals that of the atom and values which emerge, if the figures are inserted in the formula, disprove its validity. It has been mentioned, chiefly because it may be regarded as the precursor of a theory which has been put forward much more recently by Bridgman. In this the electric current is attributed in the main to the flow of electrons inside the atoms, not to the motion of electrons between them. The hindrances to the free flow of electrons are found according to this theory, not in the atoms themselves, but in the gaps between the atoms. The theory was concerned chiefly to explain the increase in conductivity, usually observed under hydrostatic pressure. This, it need scarcely be said, is quite simple since pressure will tend to close the gaps between the atoms. The effect of temperature which causes expansion of the metal and raises the amplitude of the atomic vibrations is to increase the number of gaps and the resistance. Heat conduction is explained as partly electric and partly atomic though the share attributed to the atoms is far larger than one would normally expect. It seems probable that the somewhat crude assumptions which underlie it, and the additions which have become necessary in order to explain even such a fundamental quality as thermal conductivity, will militate against the acceptance of this hypothesis.

Various theories (Lindemann, Wien) were based upon the assumption that the free path of the electrons depends upon the amplitude of oscillation of the atoms. This explains at once why the resistance is proportional to the energy content of the solid, since pressure augments the forces between the atoms the frequency is increased and for a given energy, the amplitude diminished. From this point of view it is to be expected that an increase in pressure would lead to a decrease in resistance, since a decreased amplitude means an increased free path. Scarcely one of these theories progressed beyond the first tentative beginning, and none of them appear likely to survive. A theory of a totally different kind, put forward by Lindemann, endeavoured to reconcile the great heat conductivity of metals with the negligible heat capacity of the electron by treating these as forming a space-lattice, interleaved between the atomic lattice. As has been pointed out, a crystal at low temperatures conducts heat comparatively well, even though its atomic heat may be negligible. This fact, which had been plausibly explained by Debye, appears to suggest a simple mechanism for the transfer of heat in metals.

Electrons repel one another so strongly that the idea of an electron gas is almost a contradiction in terms, unless one attributes enormous velocities to the particles. At ordinary temperatures the equipartition energy would only suffice to make the particles quiver, if each atom in a solid had dissociated an electron. Under the influence of an electric field the electron space-lattice would move continuously through the atomic space-lattice, provided a source of the electrons were connected to one end of the conductor, and if the electrons were able to flow out at the other, *i.e.*, if the circuit were closed. In pure metals at extremely low temperature, it seems possible that the electron space-lattice might move almost unimpeded through the atomic space-lattice; with increasing temperature the amplitude of oscillation of the atoms increases and obstacles would be interposed to the space-lattice drift. In an impure metal a constant resistance would be superposed upon the resistance due to the thermal agitation, on account of the irregularities produced in the original atomic space-lattice by the foreign atoms embedded in it. The forces between the electrons, as was pointed out, would be of the same order as the forces between the atoms. Since the electron has a very small mass the proper frequency, and therefore the characteristic temperature of the electronic space-lattice would be extremely high, of the order of one hundred thousand degrees. Thus the heat capacity of the electrons would be negligible though, since they would form a crystal, they could conduct heat. All the minor effects can of course be explained on similar lines to those current in the theory which treats the electrons as forming a perfect gas. The main advantage which this theory possesses, besides avoiding the contradiction involved in attributing to a perfect gas, heat conductivity without heat capacity, is that it gives a plausible reason for the large increase of resistance, which may be caused by the admixture of a foreign element and also that it accounts for the fact that metal crystals may have different conductivities along different axes.

The most recent theory (Sommerfeld) treats the electrons as a completely degraded gas. It is difficult to go into this in any detail without a considerable digression upon wave mechanics and the modifications of statistical mechanics, imposed by what is usually called the quantum theory. It has been suggested by Pauli that no two electrons in an atom can have the same four quantum numbers. This simple rule explains the existence of the periodic system of the elements. The same rule was applied by Fermi to a gas. This leads at high temperatures to the ordinary laws. At low temperatures however, the gas would deviate considerably from the state predicted by the classical theory. At the absolute zero it would still exert a pressure and possess energy, for clearly since only one atom can have the four quantum numbers, all the other atoms must contain some energy. If one applies the formulae of this theory to the electrons in a metal, one finds a considerable measure of agreement with experimental fact. As in the classical electron gas theory, the number of electrons in unit volume and the time between collisions enters in the same way into the formulae for the electrical and thermal conductivities. Hence the Wiedemann-Franz constant emerges, and what is more, its absolute value agrees somewhat more closely with experiment than it does according to the classical theory. The heat capacity of the electrons is negligible, for their mass is so small that it only amounts to a fraction of one per cent of the heat capacity of the atoms. The exact meaning of the free path on this theory, is as yet perhaps not quite clear and special assumptions have to be made about it in order to explain the variation of a resistance with temperature. No obvious explanation is given for the large effect of impurities, nor does it seem easy on this theory, to account for a difference in conductivity along the different axes of a crystal. On the other hand, the fact that it is possible to obtain the Wiedemann-Franz constant without having to assume a large heat capacity, marks a notable advance.

Non-metallic Conductors.—Little accurate information is available about non-metallic conductors. Many of them exhibit departures from Ohm's Law and some of them are not even independent of the time in their electrical characteristics. Numerous specimens of various substances have been examined with considerable care, but the values found depend so much upon the treatment and form of the specimen, that no useful purpose would be served by a detailed description of the results. Thus for instance, carbon, one of the most carefully investigated substances, displays values of the conductivity according to its form, varying by as much as a factor three and if the allotropic modification, graphite is included, by as much as twenty to one. In general non-metallic conductors have a very much higher resistance than metallic conductors, carbon for instance, having a resistance two thousand times that of copper at ordinary temperatures. All of them have a negative temperature coefficient, *i.e.*, the resistance decreases with rise of temperature, unlike metals whose resistance, except for some curious alloys, invariably increases as the temperature is raised. At sufficiently high temperatures, there is in some cases a change in the sign of the temperature coefficient, but not sufficient evidence is available to allow any generalization from this. Apart from carbon in its various forms, some of the oxides and sulphides of the metallic elements, are the non-metallic conductors which have been most closely studied. Table VI. gives the resistance found in the case of copper and silver sulphide at various temperatures. It will be

TABLE VI.

Cu_2S		Ag_2S	
Temperature	Resistance in Ohms×10^{-3}	Temperature	Resistance in Ohms×10^{-3}
0	7,430	84·1	2,270
10	4,476	93	1,610
51	790	113·2	600
67	447	129·2	506
85	264	148	284
103	148	158·2	170
107	62	165·2	108
113	54	170	58
136	34	180·5	3·71
152	25	195	3·25
184	14·5	..	..
192	13	..	..

seen that the increase in conductivity is extremely large for a comparatively small change of temperature, of the same order as the change in viscosity of many substances for an equivalent change. It seems likely that it is some such effect which accounts for the temperature coefficient.

Many of these substances exhibit a very remarkable property, in that the transition of electricity from one of them to a metallic conductor placed in contact, proceeds very much more easily in one direction than the other; in some cases the resistance is more than a thousand times greater in the one than the opposite sense. It is this property which is made use of in the rectifying devices used either for high frequency currents, as in the crystal detector, or for low frequency rectification on a small scale.

One other non-metallic conductor has been the subject of the most minute examination, namely selenium. In certain modifications this substance exhibits a very curious phenomenon; its resistance is changed by illumination. The conductivity in suitable circumstances may be increased by 6% by illumination of one metre candle, the effect within wide limits being proportional to the square root of the illumination.

Many attempts have been made to utilize this property for the measurement of light and for the production of electric currents corresponding to incident light for various purposes. Unfortunately the very large temperature coefficient, the variation of its resistance with humidity, and especially the slow response of selenium to weak illumination, usually stands in the way of complete successes. The effect is probably due to some allotropic modification produced in the material by light and it is not surprising that

TABLE VII.

	Volume resistivity at 18° C ohms		Volume resistivity at 18° C ohms
Gas carbon	0·004–·007	Glass, lead	4×10^{13}
Carbon lamp filament	0·004	Fused silica	2×10^{14}
Graphite	0·003	Quartz	10^{14}
Diamond	10^{14}	Mica	10^{14}
Silicon	0·06	Shellac	10^{18}
Selenium	2×10^{16}*	Paraffin wax	10^{16}
Sulphur	10^{17}	Rubber	10^{15}
Ebonite	10^{15}	Guttapercha	10^{9}
Glass, soda	5×10^{11}	Unglazed porcelain	10^{14}

*In the dark.

NOTE: The resistances of the above depend to a great extent on the state of the surfaces, moisture, grease, etc., reducing the resistances enormously. The resistances are also greatly reduced for small increases in temperature. In actual practice, unless great care has been taken in keeping the surfaces clean, the effectual resistances of the substances may be $\frac{1}{10}$ or $\frac{1}{100}$ of the value shown in the table.

there should be a certain lag in its response to the stimulus if this view is correct.

Dielectric Conductors.—A large volume of unsystematic work for technical purposes has been carried out with what may be termed dielectric conductors or insulators. For most purposes the property required is the absence of conductivity, and therefore attention is centred mostly upon those substances which have the greatest possible resistance and can be made use of for

TABLE VIII.

Thickness in centimetres	Dielectric strength in kilovolts per centimetre
Mica	
0·001	2,000
0·010	1,150
0·02	950
0·05	750
0·10	610
Crystal Glass	
0·1	285
0·2	253
0·3	224
0·4	200
0·5	183
0·6	168

insulating cables and the like. It is evident that such substances are not those likely to be chosen if it is desired to discover the mechanism of dielectric conduction. In general, as in the case of many of the non-metallic conductors, it is of dubious validity to employ the concept of electric resistance at all, as this is often in dielectrics, a function of the time as well as of the voltage applied. The resistance at room temperature for a few of the commoner insulators are given in the Table VII. In general the conductivity increases very rapidly with rising temperature, probably for the same reason that has been suggested in the case of non-metals. The accuracy of the measurements is vitiated in many cases by the presence of moisture which is apt to form in a thin conducting layer over parts of the surface. Thus in many cases, it is more important to use an insulator which can be thoroughly dried, than to seek one of a high specific resistance. At a sufficiently high voltage all these insulators break down and a spark occurs. This so-called dielectric strength is a matter of great technical importance, but it also depends to such a large extent upon the peculiar circumstances of the experiment, that only two typical cases, mica and crystal glass, are given as examples.

Some extremely valuable work, from a scientific point of view, has been carried out in the last few years by Pohl upon the transfer of electricity in certain dielectrics. He found that many dielectrics more especially sodium chloride exhibited a form of conductivity under the influence of light. This he could show was due to the production of photo-electric electrons whose displacements formed a current. Though this can scarcely be regarded as conductivity in the ordinary sense, it does represent one of the first cases in which the movement of electricity through a dielectric has been treated upon a quantitative basis.

(F. A. L.)

CONDUCTION IN LIQUIDS

In fused salts and conducting solutions the passage of an electric current is always accompanied by definite chemical changes; the substance of the conductor or electrolyte is decomposed, and the products of the decomposition appear at the electrodes. The chemical phenomena are considered in the article ELECTROLYSIS; we are here concerned solely with the mechanism of this *electrolytic* conduction of the current. In metallic conduction it is found that the current is proportional to the applied electromotive force—a relation known by the name of Ohm's law. According to this law $I=E/R$, where I is the current, E the electromotive force and R the resistance of the circuit. Ohm's law has been confirmed in the case of metallic conduction to a very high degree of accuracy and Kohlrausch was the first to show that an electrolyte possesses a definite resistance which has a constant value when measured with different currents and by different methods.

Measurement of the Resistance of Electrolytes.—There are two effects of the passage of an electric current which prevent the possibility of measuring electrolytic resistance by the ordinary methods with the direct currents which are used in the case of metals. The products of the chemical decomposition of the electrolyte appear at the electrodes and set up the opposing electromotive force of polarization, and unequal dilution of the solution may occur in the neighbourhood of the two electrodes. The polarization at the surface of the electrodes will set up an opposing electromotive force, and the unequal dilution of the solu-

tion will turn the electrolyte into a concentration cell and produce a subsidiary electromotive force either in the same direction as that applied or in the reverse according as the anode or the cathode solution becomes the more dilute. Both effects thus involve internal electromotive forces, and prevent the application of Ohm's law to the electrolytic cell as a whole. It is therefore necessary to eliminate both these effects before attempting to measure the resistance.

The usual and most satisfactory method of measuring the resistance of electrolytes is that of Kohlrausch and Holborn, which consists in eliminating the effects of polarization by the use of alternating currents, *i.e.*, currents that are reversed in direction many times a second. The chemical action produced by the first current is thus reversed by the second current in the opposite direction, and the polarization caused by the first current on the surface of the electrodes is destroyed before it rises to an appreciable value. The polarization is also diminished by increasing the area of the electrodes, which can be brought about to a very high degree by coating the plate with platinum black. The coating is effected by passing an electric current first one way and then the other between two platinum plates immersed in a 3% solution of platinum chloride to which a trace of lead acetate is sometimes added. The platinized plates thus obtained are quite satisfactory for the investigation of strong solutions. They have the power, however, of absorbing a certain amount of salt from the solutions and of giving it up again when water or more dilute solution is placed in contact with them. The measurement of very dilute solutions is thus made difficult, but if the plates be heated to redness after being platinized a grey surface is obtained which possesses sufficient area for use with dilute solutions and yet does not absorb an appreciable quantity of salt.

Any convenient source of alternating current may be used. The currents from the secondary circuit of a small induction coil from which the condenser has been removed are satisfactory for most purposes. With such currents it is necessary to consider the effects of self-induction in the circuit and of electrostatic capacity. In balancing the resistance of the electrolyte, resistance coils may be used in which self-induction and the capacity are reduced to a minimum by winding the wire of the coil backwards and forwards in alternate layers.

With these arrangements the usual method of measuring resistance by means of Wheatstone's bridge may be adapted to the case of electrolytes. With alternating currents, however, it is impossible to use a galvanometer in the usual way. The galvanometer was therefore replaced by Kohlrausch by a telephone, which gives a sound when an alternating current passes through it. The most common plan of the apparatus is shown diagrammatically in fig. (1). The electrolytic cell and a resistance box form two arms of the bridge, and the sliding contact is moved along the metre wire which forms the other two arms till no sound, or only a minimum sound, is heard in the telephone. The position of minimum sound is more sharply obtained by connecting a variable air condenser in parallel with the conductance cell so as to balance its capacity. The resistance of the electrolyte is to that of the box as that of the right-hand end of the wire is to that of the left-hand end. A more accurate method of using alternating currents dispenses with the telephone (*Phil. Trans.*, 1900, 194, p. 321). The current from one or two voltaic cells is led to an ebonite drum turned by a motor or a hand-wheel. On the drum are fixed brass strips with wire brushes touching them in such a manner that the current from the brushes is reversed several times in each revolution of the drum. The wires from the brushes are connected with the Wheatstone's bridge. A moving coil galvanometer is used as indicator, its connections being reversed in time with those of the battery by a slightly narrower set of brass strips fixed on the other end of the ebonite commutator. Thus any residual current through the galvanometer is direct and not alternating. The high moment of inertia of the

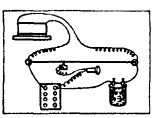

FIG. 1.—MEASUREMENT OF RESISTANCE BY WHEATSTONE'S BRIDGE AND TELEPHONE

coil makes the period of swing slow compared with the period of alternation of the current, and the slight periodic disturbances are thus prevented from affecting the galvanometer. When the measured resistance is not altered by increasing the speed of the commutator or changing the ratio of the arms of the bridge, the disturbing effects may be considered to be eliminated.

The form of vessel chosen to contain the electrolyte depends on the order of resistance to be measured. For dilute solutions the shape of cell shown in fig. (2) will be found convenient, while for more concentrated solutions, that indicated in fig. (3) is suitable. The absolute resistances of certain solutions have been determined by Kohlrausch by comparison with mercury, and, by using one of these solutions in any cell, the constant of that cell may be found once for all. From the observed resistance of any given solution in the cell the resistance of a centimetre cube —the so-called specific resistance—may be calculated. The reciprocal of this, or the conductivity, is a more generally useful constant; it is conveniently expressed in terms of a unit equal to the reciprocal of an ohm. Thus Kohlrausch found that a solution of potassium chloride, containing one-tenth of a gram equivalent (7·46 grams) per litre, has at 18° C a specific resistance of 89·37 ohms per cm. cube, or a conductivity of $1{\cdot}119\times10^{2}$ ohms or $1{\cdot}119\times10$ c.g.s. units. As temperature variation of conductivity is large, usually about 2% per degree, it is necessary to place the resistance cell in a paraffin or water bath, and to observe its temperature with some accuracy.

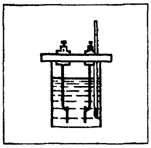

FIG. 2.—CELL FOR MEASUREMENT OF RESISTANCE OF DILUTE SOLUTIONS

An important objection to the use of the induction coil for accurate measurements is that it does not give a current of zero integral value, *i.e.*, the current is not alternating, but pulsating, having a uni-directional component. Another objection to this instrument is the difficulty of maintaining the frequency constant. A motor-driven small high frequency generator such as the Vreeland oscillator has been applied for conductance measurements. The most satisfactory source of alternating current for conductivity measurements is that provided by a thermionic value oscillator which gives a pure sine wave. The arrangement employed is illustrated in fig. (4). The frequency of the wave is varied by altering the capacity of the condenser C, which is of small capacity and continuously variable over its entire range and the condenser C' which is variable in steps of say 0·005 microfarad. Currents of from a few tenths to 25 amperes and having a frequency ranging from one-half to 5×10^{7} cycles may be obtained from this type of generator.

A principle employing direct current was adopted by E. Bouty in 1884 (*cf.* also Marie and W. A. Noyes *Journ. Amer. Chem. Soc.*, 1921). If a current be passed through two resistances in series by means of an applied electromotive force, the electric potential falls from one end of the resistances to the other, and, if Ohm's law be applied to each resistance in succession, it is seen that, since for each of them $E=IR$, and I the current is the same through both, E, the electromotive force or fall of potential between the ends of each resistance, must be proportional to the resistance between them. Thus by measuring the potential difference between the ends of the two resistances successively, their resistances may be compared. If, on the other hand, the potential differences are measured in some known units, and, similarly, the current flowing, the resistance of a single electrolyte can be determined.

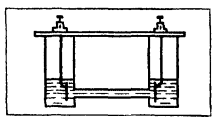

FIG. 3.—CELL FOR MEASUREMENT OF RESISTANCE OF CONCENTRATED SOLUTIONS

Equivalent Conductivity of Solutions.—The foundation of this knowledge was laid by Kohlrausch when he had developed the method of measuring electrolyte resistance described above. He expressed his results in terms of ***equivalent conductivity, i.e.***, the conductivity (κ) of the solution divided by the number (m)

of gram-equivalents of electrolyte per litre. He found that, as the concentration diminishes, the value of κ/m approaches a limit, and eventually becomes constant, that is to say, at great dilution the conductivity is proportional to the concentration. Kohlrausch first prepared very pure water by repeated distillation and found that its resistance continually increased as the process of purification proceeded. The conductivity of the water,

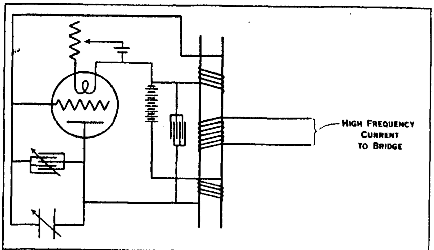

FIG. 4.—VALVE CIRCUIT FOR PROVIDING ALTERNATING CURRENT OF SINE-WAVE FORM

and of the slight impurities which must always remain, was subtracted from that of the solution made with it, and the result, divided by m, gave the equivalent conductivity of the substance dissolved. This procedure appears justifiable, for as long as conductivity is proportional to concentration it is evident that each part of the dissolved matter produces its own independent effect, so that the total conductivity is the sum of the conductivities of the parts; when this ceases to hold, the concentration of the solution has in general become so great that the conductivity of the solvent may be neglected. The general result of these experiments can be represented graphically by plotting κ/m as ordinates and $\sqrt[3]{m}$ as abscissae, $\sqrt[3]{m}$ being a number proportional to the reciprocal of the average distance between the molecules, to which it seems likely that the molecular conductivity may be related. The general types of curve for a simple neutral salt like potassium or sodium chloride and for a caustic alkali or acid are shown in fig. (5). The curve for the neutral salt reaches to a limiting value; that for the acid attains a maximum at a certain very small concentration, and falls again when the dilution is carried farther. The values of the molecular conductivities of all neutral salts are, at great dilution, of the same order of magnitude, while those of acids at their maxima are about three times as large. The influence of increasing concentration is greater with salts containing divalent ions, and greatest of all in solutions such as those of ammonia and acetic acid, which are substances of very low conductivity.

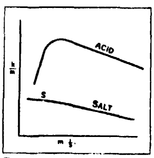

FIG. 5.—RELATION BETWEEN EQUIVALENT CONDUCTIVITY AND CONCENTRATION

Theory of Moving Ions.—The quantity of electricity flowing per second, *i.e.*, the current through the solution, depends on (1) the number of the ions concerned, (2) the charge on each ion, and (3) the velocity with which the ions travel past each other. Now, the number of ions is given by the concentration of the solution, for even if all the ions are not actively engaged in carrying the current at the same instant, they must, on any dynamical idea of chemical equilibrium, be all active in turn. The charge on each can be expressed in absolute units, and therefore the velocity with which they move past each other can be calculated. This was first done by Kohlrausch (*Göttingen Nachrichten*, 1876, and *Das Leitvermögen der Elektrolyte*, Leipzig, 1898). By combining the results of determinations of transport numbers by Hittorf's method with the sum of the velocities, as determined from the conductivities, Kohlrausch calculated the absolute velocities of different ions under stated conditions. The table shows Kohlrausch's values for the ionic velocities of three chlorides of alkali metals at 18° C, calculated for a potential gradient of 1 volt per cm. u is the velocity of the positive ion, v that of the negative ion; the numbers are in terms of a unit equal to 10^{-6} cm. per sec.:

	KCl			NaCl			LiCl		
m	$u+v$	u	v	$u+v$	u	v	$u+v$	u	v
0	1350	660	690	1140	450	690	1050	360	690
0·0001	1335	654	681	1129	448	681	1037	356	681
·001	1313	643	670	1110	440	670	1013	343	670
·01	1263	619	644	1059	415	644	962	318	644
·03	1218	597	621	1013	390	623	917	298	619
·1	1153	564	589	952	360	592	853	259	594
·3	1088	531	557	876	324	552	774	217	557
1·0	1011	491	520	765	278	487	651	169	482
3·0	911	442	469	582	206	376	463	115	348
5·0				438	153	285	334	80	254
10·0							117	25	92

These numbers show clearly that there is an increase in ionic velocity as the dilution proceeds. Moreover, if we compare the values for the chlorine ion obtained from observations on these three different salts, we see that as the concentrations diminish the velocity of the chlorine ion becomes the same in all of them. A similar relation appears in other cases, and, in general, it may be said that at great dilution the velocity of an ion is independent of the nature of the other ion present. This introduces the conception of specific ionic velocities, for which some values at 18° C are given by Kohlrausch in the following table:

K.	.	66×10^{-6} cms. per sec.	Cl.	.	69×10^{-6} cms. per sec.
Na	.	45 ,, ,, ,,	I.	.	69 ,, ,, ,,
Li	.	36 ,, ,, ,,	NO_3	.	64 ,, ,, ,,
NH_4	.	66 ,, ,, ,,	OH	.	162 ,, ,, ,,
H.	.	320 ,, ,, ,,	$C_2H_3O_2$		36 ,, ,, ,,
Ag	.	57 ,, ,, ,,	$C_3H_5O_2$		33 ,, ,, ,,

From these numbers can be deduced the conductivity of the dilute solution of any salt, and it was a comparison of the calculated with the observed values that furnished the first confirmation of Kohlrausch's theory. Some exceptions, however, are known. Thus acetic acid and ammonia give solutions of much lower conductivity than is indicated by the sum of the specific ionic velocities of their ions as determined from other compounds. An attempt to find in Kohlrausch's theory some explanation of this discrepancy shows that it could be due to one of two causes. Either the velocities of the ions must be much less in these solutions than in others, or else only a fractional part of the number of molecules present can be actively concerned in conveying the current. This point will again be considered later.

Friction on the Ions.—It is interesting to calculate the magnitude of the forces required to drive the ions with a certain velocity. A potential gradient of 1 volt per cm. leads to an electric force of 10^8 in c.g.s. units. The charge of electricity on 1 gram-equivalent of any ion is $1/\cdot0001036=9653$ units, hence the mechanical force acting on this mass is 9653×10^8 dynes. Suppose this produces a velocity u; then the force required to produce unit velocity is

$$P_o=\frac{9\cdot653\times10^{11}}{u}\text{ dynes}=\frac{9\cdot84\times10^5}{u}\text{ kg.-weight.}$$

If the ion have an equivalent weight A, then the force producing unit of velocity when acting on 1 gram is

$$P_1=9\cdot84\times\frac{10^5}{Au}\text{ kg.-weight.}$$

Thus, A being 39·1 and u being 660×10^{-6} for potassium, the aggregate force required to drive 1 gram of potassium ions with a velocity of 1 cm. per second through a very dilute solution must be equal to the weight of 38×10^6 kilograms.

Direct Measurement of Ionic Velocities.—Sir Oliver Lodge was the first to measure directly the velocity of an ion (*Brit. Ass. Report*, 1886). In a horizontal glass tube connecting two vessels filled with dilute sulphuric acid he placed a solution of sodium chloride in solid agar-agar jelly. This solid solution was made alkaline with a trace of caustic soda in order to bring out the red

colour of a little phenol-phthalein added as indicator. An electric current was then passed from one vessel to the other. The hydrogen ions from the anode vessel of acid were thus carried along the tube, and, as they travelled, decolourized the phenol-phthalein. By this method the velocity of the hydrogen ion through a jelly solution under a known potential gradient was observed to about 0·0026 cm. per sec., a number of the same order as that required by Kohlrausch's theory. Direct determinations of the velocities of a few other ions have been made by W. C. D. Whetham (*Phil. Trans.* vol. clxxxiv., A; vol. clxxxvi., A; *Phil. Mag.*, 1894). Two solutions having one ion in common, of equivalent concentrations, different densities, different colours, and nearly equal specific resistances, were placed one over the other in a vertical glass tube. In one case, for example, decinormal solutions of potassium carbonate and potassium bichromate were used. The colour of the latter is due to the presence of the bichromate group, Cr_2O_7. When a current was passed across the junction, the anions CO_3'' and Cr_2O travelled in the direction opposite to that of the current, and their velocity could be determined by measuring the rate at which the colour boundary moved. Similar experiments were made with alcoholic solutions of cobalt salts, in which the velocities of the ions were found to be much less than in water.

The behaviour of agar jelly was then investigated, and the velocity of an ion through a solid jelly was shown to be very little less than in an ordinary liquid solution. The velocities could therefore be measured by tracing the change in colour of an indicator or the formation of a precipitate. Thus decinormal jelly solutions of barium chloride and sodium chloride, the latter containing a trace of sodium sulphate, were placed in contact. Under the influence of an electromotive force the barium ions moved up the tube, disclosing their presence by the trace of insoluble barium sulphate formed. Again, a measurement of the velocity of the hydrogen, when travelling through the solution of an acetate, showed that its velocity was then only about the one-fortieth part of that found during its passage through chlorides. From this, as from the measurements on alcohol solutions, it is clear that where the equivalent conductivities are very low the effective velocities of the ions are reduced in the same proportion.

Another series of direct measurements has been made by Orme Masson (*Phil. Trans.*, vol. cxcii., A). He placed the gelatine solution of a salt, potassium chloride, for example, in a horizontal glass tube, and found the rate of migration of the potassium and chlorine ions by observing the speed at which they were replaced when a coloured anion, say, the Cr_2O_7 from a solution of potassium bichromate, entered the tube at one end, and a coloured cation, say, the Cu from copper sulphate, at the other. The coloured ions are specifically slower than the colourless ions which they follow, and in this case it follows that the coloured solution has a higher resistance than the colourless. For the same current, therefore, the potential gradient is higher in the coloured solution and lower in the colourless one. Thus a coloured ion which passes in front of the advancing boundary finds itself acted on by a smaller force and falls back into line, while a straggling colourless ion is pushed forward again. Hence a sharp boundary is preserved. B. D. Steele has shown that with these sharp boundaries the use of coloured ions is unnecessary, the junction line being visible owing to the difference in the optical refractive indices of two colourless solutions. Once the boundary is formed, too, no gelatine is necessary, and the motion can be watched through liquid aqueous solutions. (*See* R. B. Denison and B. D. Steele, *Phil. Trans.*, 1906.)

All the direct measurements which have been made on simple binary electrolytes agree with Kohlrausch's results within the limits of experimental error. His theory, therefore, probably holds good in such cases, whatever be the solvent, if the proper values are given to the ionic velocities, *i.e.*, the values expressing the velocities with which the ions actually move in the solution of the strength taken, and under the conditions of the experiment. If the specific velocity of any one ion is known, it is possible to deduce, from the conductivity of very dilute solutions, the velocity of any other ion with which it may be associated, a proceeding which does not involve the difficult task of determining the migration constant of the compound. Thus, taking the specific ionic velocity of hydrogen as 0·00032 cm. per sec., by determining the conductivity of dilute solutions of any acid, the specific velocity of the acid radicle involved can be found. Or again, since the specific velocity of silver is known, the velocities of a series of acid radicles at great dilution can be found by measuring the conductivity of their silver salts.

By such methods W. Ostwald, G. Bredig and other observers have found the specific velocities of many ions both of inorganic and organic compounds, and examined the relation between constitution and ionic velocity. The velocity of elementary ions is found to be a periodic function of the atomic weight, similar elements lying on corresponding portions of a curve drawn to express the relation between these two properties. Such a curve much resembles that giving the relation between atomic weight and viscosity in solution. For complex ions the velocity is largely an additive property; to a continuous additive change in the composition of the ion corresponds a continuous but decreasing change in the velocity. The following table gives Ostwald's results for the formic acid series:—

		Velocity	Difference for CH_2
Formic acid	HCO_2	51·2	. .
Acetic "	$H_3C_2O_2$	38·3	−12·9
Propionic "	$H_5C_3O_2$	34·3	− 4·0
Butyric "	$H_7C_4O_2$	30·8	− 3·5
Valeric "	$H_9C_5O_2$	28·8	− 2·0
Caprionic "	$H_{11}C_6O_2$	27·4	− 1·4

The Theory of Debye and Hückel.—In the investigations of Debye and Hückel a theory has been developed which though not complete may be considered to have furnished already for dilute solutions of strong electrolytes a complete explanation of the main properties (*Phys. Zeits.* 1924; *Trans. Faraday Soc.*, 1927; *see* also ELECTROLYSIS for the bearing of this theory on the activity of an electrolyte). In this theory, which assumes complete dissociation of strong electrolytes, the view has been developed that the fall of molecular conductivity observed with increasing concentration is due not to a diminution of the number of ions but to a reduction of their mobility on account of electrostatic forces. The electrostatic potential at the surface of the ion induces an ionic atmosphere of opposite charge, the density of which decreases with increasing distance from the centre of the ion. In the equilibrium condition the ionic atmosphere will possess central symmetry, but on subjecting an electrolyte to an external field so as to generate a current and a mean movement of each ion in one direction the central symmetry of the ionic system will be destroyed. If, for instance, the central ion moves to the right, then during its motion it will constantly have to build up a charge density constituting its atmosphere to the right, whereas to the left the charge density will have to die out. If the creation of the ionic atmosphere could be accomplished instantaneously, no effect of the motion would be perceptible. If, however, a finite time of relaxation exists, during the motion of the central ion the atmosphere will, in the right-hand part, never reach its equilibrium density, whereas in the left-hand part the density will constantly be larger than its equilibrium value. Since the charge density in the atmosphere always has a sign opposite to the charge of the ion, it follows that, owing to the dissymmetry of its atmosphere, the central ion will be acted upon by a force tending to decrease its velocity. As the amount of dissymmetry increases with increasing velocity, this force will also increase, so that it will have the same effect that an increase of the friction constant would have. It is shown by Debye and Hückel that the decrease of density of the ionic atmosphere with distance is given by the exponential $\epsilon^{-\chi r}$ where r is the distance and χ has the dimensions of a reciprocal length denoting the distance at which the charge density has fallen to $1/\epsilon$ of its initial value.

It can be shown (*cf.* ELECTROLYSIS) that χ is given by the equation

$$\chi^2 = \frac{4\pi}{DkT}\sum n_i \epsilon_i^2$$

when D = dielectric constant of the solvent, $k = 1{\cdot}37 \times 10^{-16}$ = Boltzmann's constant, T = absolute temperature, n_i = number of ions of kind i in 1 c.c., ϵ_i = charge of one ion of kind i. For a univalent electrolyte of concentration m calculated in mols. per litre and in the solvent water, it is found

$$\chi = 3{\cdot}27 \times 10^{7}\sqrt{m} \quad \text{or} \quad 1/\chi = 3{\cdot}06 \times 10^{-8}/\sqrt{m} \text{ cm.}$$

$1/\chi$ is called the radius of the ionic atmosphere. The conductivity λ of any electrolyte solution may be stated in a most general way to be given by the expression $\lambda = \sum \frac{n_i \epsilon_i^2}{\rho_i}$ where ρ_i is the friction coefficient of an ion of kind i. The frictional force in the medium which has to be overcome during the steady motion is accordingly given by the product $\rho_i v_i$, where v_i is the mean velocity of the ion.

The present theory is built up on the assumption of total dissociation, according to which n_i is exactly proportional to the total concentration, and the deviations of the proportionality between the conductivity and the concentration are accordingly due to changes with concentration of the friction coefficients ρ_i or their reciprocals, the mobilities.

According to the reasoning followed above, a change of mobility with concentration is to be expected, provided a time of relaxation characteristic of the ionic atmosphere exists. An expression is developed for the space distribution of ions, allowing for its variation in time by supposing a total central charge E in equilibrium with its ionic atmosphere to be destroyed at the instant $t=0$ and determining how the charge density of the atmosphere spreads out to zero density. A mathematical expression is thus derived for the charge density, or the potential, as a function of the distance from the centre r and the time t. An essential time constant τ governing the decrease and known as the time of relaxation is derived. In the case of an electrolyte with two univalent ions of equal mobility (like KCl) τ is given by the expression

$$\tau = \frac{\rho}{\chi^2 kT}.$$

For a KCl solution of m mols per litre, this gives

$$\tau = \frac{0{\cdot}55}{m} 10^{-10} \text{ sec.}$$

When an ion moves with a given constant velocity in the direction of the external field, the additional field intensity F_1, in the direction opposite to the motion of the central ion is given by the expression

$$F_1 = \frac{1}{6} \frac{E}{D} \frac{\chi\rho}{kT} v.$$

where E is the total charge of the central ion and ρ is the mean friction coefficient of the solution.

For a solution in which the ions have equal mobilities the additional force or product of the ionic charge and the additional field intensity is given by the expression

$$EF_1 = -\frac{R_0 E^2 \chi}{6DkT}$$

where $R_0 = \rho v$ is the frictional force on a central ion in an infinitely dilute solution. For a KCl solution in water of concentration m mols. per litre, this additional force has the absolute value $0{\cdot}384\sqrt{m}$ showing that the effect is of practical importance. In an infinitely dilute solution, P may be used to represent the frictional constant so that in this case $R_0 = Pv$.

In Stokes formula, the frictional force is given by the expression $R_0 = 6\pi\eta Cv$ where C is the radius of the moving sphere and η the internal friction constant of the liquid. In this formula it is supposed that no external force acts on the liquid surrounding the sphere. In the present case however the external field will also act on the charges constituting the atmosphere in accordance with the principle of electrophoresis, the relations of which have been calculated by Helmholtz. The charges in the liquid and the charge of the sphere always have opposite sign. The additional motion due to the existence of these charges will therefore have a velocity oppositely directed to the velocity of the particle. It follows that, in addition to the Stokes force, an additional force

$$R_1 = EF_0 C\chi$$

will act in a direction opposite to the direction of motion. For a uni-univalent solution in water, by substituting the value for χ it is seen that the additional force will be represented by the expression

$$R_1 = EF_0 C\sqrt{m} \times 0{\cdot}327 \times 10^{8},$$

showing that for particles of the size of ions (*i.e.*, values of C of the order of 10^{-8} cm.) this additional force will also be of practical importance.

Combining all the foregoing results and calculating the migration velocity of the central ion from the condition that the whole electric force $E(F_0+F_1)$ has to be equal to the whole frictional force R_0+R_1, we have

$$EF_0 - \frac{E^2}{6D}\frac{\rho\chi}{kT} v = \rho v + EC\chi F_0.$$

Hence it follows that the migration velocity of an ion with charge E and the frictional constant P should be represented by the formula

$$v = \frac{EF_0}{P} \frac{1 - C\chi}{1 + \frac{\rho}{P}\frac{E^2\chi}{6DkT}} = \frac{EF_0}{P}\left[1 - C\chi - \frac{\rho}{P}\frac{E^2\chi}{6DkT}\right].$$

According to this formula the correction of the migration velocity in infinite dilution is proportional to χ (the reciprocal of the radius of the ionic layer) and therefore proportional to the square root of the concentration.

In the case of a uni-univalent electrolyte, calling Λ_0 the limiting value of the molar conductivity at infinite dilution and Λ the molar conductivity at a certain small concentration, the theory leads from the above expressions for the migration velocity to the formula

$$\frac{\Lambda_0 - \Lambda}{\Lambda_0} = \left[\frac{C_1\rho_2 + C_2\rho_1}{\rho_1+\rho_2} + \frac{\rho_1^2+\rho_2^2}{2\rho_1\rho_2}\frac{\epsilon^2}{6DkT}\right]\chi$$

where ρ_1 and ρ_2 are frictional coefficients for anion and cation respectively. Substituting numerical values for solutions in water at 18°C. we have

$$\frac{\Lambda_0 - \Lambda}{\Lambda_0} = \left[0{\cdot}233 \times 10^{8}\frac{C_1\rho_2 + C_2\rho_1}{\rho_2+\rho_1} + 0{\cdot}273\frac{\rho_1^2+\rho_2^2}{2\rho_1\rho_2}\right]\sqrt{2m}.$$

It is possible to avoid the introduction of the ionic radii C_1 and C_2 by taking in accordance with Stokes formula,

$$\rho_1 = 6\pi\eta C_1, \quad \rho_2 = 6\pi\eta C_2$$

and taking η as the ordinary viscosity of the liquid. Performing this elimination gives the formula

$$\frac{\Lambda_0 - \Lambda}{\Lambda_0} = \left[\frac{1}{3\pi\eta}\frac{N\epsilon^2}{\Lambda_0} + \frac{\rho_1^2+\rho_2^2}{2\rho_1\rho_2}\frac{\epsilon^2}{6DkT}\right]\chi$$

in which $N = 6{\cdot}06 \times 10^{23}$ = Avagadro's number, or substituting numerical values,

$$\frac{\Lambda_0 - \Lambda}{\Lambda_0} = \left[\frac{35{\cdot}6}{\Lambda_0} + 0{\cdot}273\frac{\rho_1^2+\rho_2^2}{2\rho_1\rho_2}\right]\sqrt{2m}.$$

This expression can also be written in the following form which is applicable to all solvents

$$\frac{\Lambda_0 - \Lambda_c}{\Lambda_0} = \left(\frac{K_1}{D^{\frac{3}{2}}}\omega_1 + \frac{K_2}{D^{\frac{1}{2}}} b\right)\sqrt{2m},$$

where $\omega_1 = \frac{1}{2}\left(\frac{l_a}{l_c} + \frac{l_c}{l_a}\right)$, and K_1 and K_2 are universal constants varying only with the temperature l_c and l_a the mobilities of the cation and anion b the harmonic mean of the ionic radii and c the molecular concentration.

It is pointed out by Onsager (*Trans. Faraday Soc.* 1927) that on account of the Brownian movements of the central ion the

value of the additional force due to the dissymmetry of the ionic atmosphere has to be corrected. If the mobilities of the two ions are equal, his correction factor has the value $2-\sqrt{2}=0\cdot586$. Introducing this correction the theoretical expression in the case of KCl ($\rho_1=\rho_2$) becomes

$$\frac{\Lambda_0-\Lambda}{\Lambda_0}=\left[\frac{35\cdot6}{\Lambda_0}+0\cdot160\right]\sqrt{2m}$$

which gives for $\Lambda_0=129\cdot9$ the value of 0·433 for the factor which is close to its experimental value 0·461. It has been shown that these equations are in good agreement with the best conductivity data for aqueous solutions; and data compiled by H. Hartley and R. P. Bell (*Trans. Faraday Soc.*, 1927) of conductivity measurements in a large number of solvents show a general agreement in many cases with the above expressions. In other instances, however, deviations occur which appear to be due to the formation of complexes or else to lack of complete ionization of the electrolyte. In general the evidence obtained thus so far agrees so well with the theory that it seems reasonable to accept the assumption that typical strong electrolytes (salts) are practically completely dissociated at all concentrations, at least in solvents of high dielectric constant, though this theory of complete dissociation fails to cover the behaviour of those weak electrolytes which obey Ostwald's dilution law (*see* ELECTROLYSIS) just as completely as this latter law fails to cover the behaviour of highly dissociated metallic salts.

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CONDUCTION OF, IN GASES

A gas such as air when it is under normal conditions conducts electricity to a small but only to a very small extent, however small the electric force acting on the gas may be. The electrical conductivity of gases not exposed to special conditions is so small that it was only definitely established in the early years of the 20th century, although it had engaged the attention of physicists for more than a hundred years. It had been known for a long time that a body charged with electricity slowly lost its charge even when insulated with the greatest care, and though long ago some physicists believed that part of the leak of electricity took place through the air, the general view seems to have been that it was due to almost unavoidable defects in the insulation or to dust in the air, which after striking the charged body was repelled from it and went off with some of the charge. C. A. Coulomb, who made some very careful experiments which were published in 1785 (*Mém. de l'Acad. des Sciences*, 1785, p. 612), came to the conclusion that after allowing for the leakage along the threads which supported the charged body there was a balance over, which he attributed to leakage through the air. His view was that when the molecules of air come into contact with a charged body some of the electricity goes on to the molecules, which are then repelled from the body carrying their charge with them. We shall see later that this explanation is not tenable. C. Matteucci (*Ann. chim. phys.*, 1850, 28, p. 390) in 1850 also came to the conclusion that the electricity from a charged body passes through the air; he was the first to prove that the rate at which electricity escapes is less when the pressure of the gas is low than when it is high. He found that the rate was the same whether the charged body was surrounded by air, carbonic acid or hydrogen. Subsequent investigations have shown that the rate in hydrogen is in general much less than in air. Thus in 1872 E. G. Warburg (*Pogg. Ann.*, 1872, 145, p. 578) found that the leak through hydrogen was only about one-half of that through air: he confirmed Matteucci's observations on the effect of pressure on the rate of leak, and also found that it was the same whether the gas was dry or damp. He was inclined to attribute the leak to dust in the air, a view which was strengthened by an experiment of J. W. Hittorf's (*Wied. Ann.*, 1879, 7, p. 595), in which a small carefully insulated electroscope, placed in a small vessel filled with carefully filtered gas, retained its charge for several days; we know now that this was due to the smallness of the vessel and not to the absence of dust, as it has been proved that the rate of leak in small vessels is less than in large ones.

Great light was thrown on this subject by some experiments on the rates of leak from charged bodies in closed vessels made almost simultaneously by H. Geitel (*Phys. Zeit.*, 1900, 2, p. 116) and C. T. R. Wilson (*Proc. Camb. Phil. Soc.*, 1900, 11, p. 32). These observers established that (1) the rate of escape of electricity in a closed vessel is much smaller than in the open, and the larger the vessel the greater is the rate of leak; and (2) the rate of leak does not increase in proportion to the differences of potential between the charged body and the walls of the vessel: the rate soon reaches a limit beyond which it does not increase, however much the potential difference may be increased, provided, of course, that this is not great enough to cause sparks to pass from the charged body. On the assumption that the maximum leak is proportional to the volume, Wilson's experiments, which were made in vessels less than 1 litre in volume, showed that in dust-free air at atmospheric pressure the maximum quantity of electricity which can escape in one second from a charged body in a closed volume of V cubic centimetres is about $10^{-8}V$ electrostatic units.

E. Rutherford and S. T. Allan (*Phys. Zeit.*, 1902, 3, p. 225), working in Montreal, obtained results in close agreement with this. Working between pressures of from 43 to 743 millimetres of mercury, Wilson showed that the maximum rate of leak is very approximately proportional to the pressure; it is thus exceedingly small when the pressure is low—a result illustrated in a striking way by an experiment of Sir W. Crookes (*Proc. Roy. Soc.*, 1879, 28, p. 347) in which a pair of gold leaves retained an electric charge for several months in a very high vacuum. Subsequent experiments have shown that it is only in very small vessels that the rate of leak is proportional to the volume and to the pressure; in large vessels the rate of leak per unit volume is considerably smaller than in small ones. In small vessels the maximum rate of leak in different gases, is, with the exception of hydrogen, approximately proportional to the density of the gas. Wilson's results on this point are shown in the following table (*Proc. Roy. Soc.*, 1901, 60, p. 277):—

Gas	Relative rate of leak	*Rate of leak* / Sp.Gr.
Air	1·00	1
H_2	·184	2·7
CO_2	1·69	1·10
SO_2	2·64	1·21
CH_3Cl	4·7	1·09
$Ni(CO)_4$	5·1	·867

The rate of leak of electricity through gas contained in a closed vessel depends to some extent on the material of which the walls of the vessel are made; thus it is greater, other circumstances being the same, when the vessel is made of lead than when it is made of aluminium. It also varies, as Campbell and Wood (*Phil. Mag.* [6], 13, p. 265) have shown, with the time of the day, having a well-marked minimum at about 3 o'clock in the morning: it also varies from month to month. Rutherford (*Phys. Rev.*, 1903, 16, p. 183), Cooke (*Phil. Mag.*, 1903 [6], 6, p. 403) and M'Clennan and Burton (*Phys. Rev.*, 1903, 16, p. 184) have shown that the leak in a closed vessel can be reduced by about 30% by surrounding the vessel with sheets of thick lead, but that the reduction is not increased beyond this amount, however thick the lead sheets may be. This result indicates that part of the leak is due to a very penetrating kind of radiation, which can get through the thin walls of the vessel but is stopped by the thick lead. A large part of the leak we are describing is due to the presence of radioactive substances such as radium and thorium in the earth's crust and in the walls of the vessel, and to the gaseous radioactive emanations which diffuse from them into the atmosphere. This explains the very interesting effect discovered by J. Elster and H. Geitel (*Phys. Zeit.*, 1901, 2, p. 560), that the rate of leak in caves and cellars when the air is stagnant and only renewed slowly is much greater than in the open air.

In some cases the difference is very marked; thus they found that in the cave called the Baumannshöhle in the Harz mountains the electricity escaped at seven times the rate it did in the air outside. In caves and cellars the radioactive emanations from the walls can accumulate and are not blown away as in the open air.

The conductivity of normal air arises from several causes; part of it may be due to the presence of radioactive substances in the walls of the vessel in which the gas is contained, or to a little radioactive emanation in the gas itself. The conductivity is so small that a mere trace of radioactive substances or of radioactive properties in ordinary matter would be sufficient to account for it. The metal of the containing vessel has certainly a considerable effect on the conductivity of the gas inside; this may, however, be due not to an intrinsic radiation of the metal but to a radiation excited by the passage through the metal of a very penetrating radiation for the existence of which there is strong evidence. That the intrinsic radioactivity of the metal and gas cannot be the sole cause of the conductivity is shown by experiments like that made by M'Clennan (*Phil. Mag.*, v. 24, p. 520, 1912), who measured the conductivity in a hermetically sealed vessel in Canada, England and Scotland and on board a steamship in the Atlantic; he found that the conductivity was much the same at the different land stations, and could be represented by the production of about 9 ions per c.c. of the gas per sec., but that the conductivity over the sea was considerably less, and was equivalent to only 6 ions per c.c. per sec. This indicates that some of the conductivity of the gas is due to radiation coming from the land, and that this radiation is cut off by the ocean. This is confirmed by the fact discovered by M'Clennan and M'Collum (*Phil. Mag.*, vi. 22, p. 629, 1911), Wulf (*Phys. Tech.* xi. p. 811) and Bergwitz (*Hahlibakonschrift,* Brunswick, 1910) that at the top of high towers the conductivity is less than on the ground; this is what we should expect since the radiation is absorbed by the atmosphere. Observations on the conductivity of the air in vessels taken up in balloons by Gockel (*Phys. Zeit.*, x. p. 845, 1909; xii. p. 595, 1911), Hess (*Phys. Zeit.*, xii. p. 998, 1911), and especially by Kolhörster (*Phys. Zeit.*, xiv. pp. 1066, 1153, 1913, *Deutsch. Phys. Gesell. Verh.*, xvi. 14, p. 719, 1914) have brought to light the very interesting fact that the diminution in the conductivity with height ceases when the height exceeds some two kilometres and at greater altitudes is succeeded by an *increase* in conductivity with altitude.

Kolhörster found that at the height of nine kilometres the conductivity in a sealed vessel was some ten times that at the surface of the earth. These variations of the conductivity with the height are what would occur if the conductivity were produced by radiations of two different types (1) a radiation coming from the ground and (2) another coming from the sky. The effects due to (1) would diminish as the height increased while that due to (2) would increase. Estimates of the amount of conductivity due to (2) at the surface of the earth have been made by various observers, and it would seem that it may be represented by the production of about 1·5 ions per c.c. per sec.; as the conductivity at sea-level generally requires the production of from 10–20 ions per c.c. per sec.; much the greater part of the conductivity at the earth's surface must be due to radiation of type 1. Millikan and Bowen give the following results for the conductivity due to radiation of type 2 at different altitudes, the numbers being the number of ions produced per c.c. per sec.: 1·4 at sea-level, 2·6 at 1,600 metres, 4·8 at 1,600 metres, 5·9 at 4,300 metres. Kolhörster (Berlin, *Berichte*, 1923, p. 366) by making observations at the surface, and in caverns of glaciers on the Jungfrau, measured the absorption of these rays by ice, and found an absorption coefficient of about 2·5 per metre; this is much smaller than that of the γ radiation from any known radioactive substance. He found a diurnal variation in the amount of the radiation and suggested that it might be connected with the Milky Way.

Many observations on this radiation have been made by Millikan and his collaborators (*Nature*, Jan. 7, 1928), who have measured the conductivity in vessels submerged at different depths in two mountain lakes on Mount Whitney. Lake Muir, at an altitude of 11,800 ft., and Arrowhead lake at an altitude of 5,100. These lakes are fed by melted snow so that the water is not likely to contain radioactive matter. It appears from these measurements that the radiation is by no means homogeneous, as the absorption coefficient was greater at the surface of the lake than at the greatest depth at which observations were taken. No trace of the diurnal effect observed by Kolhörster was detected. It was found, too, from observations made in the southern hemisphere on the Andes in Bolivia, that both the character and the amount of the radiation was much the same in the two hemispheres, indicating that the radiation comes pretty uniformly from all parts of the heavens. Applying an expression due to Compton for the connection between the absorption and wave-length it was found that the wave length of the most penetrating radiation was ·00038 Å; the quantum of energy corresponding to this wave-length is about 32 million volts. This is much greater than the energy associated with any known γ radiation. Many suggestions have been made as to its origin. Jeans and Eddington have suggested that it arises from the coalescence of an electron with a positive particle and the conversion of their energy and mass into those of radiation; this would give a radiation more penetrating than that found though it might be degraded by passing through matter. C. T. R. Wilson has suggested the possibility of the radiation being excited by electrons which have acquired energy amounting to millions of volts under the action of something analogous to thunderstorms. This is in accordance with the laws which govern the passage of electrons through gases but Millikan finds no difference in the amount of radiation in regions where thunderstorms are frequent and in those where they are rare. We do not know enough at present about these rays to decide either as to their nature or the place of their origin; it is evident, however, that they raise questions of the greatest interest and importance.

The electrical conductivity of gases in the normal state is, as we have seen, exceedingly small, so small that the investigation of its properties is a matter of considerable difficulty; there are, however, many ways by which the electrical conductivity of a gas can be increased so greatly that the investigation becomes comparatively easy. Gases drawn from the neighbourhood of flames, electric arcs and sparks, or glowing pieces of metal or carbon are conductors, as are also gases through which Röntgen or cathode rays or rays of positive electricity are passing; the rays from the radioactive metals, radium, thorium, polonium and actinium, produce the same effect, as does also ultra-violet light of exceedingly short wave-length. The gas, after being made a conductor of electricity by any of these means, is found to possess certain properties; thus it retains its conductivity for some little time after the agent which made it a conductor has ceased to act; the conductivity, however, diminishes very rapidly and finally gets too small to be appreciable.

This and several other properties of conducting gas may readily be proved by the aid of the apparatus represented in fig. 1. V is a testing vessel in which an electroscope is placed. Two tubes A and C are fitted into the vessel, A being connected with a water pump, while the far end of C is in the region where the gas is exposed to the agent, which makes it a conductor of electricity. Let us suppose that the gas is made conducting by Röntgen rays produced by a vacuum tube which is placed in a box, covered except for a window at B with lead so as to protect the electroscope from the direct action of the rays. If a slow current of air is drawn by the water pump through the testing vessel, the charge on the electroscope will gradually leak away. The leak, however, ceases when the current of air is stopped. This result shows that the gas retains its conductivity during the time taken by it to pass from one end to the other of the tube C.

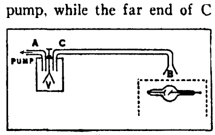

FIG. 1

The gas loses its conductivity when filtered through a plug of glass-wool, or when it is made to bubble through water. This can readily be proved by inserting in the tube C a plug of glass-wool or a water trap; then if by working the pump a little harder

the same current of air is produced as before, it will be found that the electroscope will now retain its charge, showing that the conductivity can, as it were, be filtered out of the gas. The conductivity can also be removed from the gas by making the gas traverse a strong electric field. We can show this by replacing the tube C by a metal tube with an insulated wire passing down the axis of the tube. If there is no potential difference between the wire and the tube then the electroscope will leak when a current of air is drawn through the vessel, but the leak will stop if a considerable difference of potential is maintained between the wire and the tube: this shows that a strong electric field removes the conductivity from the gas.

The fact that the conductivity of the gas is removed by filtering shows that it is due to something mixed with the gas which is removed from it by filtration, and since the conductivity is also removed by an electric field, the cause of the conductivity must be charged with electricity so as to be driven to the sides of the tube by the electric force. Since the gas as a whole is not electrified either positively or negatively, there must be both negative and positive charges in the gas, the amount of electricity of one sign being equal to that of the other. We are thus led to the conclusion that the conductivity of the gas is due to electrified particles being mixed up with the gas, some of these particles having charges of positive electricity, others of negative. These electrified particles are called *ions*, and the process by which the gas is made a conductor is called the ionization of the gas. We shall show later that the charges and masses of the ions can be determined, and that the gaseous ions are not identical with those met with in the electrolysis of solutions.

One very characteristic property of conduction of electricity through a gas is the relation between the current through the gas and the electric force which gave rise to it. This relation is not in general that expressed by Ohm's law, which always, as far as our present knowledge extends, expresses the relation for conduction through metals and electrolytes. With gases, on the other hand, it is only when the current is very small that Ohm's law is true. If we represent graphically by means of a curve the relation between the current passing between two parallel metal plates separated by ionized gas and the difference of potential between the plates, the curve is of the character shown in fig. 2, when the ordinates represent the current and the abscissae the difference of potential between the plates. We see that when the potential difference is very small, *i.e.*, close to the origin, the curve is approximately straight, but that soon the current increases much less rapidly than the potential difference, and that a stage is reached when no appreciable increase of current is produced when the potential difference is increased; when this stage is reached the current is constant, and this value of the current is called the "saturation" value. When the potential difference approaches the value at which sparks would pass through the gas, the current again increases with the potential difference; thus the curve representing the relation between the current and potential difference over very wide ranges of potential difference has the shape shown in fig. 3; curves of this kind have been obtained by von Schweidler (*Wien. Ber.*, 1899, 108, p. 273), and J. E. S. Townsend (*Phil. Mag.*, 1901 [6], 1, p. 198). We shall discuss later the causes of the rise in the current with large potential differences, when we consider ionization by collision.

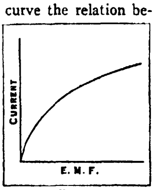

FIG. 2

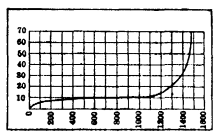

FIG. 3

The general features of the earlier part of the curve are readily explained on the ionization hypothesis. On this view the Röntgen rays or other ionizing agent acting on the gas between the plates, produces positive and negative ions at a definite rate. Let us suppose that q positive and q negative ions are by this means produced per second between the plates; these under the electric force will tend to move, the positive ones to the negative plate, the negative ones to the positive. Some of these ions will reach the plate, others before reaching the plate will get so near one of the opposite sign that the attraction between them will cause them to unite and form an electrically neutral system; when they do this they end their existence as ions. The current between the plates is proportional to the number of ions which reach the plates per second. Now it is evident that we cannot go on taking more ions out of the gas than are produced; thus we cannot, when the current is steady, have more than q positive ions driven to the negative plate per second, and the same number of negative ions to the positive. If each of the positive ions carries a charge of e units of positive electricity, and if there is an equal and opposite charge on each negative ion, then the maximum amount of electricity which can be given to the plates per second is qe, and this is equal to the saturation current. Thus if we measure the saturation current, we get a direct measure of the ionization, and this does not require us to know the value of any quantity except the constant charge on the ion. If we attempted to deduce the amount of ionization by measurements of the current before it was saturated, we should require to know in addition the velocity with which the ions move under a given electric force, the time that elapses between the liberation of an ion and its combination with one of the opposite sign, and the potential difference between the plates. Thus if we wish to measure the amount of ionization in a gas we should be careful to see that the current is saturated.

The difference between conduction through gases and through metals is shown in a striking way when we use potential differences large enough to produce the saturation current. Suppose we have got a potential difference between the plates more than sufficient to produce the saturation current, and let us increase the distance between the plates. If the gas were to act like a metallic conductor this would diminish the current, because the greater length would involve a greater resistance in the circuit. In the case we are considering the separation of the plates will *increase* the current, because now there is a larger volume of gas exposed to the rays; there are therefore more ions produced, and as the saturation current is proportional to the number of ions the saturation current is increased. If the potential difference between the plates were much less than that required to saturate the current, then increasing the distance would diminish the current; the gas for such potential differences obeys Ohm's law and the behaviour of the gaseous resistance is therefore similar to that of a metallic one.

In order to produce the saturation current the electric field must be strong enough to drive each ion to the electrode before it has time to enter into combination with one of the opposite sign. Thus when the plates in the preceding example are far apart, it will take a larger potential difference to produce this current than when the plates are close together. The potential difference required to saturate the current will increase as the square of the distance between the plates, for if the ions are to be delivered in a given time to the plates their speed must be proportional to the distance between the plates. But the speed is proportional to the electric force acting on the ion; hence the electric force must be proportional to the distance between the plates, and as in a uniform field the potential difference is equal to the electric force multiplied by the distance between the plates, the potential difference will vary as the square of this distance.

The potential difference required to produce saturation will, other circumstances being the same, increase with the amount of ionization, for when the number of ions is large and they are crowded together, the time which will elapse before a positive one combines with a negative will be smaller than when the number of ions is small. The ions have therefore to be removed more quickly from the gas when the ionization is great than when it is small; thus they must move at a higher speed and must therefore be acted upon by a larger force.

When the ions are not removed from the gas, they will increase until the number of ions of one sign which combine with ions of

the opposite sign in any time is equal to the number produced by the ionizing agent in that time. We can easily calculate the number of free ions at any time after the ionizing agent has commenced to act.

Coefficient of Recombination.—Let q be the number of ions (positive or negative) produced in one cubic centimetre of the gas per second by the ionizing agent, n_1, n_2, the number of free positive and negative ions respectively per cubic centimetre of the gas. The number of collisions between positive and negative ions per second in one cubic centimetre of the gas is proportional to n_1n_2. If a certain fraction of the collisions between the positive and negative ions result in the formation of an electrically neutral system, the number of ions which disappear per second in a cubic centimetre will be equal to $\alpha n_1, n_2$, where α is a quantity which is independent of n_1, n_2; hence if t is the time since the ionizing agent was applied to the gas, we have

$$dn_1/dt = q - \alpha n_1 n_2,\ dn_2/dt = q - \alpha n_1 n_2.$$

Thus $n_1 - n_2$ is constant, so if the gas is uncharged to begin with, n_1 will always equal n_2. Putting $n_1 = n_2 = n$ we have

$$dn/dt = q - \alpha n^2 \qquad (1),$$

the solution of which is, since $n = 0$ when $t = 0$,

$$n = \frac{k(\epsilon^{2k\alpha t} - 1)}{\epsilon^{2k\alpha t} + 1} \qquad (2),$$

if $k^2 = q/\alpha$. Now the number of ions when the gas has reached a steady state is got by putting t equal to infinity in the preceding equation, and is therefore given by the equation

$$n_0 = k = \sqrt{(q/\alpha)}.$$

We see from equation (2) that the gas will not approximate to its steady state until $2k\alpha t$ is large, that is until t is large compared with $1/2k\alpha$ or with $1/2\sqrt{(q\alpha)}$. We may thus take $1/2\sqrt{(q\alpha)}$ as a measure of the time taken by the gas to reach a steady state when exposed to an ionizing agent; as this time varies inversely as $\sqrt{q}$ we see that when the ionization is feeble it may take a very considerable time for the gas to reach a steady state. Thus in the case of our atmosphere where the production of ions is only at the rate of about 30 per cubic centimetre per second, and where, as we shall see, α is about 10^{-6}, it would take some minutes for the ionization in the air to get into a steady state if the ionizing agent were suddenly applied.

We may use equation (1) to determine the rate at which the ions disappear when the ionizing agent is removed. Putting $q = 0$ in that equation we get $dn/\alpha t = \alpha n^2$.

Hence
$$n = n_0/(1 + n_0\alpha t) \qquad (3),$$

where n_0 is the number of ions when $t = 0$. Thus the number of ions falls to one-half its initial value in the time $1/n_0\alpha$. The quantity α is called the *coefficient of recombination*, and its value for different gases has been determined by Rutherford (*Phil. Mag.* 1897 [5], 44, p. 422), Townsend (*Phil. Trans.*, 1900, 193, p. 129), McClung (*Phil. Mag.*, 1902 [6], 3, p. 283), Langevin (*Ann. chim. phys.* [7], 28, p. 289), Retschinsky (*Ann. d. Phys.*, 1905, 17, p. 518), Hendred (*Phys. Rev.* 1905, 21, p. 314), Rümelin (*Phys. Zeits.*, ix. p. 657, 1908), Thirkill (*Proc. Roy. Soc.*, 87, p. 477, 1913), Erikson (*Phil. Mag.*, vi. 18 p. 328, 1909; 23, p. 747, 1912). The values of α/e, e being the charge on an ion in electrostatic measure as determined by these observers for different gases, is given in the following table:—

	Townsend	McClung	Langevin	Retschinsky	Hendred
Air	3,420	3,380	3,200	4,140	3,500
O_2	3,380	..	..	..	..
CO_2	3,500	3,490	3,400	..	..
H_2	3,020	2,940	..	..	..

The gases in these experiments were carefully dried and free from dust; the apparent value of α is much increased when dust or small drops of water are present in the gas, for then the ions get caught by the dust particles, the mass of a particle is so great compared with that of an ion that they are practically immovable under the action of the electric field, and so the ions clinging to them escape detection when electrical methods are used. Taking e as 4.77×10^{-10}, we see that α is about 1.6×10^{-6}, so that the number of recombinations in unit time between n positive and n negative ions in unit volume is $1.6 \times 10^{-6} n^2$. The kinetic theory of gases shows that with $2n$ molecules of air per cubic centimetre the number of collisions per second is $4 \times 10^{-10} n^2$ at a temperature of 0° C. Thus we see that the number of recombinations between oppositely charged ions is enormously greater than the number of collisions between the same number of neutral molecules. We shall see that the difference in size between the ion and the molecule is not nearly sufficient to account for the difference between the collisions in the two cases; the difference is due to the force between the oppositely charged ions, which drags ions into collisions which but for this force would have missed each other.

Several methods have been used to measure α. In one method air, exposed to some ionizing agent at one end of a long tube, is slowly sucked through the tube and the saturation current measured at different points along the tube. These currents are proportional to the values of n at the place of observation: if we know the distance of this place from the end of the tube when the gas was ionized and the velocity of the stream of gas, we can find t in equation (3), and knowing the value of n we can deduce the value of α from the equation

$$1/n_1 - 1/n_2 = \alpha(t_1 - t_2),$$

where n_1 n_2 are the values of n at the times t_1, t_2 respectively. In this method the tubes ought to be so wide that the loss of ions by diffusion to the sides of the tube is negligible. This method does not involve the mobility of the ions, *i.e.*, the speed they acquire under electric forces. Another method which has the same advantage is due to Rümelin. In this the gas is exposed continuously to the ionizing agent, while the electric field is applied to the gas by means of a rotating sector and is adjusted so as to be *zero* during one part of the revolution of the sector and great enough to produce saturation during the remainder. The current sent through the gas by this field is measured and from it the value of α can be calculated. There are other methods which involve the knowledge of the mobility of the ions; we shall defer the consideration of these methods until we have discussed this question.

In measuring the value of α it should be remembered that the theory of the methods supposes that the ionization is uniform throughout the gas. If the total ionization throughout a gas remains constant, but instead of being uniformly distributed is concentrated in patches, it is evident that the ions will recombine more quickly in the second case than in the first, and that the value of α will be different in the two cases. This probably explains the large values of α obtained by Retschinsky, who ionized the gas by the α rays from radium, a method which produces very patchy ionization.

Variation of α with the Pressure of the Gas.—This question was first investigated by Langevin (*Ann. Chem. Phys.*, 1903, 28, p. 287) who found that at low pressures α was less than at high, thus at the pressure of one-fifth of an atmosphere the value of α for air was about one-fifth of that at atmospheric pressure. He showed, too, that the value of α reached a maximum at a certain pressure—for air about two atmospheres— and fell away fairly rapidly with any further increase in pressure. A very valuable investigation of the effect of pressure on the value of α was made by Thirkill (*Proc. Roy. Soc.*, 88, p. 477, 1913), who showed that for pressures not exceeding one atmosphere α is very approximately a linear function of the pressure, the gases he investigated were air, carbon dioxide, carbon monoxide, sulphur dioxide and nitrous oxide.

Variation of α with Temperature.—The variation of α with temperature has been investigated for air, carbonic acid and hydrogen at constant density when ionized by α rays by Erikson (*Phil. Mag.*, vi. 18, p. 328, 1909; 23, p. 747, 1912) and for air at constant pressure ionized by X-rays by Phillips (*Proc. Roy. Soc.* A. 83, p. 246, 1910). It was found that over a very wide range of temperature α for hydrogen can be repre-

sented by a formula of the type $\alpha = C\theta^{-n}$ when θ is the absolute temperature and C a constant, and though such a formula does not hold for air and carbonic acid at temperatures much below 0° C, it represents the value of α with fair accuracy at higher temperatures. Erikson's experiments give $n = 2{\cdot}42$, $2{\cdot}35$, $2{\cdot}30$, for air, carbonic acid and hydrogen respectively, while Phillips (at constant pressure) finds $n = 2$.

Diffusion of the Ions.—The ionized gas acts like a mixture of gases, the ions corresponding to two different gases, the non-ionized gas to a third. If the concentration of the ions is not uniform, they will diffuse through the non-ionized gas in such a way as to produce a more uniform distribution. A very valuable series of determinations of the coefficient of diffusion of ions through various gases has been made by Townsend (*Phil. Trans.*, 1900, A, 193, p. 129). The method used was to suck the ionized gas through narrow tubes; by measuring the loss of both the positive and negative ions after the gases had passed through a known length of tube, and allowing for the loss by recombination, the loss by diffusion and hence the coefficient of diffusion could be determined. Salles, Franck and Westphal have used similar methods. Salles found that the material of which the tubes are made has no influence on the diffusion. The following tables give the values of the coefficients of diffusion D on the C.G.S. system of units.

Gas	*D* for +ions	*D* for −ions	Author
Air, dry	·028	·043	Townsend
,, ,,	·032	·042	Salles
,, ,,	·029	·045	Franck and Westphal
,, moist	·032	·035	Townsend
Oxygen, dry	·025	·0396	Townsend
,, ,,	·030	·041	Salles
,, moist	·0288	·0358	Townsend
Carbon dioxide, dry	·023	·026	Townsend
,, ,, ,,	·025	·026	Salles
,, ,, moist	·0245	·0255	Townsend
Hydrogen, dry	·123	·190	Townsend
,, moist	·128	·142	Townsend
Nitrogen, dry	·029	·0414	Salles

It is interesting to compare with these coefficients the values of D when various gases diffuse through each other. D for hydrogen through air is ·634, for oxygen through air ·177, for the vapour of isobutyl amide through air ·042. We thus see that the velocity of diffusion of ions through air is much less than that of the simple gas, but that it is quite comparable with that of the vapours of some complex organic compounds.

The preceding tables show that the negative ions diffuse more rapidly than the positive, especially in dry gases. The superior mobility of the negative ions was observed first by Zeleny (*Phil. Mag.*, 1898 [5], 46, p. 120), who showed that the velocity of the negative ions under an electric force is greater than that of the positive. It will be noticed that the difference between the mobility of the negative and the positive ions is much more pronounced in dry gases than in moist. The difference in the rates of diffusion of the positive and negative ions is the reason why ionized gas, in which, to begin with, the positive and negative charges were of equal amounts, sometimes becomes electrified even although the gas is not acted upon by electric forces. Thus, for example, if such gas be blown through narrow tubes, it will be positively electrified when it comes out, for since the negative ions diffuse more rapidly than the positive, the gas in its passage through the tubes will lose by diffusion more negative than positive ions and hence will emerge positively electrified. Zeleny showed that this effect does not occur when, as in carbonic acid gas, the positive and negative ions diffuse at the same rates. Townsend (*loc. cit.*) showed that the coefficient of diffusion of the ions is the same whether the ionization is produced by Röntgen rays, radioactive substances, ultra-violet light, or electric sparks. The ions produced by chemical reactions and in flames are much less mobile; thus, for example, Bloch (*Ann. chim. phys.*, 1905 [8], 4, p. 25) found that for the ions produced by drawing air over phosphorus the value of α/e was between 1 and 6 instead of over 3,000, the value when the air was ionized by Röntgen rays.

Velocity of Ions in an Electric Field.—The velocity of ions in an electric field, which is of fundamental importance in conduction, is very closely related to the coefficient of diffusion. Measurements of this velocity for ions produced by Röntgen rays have been made by Rutherford (*Phil. Mag.* [5], 44, p. 422), Zeleny (*Phil. Mag.* [5], 46, p. 120), Langevin (*Ann. Chim. Phys.*, 1903, 28, p. 289), Phillips (*Proc. Roy. Soc.* 78, A, p. 167), and Wellisch (*Phil. Trans.*, 1909, 209, p. 249). The ions produced by radioactive substance have been investigated by Rutherford (*Phil. Mag.* [5], 47, p. 109) and by Franck and Pohl (*Verh. deutsch. phys. Gesell.*, 1907, 9 p. 69), Tyndall and Grindley (*Proc. Roy. Soc.*, A, 110, p. 341; Laporte, C.R. 172, p. 1028, 1921; 182, pp. 620–781, 1926; 183, pp. 119–287), and the negative ions produced when ultra-violet light falls on a metal plate by Rutherford (*Proc. Camb. Phil. Soc.* 9, p. 401), Townsend and Tizard (*Proc. Roy. Soc.*, A, 87, p. 357, 1912), H. A. Wilson (*Phil. Trans.* 192, p. 409), Marx (*Ann. de Phys.* 11, p. 765); Moreau (*Journ. de Phys.* 4, 11, p. 558; *Ann. Chim. Phys.* 7, 30, p. 5) and Gold (*Proc. Roy. Soc.* 79, p. 43) have investigated the velocities of ions produced by putting various salts into flames; McClelland (*Phil. Mag.* 46, p. 29) the velocity of the ions in gases sucked from the neighbourhood of flames and arcs; Townsend (*Proc. Camb. Phil. Soc.* 9, p. 345) and Bloch (*loc. cit.*) the velocity of ions produced by chemical reaction; and Chattock (*Phil. Mag.* [5], 48, p. 401) and Franck (*Ann. der. Phys.*, 21, p. 972, 1908), the velocity of the ions produced when electricity escapes from a sharp needle point into a gas. Though so much work has been done on the mobility of the ions there are many points which are still unsettled. The experiments of the earlier observers were more discordant than could be accounted for by errors of observation; in some cases, indeed, they were contradictory. We know now that the mobility of the ions is profoundly affected by causes which at first sight appear trivial and may well have escaped specification in the earlier experiments. One of these causes is the age of the ions, the mobility of a freshly formed ion is often greater than that of an older one, a fact brought out clearly by Erikson's experiments; thus since the age of the ion influences its mobility, observers would obtain different results unless by chance it happened that the time which elapsed between the formation of the ion and the time that it came under observation was the same in the two cases. Another reason for the want of agreement is that, as we shall see, minute traces of an impurity in the gas may produce very large effects on the mobility.

Several methods have been employed to determine these velocities. The one most frequently employed is to find the electromotive intensity required to force an ion against the stream of gas moving with a known velocity parallel to the lines of electric force. Thus, of two perforated plane electrodes vertically over each other, suppose the lower to be positively, the upper negatively electrified, and suppose that the gas is streaming vertically downwards with the velocity V; then unless the upward velocity of the positive ion is greater than V, no positive electricity will reach the upper plate. If we increase the strength of the field between the plates, and hence the upward velocity of the positive ion, until the positive ions just begin to reach the upper plate, we know that with this strength of field the velocity of the positive ion is equal to V. By this method, which has been used by Rutherford, Zeleny, H. A. Wilson and Erikson the velocity of ions in fields of various strengths has been determined.

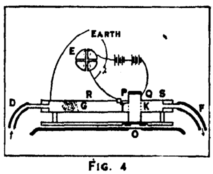

FIG. 4

The arrangement used by Zeleny is represented in fig. 4. P and Q are square brass plates. They are bored through their centres, and to the openings the tubes R and S are attached, the space between the plates being covered in so as to form a closed box. K is a piece of wire gauze completely covering the opening in Q; T is an insulated piece of wire gauze nearly but not quite filling the opening in the plate P, and connected with one pair of quadrants of an electrometer E. A plug of glass wool G filters

out the dust from a stream of gas which enters the vessel by the tube D and leaves it by F; this plug also makes the velocity of the flow of the gas uniform across the section of the tube. The Röntgen rays to ionize the gas were produced by a bulb at O, the bulb and coil being in a lead-covered box, with an aluminium window through which the rays passed. Q is connected with one pole of a battery of cells, P and the other pole of the battery are put to earth. The changes in the potential of T are due to ions giving up their charges to it. With a given velocity of air-blast the potential of T was found not to change unless the difference of potential between P and Q exceeded a critical value. The field corresponding to this critical value thus made the ions move with the known velocity of the blast.

Another method which has been employed by Rutherford and McClelland is based on the action of an electric field in destroying the conductivity of gas streaming through it. Suppose that BAB, DCD (fig. 5) are a system of parallel plates boxed so that a stream of gas, after flowing between BB, passes between DD without loss of gas in the interval. Suppose the plates DD

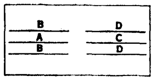

FIG. 5

are insulated, and connected with one pair of quadrants of an electrometer, by charging up C to a sufficiently high potential we can drive all the positive ions which enter the system DCD against the plates D; this will cause a deflexion of the electrometer, which in one second will be proportional to the number of positive ions which have entered the system in that time. If we charge A up to a high potential, B being put to earth, we shall find that the deflexion of the electrometer connected with DD is less than it was when A and B were at the same potential, because some of the positive ions in their passage through BAB are driven against the plates B. If u is the velocity along the lines of force in the uniform electric field between A and B, and t the time it takes for the gas to pass through BAB, then all the positive ions within a distance ut of the plates B will be driven up against these plates, and thus, if the positive ions are equally distributed through the gas, the number of positive ions which emerge from the system when the electric field is on will bear to the number which emerge when the field is off the ratio of $1-ut/l$ to unity, where l is the distance between A and B. This ratio is equal to the ratio of the deflexions in one second of the electrometer attached to D, hence the observations of this instrument give $1-ut/l$. If we know the velocity of the gas and the length of the plates A and B, we can determine t, and since l can be easily measured, we can find u, the velocity of the positive ion in a field of given strength. By charging A and C negatively instead of positively we can arrive at the velocity of the negative ion. In practice it is more convenient to use cylindrical tubes with coaxial wires instead of the systems of parallel plates, though in this case the calculation of the velocity of the ions from the observations is a little more complicated, inasmuch as the electric field is not uniform between the tubes.

A method which gives very accurate results, though it is only applicable in certain cases, is the one used by Rutherford to measure the velocity of the negative ions produced close to a metal plate by the incidence on the plate of ultra-violet light.

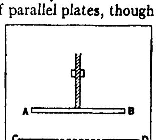

FIG. 6

The principle of the method is as follows:—AB (fig. 6) is an insulated horizontal plate of well-polished zinc, which can be moved vertically up and down by means of a screw; it is connected with one pair of quadrants of an electrometer, the other pair of quadrants being put to earth. CD is a base-plate with a hole EF in it; this hole is covered with fine wire gauze, through which ultraviolet light passes and falls on the plate AB. The plate CD is connected with an alternating current dynamo, which produces a simply-periodic potential difference between AB and CD, the other pole being put to earth. Suppose that at any instant the plate CD is at a higher potential than AB, then the negative ions from AB will move towards CD, and will continue to do so as long as the potential of CD is higher than that of AB. If, however, the potential difference changes sign before the negative ions reach CD, these ions will go back to AB. Thus AB will not lose any negative charge unless the distance between the plates AB and CD is less than the distance traversed by the negative ion during the time the potential of CD is higher than that of AB. By altering the distance between the plates until CD just begins to lose a negative charge, we find the velocity of the negative ion under unit electromotive intensity. Suppose the difference of potential between AB and CD is equal to $a \sin pt$, then if d is the distance between the plates the electric intensity is equal to $a \sin pt/d$; if we suppose the velocity of the ion is proportional to the electric intensity; and if u is the velocity for unit electric intensity, the velocity of the negative ion will be $ua \sin pt/d$. Hence if x represent the distance of the ion from AB

$$\frac{dx}{dt} = \frac{ua}{d}\sin pt$$

$$x = \frac{ua}{pd}(1-\cos pt), \text{ if } x=0 \text{ when } t=0.$$

Thus the greatest distance the ion can get from the plate is equal to $2au/pd$, and, if the distance between the plates is gradually reduced to this value, the plate AB will begin to lose a negative charge; hence when this happens

$$d=2au/pd, \quad \text{or } u=pd^2/2a,$$

an equation by means of which we can find u.

Instead of using a harmonically varying field we may by a rotating commutation apply a constant force for a certain time and then reverse the force taking care that the time it is applied after reversal is longer than the other time. Unless the ion can travel across the distance between the plates before the field is reversed the electrometer will not receive a charge; this gives the means of finding the mobility of the ions.

In this form the method is not applicable when ions of both signs are present. Franck and Pohl (*Verh. deutsch. physik. Gesell.* 1907, 9 p. 69) have by a slight modification removed this restriction. The modification consists in confining the ionization to a layer of gas below the gauze EF. If the velocity of the positive ions is to be determined, these ions are forced through the gauze by applying to the ionized gas a small constant electric force acting upwards; if negative ions are required, the constant force is reversed. After passing through the gauze the ions are acted upon by alternating forces as in Rutherford's method. Loeb (*Phys. Review*, XXI., p. 720, 1923) has shown that the disturbance of the electric field due to spreading of the lines of force due to the subsidiary field through the gauze may involve serious corrections to the simple theory.

Langevin (*Ann. chim. phys.*, 1903, 28, p. 289) devised a method of measuring the velocity of the ions which has been extensively used; it has the advantage of not requiring the rate of ionization to remain uniform. The general idea is as follows. Suppose that we expose the gas between two parallel plates A, B, to Röntgen rays or some other ionizing agent, then stop the rays and apply a uniform electric field to the region between the plates. If the force on the positive ion is from A to B, the plate B will receive a positive charge of electricity. After the electric force has acted for a time T reverse it. B will now begin to receive negative electricity and will go on doing so until the supply of negative ions is exhausted. Let us consider how the quantity of positive electricity received by B will vary with T. To fix our ideas, suppose the positive ions move more slowly than the negative; let T_2 and T_1 be respectively the times taken by the positive and negative ions to move under the electric field through a distance equal to AB, the distance between the planes. Then if T is greater than T_2 all the ions will have been driven from between the plates before the field is reversed, and therefore the positive charge received by B will not depend upon T. Next let T be less than T_2 but greater than T_1; then at the time when the field is reversed all the negative ions will have been driven from between the plates, so that the positive charge received by B will not be neutralized by the arrival of fresh ions coming to it after the reversal of the field. The number of positive ions driven against the plate

B will be proportional to T. Thus if we measure the value of the positive charge on B for a series of values of T, each value being less than the preceding, we shall find that until T reaches a certain value the charge remains constant, but as soon as we reduce the time below this value the charge diminishes. The value of T when the diminution in the field begins is T_2, the time taken for a positive ion to cross from A to B under the electric field; thus from T_2 we can calculate the velocity of the positive ion in this field. If we still further diminish T, we shall find that we reach a value when the diminution of the positive charge on B with the time suddenly becomes much more rapid; this change occurs when T falls below T_1 the time taken for the negative ions to go from one plate to the other, for now when the field is reversed there are still some negative ions left between the plates, and these will be driven against B and rob it of some of the positive charge it had acquired before the field was reversed. By observing the time when the increase in the rate of diminution of the positive charge with the time suddenly sets in we can determine T_1, and hence the velocity of the negative ions.

The velocity of the ions produced by the discharge of electricity from a fine point was determined by Chattock by an entirely different method. In this case the electric field is so strong and the velocity of the ion so great that the preceding methods are not applicable. Suppose P represents a vertical needle discharging electricity into air, consider the force acting on the ions included between two horizontal planes A, B. If P is the density of the electrification, and Z the vertical component of the electric intensity, F, the resultant force on the ions between A and B, is vertical and equal to

$$\iiint Z\rho\,dx\,dy\,dz.$$

Let us suppose that the velocity of the ion is proportional to the electric intensity, so that if w is the vertical velocity of the ions, which are supposed all to be of one sign, $w=RZ$.

Substituting this value of Z, the vertical force on the ions between A and B is equal to

$$\frac{1}{R}\iiint w\rho\,dx\,dy\,dz.$$

But $\iint wp\,dx\,dy=\iota$, where ι, is the current streaming from the point. This current, which can be easily measured by putting a galvanometer in series with the discharging point, is independent of z, the vertical distance of a plane between A and B below the charging point. Hence we have

$$F=\frac{\iota}{R}\int dz=\frac{\iota}{R}.z.$$

This force must be counterbalanced by the difference of gaseous pressures over the planes A and B; hence if p_B and p_A denote respectively the pressures over B and A, we have

$$p_B-p_A=\frac{\iota}{R}z.$$

Hence by the measurement of these pressures we can determine R, and hence the velocity with which an ion moves under a given electric intensity.

There are other methods of determining the velocities of the ions, but as these depend on the theory of the conduction of electricity through a gas containing charged ions, we shall consider them in our discussion of that theory.

By the use of these methods it has been shown that the velocities of the ions in a given gas are the same whether the ionization is produced by Röntgen rays, radioactive substances, ultra-violet light, or by the discharge of electricity from points. When the ionization is produced by chemical action the ions are very much less mobile, moving in the same electric field with a velocity less than one-thousandth part of the velocity of the first kind of ions. On the other hand, as we shall see later, the velocity of the negative ions in flames is enormously greater than that of even the first kind of ion under similar electric fields and at the same pressure. But when these negative ions get into the cold part of the flame, they move sluggishly with velocities of the order of those possessed by the second kind. The results of the various determinations of the velocities of the ions are given in the following table. The velocities are in centimetres per second under an electric force of one volt per centimetre, the pressure of the gas being 1 atmosphere. V+ denotes the velocity of the positive ion, V− that of the negative. V is the mean velocity of the positive and negative ions.

Velocities of Ions: Ions Produced by Röntgen Rays

Gas	V+	V−	V	Observer
Air	..	..	1·6	Rutherford
„ (dry)	1·36	1·87	..	Zeleny
„ „	1·60	1·70	..	Langevin
„ „	1·39	1·78	..	Phillips
„ „	1·54	1·78	..	Wellisch
„ (moist)	1·37	1·81	..	Zeleny
Oxygen (dry)	1·36	1·80	..	„
„ (moist)	1·29	1·52	..	„
Carbonic acid (dry)	0·76	0·81	..	„
„ „	0·86	0·90	..	Langevin
„ „	0·81	0·85	..	Wellisch
„ „ (moist)	0·82	0·75	..	Zeleny
Hydrogen (dry)	6·70	7·95	..	„
„ (moist)	5·30	5·60	..	„
Nitrogen	..	..	1·6	Rutherford
Sulphur dioxide	0·44	0·41	..	Wellisch
Hydrochloric acid	..	..	1·27	Rutherford
Chlorine	..	..	1·0	„
Helium (dry)	5·09	6·31	..	Franck and Pohl
Carbon monoxide	1·10	1·14	..	Wellisch
Nitrous oxide	0·82	0·90	..	„
Ammonia	0·74	0·80	..	„
Aldehyde	0·31	0·30	..	„
Ethyl alcohol	0·34	0·27	..	„
Acetone	0·31	0·29	..	„
Ethyl chloride	0·33	0·31	..	„
Pentane	0·36	0·35	..	„
Methyl acetate	0·33	0·36	..	„
Ethyl formate	0·30	0·31	..	„
„ ether	0·29	0·31	..	„
„ acetate	0·31	0·28	..	„
Methyl bromide	0·29	0·28	..	„
„ iodide	0·21	0·22	..	„
Carbon tetrachloride	0·30	0·31	..	„
Ethyl iodide	0·17	0·16	..	„

Ions Produced by Ultra-violet Light

Air	1·4	Rutherford
Hydrogen	3·9	„
Carbonic acid	0·78	„

Ions in Gases Sucked from Flames

Velocities varying from ·04 to ·23 McClelland

Ions in Flames Containing Salts

Negative ions	12,000 cm./sec./volt/cm.	Gold
	7,200–11,900	Wilckens
	10,000	H. A. Wilson
Positive ions for	2·5	Andrade
Salts of alkali metals	1	H. A. Wilson

The much larger values, of the order 100 cm./sec./volt/cm., obtained by earlier workers for the velocity of positive ions in flames seem very doubtful.

Ions Liberated by Chemical Action

Velocities of the order of 0·0005 cm./sec. Bloch

Ions from Point Discharge

Hydrogen	5·4	7·43	6·41	Chattock
Carbonic acid	0·83	0·925	0·88	„
Air	1·32	1·80	1·55	„
Oxygen	1·30	1·85	1·57	„

It will be seen from this table that the greater mobility of the negative ions is very much more marked in the case of the lighter and simpler gases than in that of the heavier and more complicated ones; with the vapours of organic substances there seems but little difference between the mobilities of the positive and negative ions; indeed in one or two cases the positive seem slightly but very slightly the more mobile of the two. In

the case of the simple gases the difference is much greater when the gases are dry than when they are moist. It has been shown by direct experiment that the velocities are directly proportional to the electric force.

Variation of Velocities with Pressure.—Until the pressure gets low the velocities of the ions, negative as well as positive, vary inversely as the pressure. Langevin (*loc. cit.*) was the first to show that at very low pressures the velocity of the negative ions increases more rapidly as the pressure is diminished than this law indicates. If the nature of the ion did not change with the pressure, the kinetic theory of gases indicates that the velocity would vary inversely as the pressure, so that Langevin's results indicate a change in the nature of the negative ion when the pressure is diminished below a certain value. Kovarik has determined the mobility of the negative ions in air and CO_2 down to a pressure of 1 cm. and finds that at these low pressures the value of pV where p is the pressure and V the mobility increases rapidly as the pressure diminishes. The increase in the case of $pV-$ indicates that the structure of the negative ion gets simpler as the pressure is reduced. Wallisch, in some experiments made at the Cavendish laboratory, found that the diminution in the value of $pV-$ at low pressures is much more marked in some gases than in others, and in some gases he failed to detect it; but it must be remembered that it is difficult to get measurements at pressures of only a few millimetres, as the amount of ionization is so exceedingly small at such pressures that the quantities to be observed are hardly large enough to admit of accurate measurements by the methods available at higher pressures.

The key to the behaviour of the negative ion is the fact that it begins by being an electron and does not unite with a molecule of the gas to form a normal ion until it has made a large number of collisions with the molecules of the gas through which it is passing. This number has been determined by Loeb (*Phys. Rev.*, 17, p. 89, 1921; *Phil. Mag.*, 43, p. 229, 1922), who finds that it is independent of the pressure of the gas but varies enormously from one gas to another; thus in pure nitrogen, helium, argon and carbon monoxide in which this number is infinity the electrons never unite with the molecules; in CO_2 the number is about three millions, in air about 30 thousand, in oxygen three thousand and in chlorine less than two thousand. When in the electronic state the mobility is very high. Thus Franck found that the mobility of the negative ion in very pure argon was 206, while if 1% of oxygen was added the mobility fell to 1·7 and in pure helium Franck and Gehlhoff found that the mobility of the negative ion was 509. Haines obtains still larger values for nitrogen and Loeb has shown that these high mobilities vary with the strength of the electric field. The life of the electron is much reduced by the presence of a trace of water vapour.

Most measurements of the mobilities of ions amount to measuring the time taken by the ion to pass through a given length in the gas; if the ion begins as an electron the mobility measured will be a mean value depending on the proportion of the time it is an electron to the time of transit. If the pressure is lowered the time in the electronic state is increased, since the number of collisions the electron makes before leaving this state is unaltered by the change in pressure, while the time between each collision varies inversely as the pressure. The time of transit will be less at low pressures than at high, so that the proportion between the time in the electronic state and the time of transit will vary inversely as the square of the pressure. Thus the high mobility of the electron will produce much greater increase in the mobility at low pressures than at high, and will account for the effects observed by Langevin and Kovarik. It will also account for the fact that the rapid increase of the mobility at low pressures is much more marked in gases which have been carefully dried than in those which contain a trace of water vapour, and that these mobilities depend upon the strength of the electric field.

Effect of Temperature on the Velocity of the Ions.—Phillips (*Proc. Roy. Soc.*, 1906, 78, p. 167) investigated, using Langevin's method, the velocities of the + and − ions through air at atmospheric pressure at temperatures ranging from that of boiling liquid air to 411° C; R_1 and R_2 are the velocities of the + and − ions respectively when the force is a volt per centimetre.

R_1	R_2	Temperature absolute
2·00	2·495	411°
1·95	2·40	399°
1·85	2·30	383°
1·81	2·21	373°
1·67	2·125	348°
1·60	2·00	333°
1·39	1·785	285°
0·945	1·23	209°
0·235	0·235	94°

We see that except in the case of the lowest temperature, that of liquid air, where there is a great drop in the velocity, the velocities of the ions are proportional to the absolute temperature; since the pressure is constant this implies that at constant density the mobility is independent of the temperature. On the hypothesis of an ion of constant size we should, from the kinetic theory of gases, expect the velocity to be proportional to the square root of the absolute temperature, if the charge on the ion did not affect the number of collisions between the ion and the molecules of the gas through which it is moving. If the collisions were brought about by the electrical attraction between the ions and the molecules, the velocity would be proportional to the absolute temperature. The mobility of ions at high temperatures such as those which occur in flames has been the subject of several experiments. The first determination was made in 1899 by H. A. Wilson (*Phil. Tran.*, A, 192, p. 499) who measured the mobility of positive ions in flames containing the vapour of alkali metals and found that it was 62 cm./sec. Andrade, in 1912 (*Phil. Mag.*, 6, 23, 865) by a different method obtained the value 2·5 cm./sec. for strontium ions in a flame. H. A. Wilson, in a later investigation (*Phil. Trans.*, A, 216, p. 63, 1916) came to the conclusion that his earlier values were much too high and estimated the true value as 1 cm./sec., which is of the same order as that obtained by Andrade.

The great effect of temperature is also shown in some experiments of McClelland (*Phil. Mag.* [5], 46, p. 29) on the velocities of the ions in gases drawn from Bunsen flames and arcs; he found that these depended upon the distance the gas had travelled from the flame. Thus, the velocity of the ions at a distance of 5·5 cm. from the Bunsen flame when the temperature was 230° C was ·23 cm./sec. for a volt per centimetre; at a distance of 10 cm. from the flame when the temperature was 160° C the velocity was ·21 cm./sec.; while at a distance of 14·5 cm. from the flame when the temperature was 105° C the velocity was only ·04 cm./sec. If the temperature of the gas at this distance from the flame was raised by external means, the velocity of the ions increased.

We can derive some information as to the constitution of the ions by calculating the velocity with which a molecule of the gas would move in the electric field if it carried the same charge as the ion. From the theory of the diffusion of gases, as developed by Maxwell, we know that if the particles of a gas A are surrounded by a gas B, then, if the partial pressure of A is small, the velocity u with which its particles will move when acted upon by a force Xe is given by the equation

$$u=\frac{Xe}{(p_1/N_1)}D,$$

where D represents the coefficient of inter-diffusion of A into B, and N_1 the number of particles of A per cubic centimetre when the pressure due to A is p_1. Let us calculate by this equation the velocity with which a molecule of hydrogen would move through hydrogen if it carried the charge carried by an ion, which we shall prove shortly to be equal to the charge carried by an atom of hydrogen in the electrolysis of solutions. Since p_1/N_1 is independent of the pressure, it is equal to Π/N, where Π is the atmospheric pressure and N the number of molecules in the cubic centimetre of gas at atmospheric pressure. Now $Ne=1{\cdot}22\times10^{10}$, if e is measured in electrostatic units; $\Pi=10^6$ and D in this case is the coefficient of diffusion of hydrogen into itself, and is equal to

1·7. Substituting these values we find

$$u = 1{\cdot}97 \times 10^4 X.$$

If the potential gradient is 1 volt per centimetre, $X = 1/300$. Substituting this value for X, we find $u = 66$ cm./sec., for the velocity of a hydrogen molecule. We have seen that the velocity of the ion in hydrogen is only about 5 cm./sec., so that the ion moves more slowly than it would if it were a single molecule. One way of explaining this is to suppose that the ion is bigger than the molecule, and is in fact an aggregation of molecules, the charged ion acting as a nucleus around which molecules collect like dust round a charged body. This view is supported by the effect produced by moisture in diminishing the velocity of the negative ion, for, as C. T. R. Wilson (*Phil. Trans.* 193, p. 289) has shown, moisture tends to collect round the ions, and condenses more easily on the negative than on the positive ion. In connection with the velocities of ions in the gases drawn from flames, we find other instances which suggest that condensation takes place round the ions. An increase in the size of the system is not, however, the only way by which the velocity might fall below that calculated for the hydrogen molecule, for we must remember that the hydrogen molecule, whose coefficient of diffusion is 1·7, is not charged, while the ion is. The forces exerted by the ion on the other molecules of hydrogen are not the same as those which would be exerted by a molecule of hydrogen, and as the coefficient of diffusion depends on the forces between the molecules, the coefficient of diffusion of a charged molecule into hydrogen might be very different from that of an uncharged one.

Wellisch (*loc. cit.*) has shown that the effect of the charge on the ion is sufficient in many cases to explain the small velocity of the ions, even if there were no aggregation.

Mixture of Gases.—The ionization of a mixture of gases raises some very interesting questions. If we ionize a mixture of two very different gases, say hydrogen and carbonic acid, and investigate the nature of the ions by measuring their velocities, the question arises, shall we find two kinds of positive and two kinds of negative ions moving with different velocities, as we should do if some of the positive ions were positively charged hydrogen molecules, while others were positively charged molecules of carbonic acid; or shall we find only one velocity for the positive ions and one for the negative? Many experiments have been made on the velocity of ions in mixtures of two gases, but as yet no evidence has been found of the existence of two different kinds of either positive or negative ions in such mixtures, although some of the methods for determining the velocities of the ions, especially Langevin's, ought to give evidence of this effect, if it existed. The experiments seem to show that the mobilities depend on the nature of the gas through which the ions move but not upon the nature of the ions themselves. Thus Blanc found that the mobility of an ion made in CO_2 and driven through air was the same as that of an ion made in the air itself.

Grindley and Tyndall (*Phil. Mag.*, 48, p. 711, 1924) show that the mobility through air of ions formed in H_2,NH_3,$CO_2$$(C_2H_5)_2O$; and $CHCl_3$ was practically the same as that of ordinary air ions. Erikson finds that argon, CO_2, and H_2 ions in air have the same mobility as air ions. Further, Rutherford has shown that the mobility of the heavy "recoil atoms" from radioactive substances, which have an atomic weight greater than 200 have in air the same mobility as air atoms. This is important because the radioactive nature of the ions was tested at the end of their path: so that this disposes of the attractive hypothesis that the charge keeps passing from one molecule to another so that however the ion may start, it is soon a molecule of the gas through which it is passing. Wellisch made very important experiments on mixed gases, *e.g.*, mixtures of SO_2 and O_2 and of ethyl ether and air, and found that he could only detect one type of positive and one of negative ions. The only exception to this result seems to be the fact discovered by Erikson that in air positive ions when they are "old," *i.e.*, after some tenths of a second has elapsed since their formation, have only a mobility of about ·7 of that of newly formed positive ions, he found no difference between young and old negative ions.

The most important results which have emerged from experiments on the mobility of the ions are:—

1. The mobility of the ions, especially in the lighter gases, is much less than it would be if the ion consists of a single molecule having the same free path as an uncharged molecule.
2. The mobility of the ions depends only on the gas through which they move, so that though in a mixture of gases there may be ions of different kinds, all the ions of the same sign have the same mobility. An exception to this is the discovery by Erikson that aged ions have a smaller mobility than fresh ones.
3. In the lighter gases the mobility of the negative ions is greater than that of the positive.
4. The mobility of the negative ions is diminished by traces of the vapours of water and various alcohols.
5. For positive ions the product of the mobility and pressure is constant over a very wide range of pressure; for negative ions, however, the product at low pressure rapidly increases as the pressure diminishes.
6. Experiments with heavy ions from radioactive elements show that these have the normal mobility and retain their identity whilst in the electric field.

It is helpful to consider the various conditions which on the kinetic theory of gases would affect the mobility of the ions. The mobility of the ion is proportional to the coefficient of diffusion of the ion through the gas and this coefficient is equal to

$$\epsilon\lambda \int \frac{1}{\pi h}\left(\frac{1}{m_1}+\frac{1}{m_2}\right)$$

ϵ is a numerical constant, λ the free path of the iron through the gas; m_1, m_2 the masses of the ion and molecule respectively and $h = RT/2$ where T is the absolute temperature and R the gas constant. First consider the effect of the electric charge on the free path, supposing for the moment that the mass of the ion is the same as that of a molecule. The attraction between an ion and a molecule will in consequence of the charge be greater than that between uncharged molecules; the ion and the molecules will be dragged together and the free path of the ion less than that of the molecule. Thus λ will be less for the ion than for the molecule and the coefficient of diffusion less. If λ^1 is the free path of the ion, λ that of the uncharged molecule, w the work required to separate an ion from a molecule with which it is in contact, we can show that if the form between the ion and the molecule varies inversely as the fifth power of the distance

$$\frac{\lambda^1 = \lambda}{1+\alpha(w/RT)^{1/2}}$$

when α is a numerical constant. We see from this expression that if we are to explain the slow diffusion of the ion by the charge alone, w must be large compared with RT, *i.e.*, the work required to separate an ion from a molecule must be large compared with the kinetic energy of a molecule due to thermal agitation. It follows, however, from the principles of thermodynamics that in this case the ions will unite with the molecules and form aggregates, and thus that any considerable diminution in the free path is inconsistent with the ions being monomolecular.

Let us turn now to the effect of mass upon the mobility of the ion; we see from the expression for the coefficient of diffusion that the mobility is proportional to

$$\sqrt{\frac{1}{m_1}+\frac{1}{m_2}}$$

Thus when the mass of the ion, is one, two, three—or an infinite number of times that of the molecule the mobilities are in the ratio 1·41, 1·22, 1·15–1. Though these differences are not very large they are much greater than is consistent with the experimental fact that there is only one mobility for all positive and another for all negative in the same gas. While the mobility of a light ion through a heavy gas will be much greater than that of one formed by a molecule of this gas, thus from the formula the mobility of a hydrogen ion through methyl iodide would be six times that of a methyl iodide ion. We are forced to the conclusion that the ions cannot remain unaltered during their path through

the gas, but must pass through various phases in which they have different mobilities, and that the mobility measured by the usual methods is an average value and not its value in any particular phase.

Recombination.—Several methods enable us to deduce the coefficient of recombination of the ions when we know their velocities. Perhaps the simplest of these consists in determining the relation between the current passing between two parallel plates immersed in ionized gas and the potential difference between the plates. For let q be the amount of ionization, *i.e.*, the number of ions produced per second per unit volume of the gas, A the area of one of the plates, and d the distance between them; then if the ionization is constant through the volume, the number of ions of one sign produced per second in the gas is qAd. Now if i is the current per unit area of the plate and e the charge on an ion, iA/e ions of each sign are driven out of the gas by the current each second. In addition to this source of loss of ions there is the loss due to the recombination; if n is the number of positive or negative ions per unit volume, then the number which recombine per second is αn^2 per cubic centimetre, and if n is constant through the volume of the gas, as will approximately be the case if the current through the gas is only a small fraction of the saturation current, the number of ions which disappear per second through recombination is $\alpha n^2 \cdot Ad$. Hence, since when the gas is in a steady state the number of ions produced must be equal to the number which disappear, we have

$$qAd = iA/e + \alpha n^2 \cdot Ad,$$

$$q = i/ed + \alpha n^2.$$

If u_1 and u_2 are the velocities with which the positive and negative ions move, nu_1e and nu_2e are respectively the quantities of positive electricity passing in one direction through unit area of the gas per second, and of negative in the opposite direction, hence

$$i = nu_1e + nu_2e.$$

If X is the electric force acting on the gas, k_1 and k_2 the velocities of the positive and negative ions under unit force, $u_1 = k_1X$, $u_2 = k_2X$; hence

$$n = i/(k_1+k_2)Xe,$$

and we have

$$q = \frac{i}{ed} + \frac{\alpha i^2}{(k_1+k_2)^2e^2X^2}$$

But qed is the saturation current per unit area of the plate; calling this I, we have

$$I - i = \frac{d\alpha i^2}{e(k_1+k_2)^2X^2}$$

or

$$\frac{\alpha}{e} = X^2(I-i)\ (k_1+k_2)^2/di^2$$

Hence if we determine corresponding values of X and i we can deduce the value of α/e if we also know (k_1+k_2). The value of I is easily determined, as it is the current when X is very large. The preceding result only applies when i is small compared with I, as it is only in this case that the values of n and X are uniform throughout the volume of the gas. Another method which answers the same purpose is due to Langevin (*Ann. Chim. Phys.*, 1903, 28, p. 289); it is as follows. Let A and B be two parallel planes immersed in a gas, and let a slab of the gas bounded by the planes a, b parallel to A and B be ionized by an instantaneous flash of Röntgen rays. If A and B are at different electric potentials, then all the positive ions produced by the rays will be attracted by the negative plate and all the negative ions by the positive, if the electric field were exceedingly large they would reach these plates before they had time to recombine, so that each plate would receive N_0 ions if the flash of Röntgen rays produced N_0 positive and N_0 negative ions. With weaker fields the number of ions received by the plates will be less as some of them will recombine before they can reach the plates. We can find the number of ions which reach the plates in this case in the following way:—In consequence of the movement of the ions the slab of ionized gas will broaden out and will consist of three portions, one in which there are nothing but positive ions,—this is on the side of the negative plate,—another on the side of the positive plate in which there are nothing but negative ions, and a portion between these in which there are both positive and negative ions; it is in this layer that recombination takes place, and here if n is the number of positive or negative ions at the time t after the flash of Röntgen rays,

$$n = n_0/(1+\alpha n_0 t).$$

With the same notation as before, the breadth of either of the outer layers will in time dt increase by $X(k_1+k_2)dt$, and the number of ions in it by $X(k_1+k_2)ndt$; these ions will reach the plate, the outer layers will receive fresh ions until the middle one disappears, which it will do after a time $l/X(k_1+k_2)$, where l is the thickness of the slab ab of ionized gas; hence N, the number of ions reaching either plate, is given by the equation

$$N = \int_0^{l/X(k_1+k_2)} \frac{n_0X(k_1+k_2)}{1+n_0\alpha t}\,dt = \frac{X(k_1+k_2)}{\alpha}\log\left(1+\frac{n_0\alpha l}{X(k_1+k_2)}\right).$$

If Q is the charge received by the plate,

$$Q = Ne = \frac{X}{4\pi\epsilon}\log\left(1+\frac{Q_0\epsilon}{4\pi X}\right),$$

where $Q_0 = n_0le$ is the charge received by the plate when the electric force is large enough to prevent recombination, and $\epsilon = \alpha 4e(k_1+k_2)$. We can from this result deduce the value of ϵ and hence the value of α when k_1+k_2 is known.

Distribution of Electric Force When a Current Is Passing Through an Ionized Gas.—Let the two plates be at right angles to the axis of x; then we may suppose that between the plates the electric intensity X is everywhere parallel to the axis of x. The velocities of both the positive and negative ions are assumed to be proportional to X. Let k_1X, k_2X represent these velocities respectively; let n_1, n_2 be respectively the number of positive and negative ions per unit volume at a point fixed by the co-ordinate x; let q be the number of positive or negative ions produced in unit time per unit volume at this point; and let the number of ions which recombine in unit volume in unit time be αn_1n_2; then if e is the charge on the ion, the volume density of the electrification is $(n_1-n_2)e$, hence

$$\frac{dX}{dx} = 4\pi(n_1-n_2)e. \qquad (1)$$

If I is the current through unit area of the gas and if we neglect any diffusion except that caused by the electric field,

$$n_1ek_1X + n_2ek_2X = I. \qquad (2)$$

From equations (1) and (2) we have

$$n_1e = \frac{1}{k_1+k_2}\left(\frac{I}{X} + \frac{k_2}{4\pi}\frac{dX}{dx}\right), \qquad (3)$$

$$n_2e = \frac{1}{k_1+k_2}\left(\frac{I}{X} - \frac{k_1}{4\pi}\frac{dX}{dx}\right), \qquad (4)$$

and from these equations we can, if we know the distribution of electric intensity between the plates, calculate the number of positive and negative ions.

In a steady state the number of positive and negative ions in unit volume at a given place remains constant, hence neglecting the loss by diffusion, we have

$$\frac{d}{dx}(k_1n_1X) = q - \alpha n_1n_2 \qquad (5)$$

$$-\frac{d}{dx}(k_2n_2X) = q - \alpha n_1n_2. \qquad (6)$$

If k_1 and k_2 are constant, we have from (1), (5) and (6)

$$\frac{d^2X^2}{dx^2} = 8\pi e(q-\alpha n_1n_2\left(\frac{1}{k_1}+\frac{1}{k_2}\right), \qquad (7)$$

an equation which is very useful, because it enables us, if we know the distribution of X^2, to find whether at any point in the

gas the ionization is greater or less than the recombination of the ions. We see that $q-\alpha n_1n_2$, which is the excess of ionization over recombination, is proportional to d^2X^2/dx^2. Thus when the ionization exceeds the recombination, *i.e.*, when $q-\alpha n_1n_2$ is positive, the curve for X^2 is convex to the axis of x, while when the recombination exceeds the ionization the curve for X^2 will be concave to the axis of x. Thus, for example, fig. 7 represents the curve for X^2 observed by Graham (*Wied. Ann.* 64, p. 49) in a tube through which a steady current is passing. Interpreting it by equation (7), we infer that ionization was much in excess of recombination at A and B, slightly so along C, while along D the recombination exceeded the ionization. Substituting in equation (7) the values of n_1, n_2 given in (3), (4), we get

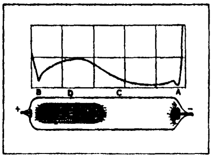

FIG. 7

$$\frac{d^2X^2}{dx^2}=8\pi e\left[q-\frac{\alpha}{e^2X^2(k_1+k_2)^2}\left(I+\frac{k_2}{8\pi}\frac{dX^2}{dx}\right)\left(I-\frac{k_2}{8\pi}\frac{dX^2}{dx}\right)\right]\left(\frac{1}{k_1}+\frac{1}{k_2}\right) \qquad (8).$$

This equation can be solved (*see* Thomson, *Phil. Mag.* xlvii. p. 253), when q is constant and $k_1=k_2$. From the solution it appears that if X_1 be the value of x close to one of the plates, and X_0 the value midway between them.

$$X_1/X_0=\beta^{-\frac{\beta}{2(1-\beta)}}$$

where $\beta=8\pi ek_1/\alpha$.

Since $e=4\cdot77\times10^{-10}$, $\alpha=1\cdot6\times10^{-6}\times10^{-6}$, and k^1 for air at atmospheric pressure $=520$, β is about 3·9 for air at atmospheric pressure and it becomes much greater at lower pressures.

Thus X_1/X_0 is always greater than unity, and the value of the ratio increases from unity to infinity as β increases from zero to infinity. As β does not involve either q or I, the ratio of X_1 to X_0 is independent of the strength of the current and of the intensity of the ionization.

No general solution of equation (8) has been found when k_1 is not equal to k_2, but we can get an approximation to the solution when q is constant. The equations (1), (2), (3), (4) are satisfied by the values—

$$n_1=n_2=(q/\alpha)^{\frac{1}{2}}$$

$$k_1n_1Xe=\frac{k_1}{k_1+k_2}I,$$

$$k_2n_2Xe=\frac{k_2}{k_1+k_2}I,$$

$$X=\left(\frac{\alpha}{q}\right)^{\frac{1}{2}}\frac{I}{e(k_1+k_2)}.$$

These solutions cannot, however, hold right up to the surface of the plates, for across each unit of area, at a point P, $k_1I/(k_1+k_2)e$ positive ions pass in unit time, and these must all come from the region between P and the positive plate. If λ is the distance of P from this plate, this region cannot furnish more than $q\lambda$ positive ions, and only this number if there are no recombinations. Hence the solution cannot hold when $q\lambda$ is less than $k_1I/(k_1+k_2)e$, or where λ is less than $k_1I/(k_1+k_2)qe$.

Similarly the solution cannot hold nearer to the negative plate than the distance $k_2I/(k_1+k_2)qe$.

The force in these layers will be greater than that in the middle of the gas, and so the loss of ions by recombination will be smaller in comparison with the loss due to the removal of the ions by the current. If we assume that in these layers the loss of ions by recombination can be neglected, we can by the method of the next article find an expression for the value of the electric force at any point in the layer. This, in conjunction with the value $X_0=\left(\frac{\alpha}{q}\right)^{\frac{1}{2}}\frac{I}{e(k_1+k_2)}$ for the gas outside the layer, will give the value of X at any point between the plates. It follows from this investigation that if X_1 and X_2 are the values of X at the positive and negative plates respectively, and X_0 the value of X outside the layer,

$$X_1=X_0\left(1+\frac{k_1}{k_2}\frac{1}{\epsilon}\right)^{\frac{1}{2}},\quad X_2=X_0\left(1+\frac{k_2}{k_1}\frac{1}{\epsilon}\right)^{\frac{1}{2}},$$

where $\epsilon=\alpha/4\pi e(k_1+k_2)$. Langevin found that for air at a pressure of 152 mm. $\epsilon=0\cdot01$, at 375 mm. $\epsilon=0\cdot06$, and at 760 mm. $\epsilon=0\cdot27$. Thus at fairly low pressures $1/\epsilon$ is large, and we have approximately

$$X_1=X_0\left(\frac{k_1}{k_2}\right)^{\frac{1}{2}}\frac{1}{\sqrt{\epsilon}},\quad X_2=X_0\left(\frac{k_1}{k_2}\right)^{\frac{1}{2}}\frac{1}{\sqrt{\epsilon}}.$$

Therefore $\qquad X_1/X_2=k_1/k_2,$

or the force at the positive plate is to that at the negative plate as the velocity of the positive ion is to that of the negative ion. Thus the force at the negative plate is greater than that at the positive. The falls of potential V_1, V_2 at the two layers when $1/\epsilon$ is large can be shown to be given by the equations

$$V_1=8\pi^2\left(\frac{\epsilon}{q\alpha}\right)^{\frac{3}{2}}k_1\left(\frac{k_1}{k_2}\right)^{\frac{1}{2}}i^2,$$

$$V_2=8\pi^2\left(\frac{\epsilon}{q\alpha}\right)^{\frac{3}{2}}k_2\left(\frac{k_2}{k_1}\right)^{\frac{1}{2}}i^2,$$

hence $\qquad V_1/V_2=k_1^2/k_2^2,$

so that the potential falls at the electrodes are proportional to the squares of the velocities of the ions. The change in potential across the layers is proportional to the square of the current, while the potential change between the layers is proportional to the current, the total potential difference between the plates is the sum of these changes, hence the relation between V and i will be of the form

$$V=Ai+Bi^2.$$

Mie (*Ann. der. Phys.*, 1904, 13, p. 857) has by the method of successive approximations obtained solutions of equation (8) (i.) when the current is only a small fraction of the saturation current, (ii.) when the current is nearly saturated. The results of his investigations are represented in fig. 8, which represents the distribution of electric force along the path of the current for various values of the current expressed as fractions of the saturation current. It will be seen that until the current amounts to about one-fifth of the maximum current, the type of solution is the one just indicated, *i.e.*, the electric force is constant except in the neighbourhood of the electrodes when it increases rapidly.

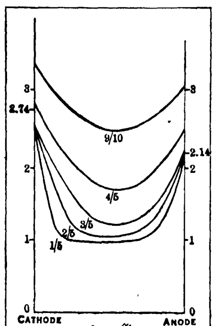

FIG. 8

Though we are unable to obtain a general solution of the equation (8), there are some very important special cases in which that equation can be solved without difficulty. We shall consider two of these, the first being that when the current is saturated. In this case there is no loss of ions by recombination, so that using the same notation as before we have

$$\frac{d}{dx}(n_1k_1X)=q,$$

$$\frac{d}{dx}(n_2k_2X)=-q.$$

The solutions of which if q is constant are

$$n_1k_1X=qx,$$

$$n_2k_2X=I/e-qx=q(l'-x),$$

if l is the distance between the plates, and $x=0$ at the positive electrode. Since

$$dX/dx=4\pi(n_1-n_2)e,$$

we get

$$\frac{1}{8\pi}\frac{dX^2}{d^2x}=qx\left\{\frac{1}{k_1}+\frac{1}{k_2}\right\}-q\frac{l}{k_2},$$

or

$$\frac{X^2}{8\pi}=q\frac{x^2}{2}\left(\frac{1}{k_1}+\frac{1}{k_2}\right)-q\frac{lx}{k_2}+C,$$

where C is a quantity to be determined by the condition that $\int_0^l Xdx=V$, where V is the given potential difference between the plates. When the force is a minimum $dX/dx=0$, hence at this point

$$x=\frac{lk_1}{k_1+k_2},\ l-x=\frac{lk_2}{k_1+k_2}.$$

Hence the ratio of the distances of this point from the positive and negative plates respectively is equal to the ratio of the velocities of the positive and negative ions.

The other case we shall consider is the very important one in which the velocity of the negative ion is exceedingly large compared with the positive; this is the case in flames where, as Gold (*Proc. Roy. Soc.* 97, p. 43) has shown, the velocity of the negative ion is many thousand times the velocity of the positive; it is also very probably the case in all gases when the pressure is low. We may get the solution of this case either by putting $k_1/k_2=0$ in equation (8). In this case the electric force except close to the cathode is constant and given by the equation

$$X_0=\sqrt{\left(\frac{\alpha}{q}\frac{i}{\epsilon k_2}\right)}.$$

The force at the cathode is approximately

$$2\left(\frac{\pi e}{qk_1}\right)^{\frac{1}{2}}\frac{i}{e}.$$

The thickness of the space within which the force falls from this value to X_0 is

$$\frac{i}{qe}$$

and the fall of potential in crossing this space is

$$\left(\frac{\pi e}{q^3k_1}\right)^{\frac{1}{2}}\frac{i^2}{e^2}$$

if l is the distance between the electrodes, V the total fall of potential is given by the equation

$$V=\left(\frac{\pi e}{q^3k_1}\right)^{\frac{1}{2}}\frac{i^2}{e^2}+\left(l-\frac{i}{qe}\right)\left(\frac{\alpha}{qk_2^2}\right)^{\frac{1}{2}}\frac{i}{e}.$$

If the cathode itself emits electrons, these will help to carry the current, and the thickness of the region of large force next the cathode will be $(i-i^0)$ where i^0 is the current carried by the electrons coming from the cathode. This will make the fall of potential at the cathode proportional to $i\,(i-i^0)$ instead of to i^2. The fall of potential at the cathode is proportional to the square of the current, while the fall in the rest of the circuit is directly proportional to the current. In the case of flames or hot gases, the fall of potential at the cathode is much greater than that in the rest of the circuit, so that in such cases the current through the gas varies nearly as the square root of the potential difference. The equation we have just obtained is of the form

$$V=Ai+Bi^2,$$

and H. A. Wilson has shown that a relation of this form represents the results of his experiments on the conduction of electricity through flames.

The expression for the fall of potential at the cathode is inversely proportional to $q^{3/2}$, q being the number of ions produced per cubic centimetre per second close to the cathode; thus any increase in the ionization at the cathode will diminish the potential fall at the cathode, and as practically the whole potential difference between the electrodes occurs at the cathode, a diminution in the potential fall there will be much more important than a diminution in the electric force in the uniform part of the discharge, where the force is comparatively insignificant. This consideration explains a very striking phenomenon discovered many years ago by Hittorf, who found that if he put a wire carrying a bead of a volatile salt into the flame, it produced little effect upon the current, unless it were placed close to the cathode where it gave rise to an enormous increase in the current, sometimes increasing the current more than a hundredfold. The introduction of the salt increases very largely the number of ions produced, so that q is much greater for a salted flame than for a plain one. Thus Hittorf's result coincides with the conclusions we have drawn from the theory of this class of conduction.

The fall of potential at the cathode is proportional to $i-i_0$, where i_0 is the stream of negative electricity which comes from the cathode itself, thus as i_0 increases the fall of potential at the cathode diminishes and the current sent by a given potential difference through the gas increases. Now all metals give out negative particles when heated, at a rate which increases very rapidly with the temperature, but at the same temperature some metals give out more than others. If the cathode is made of a metal which emits large quantities of negative particles, $(i-i_0)$ will for a given value of i be smaller than if the metal only emitted a small number of particles; thus the cathode fall will be smaller for the metal with the greater emissivity, and the relation between the potential difference and the current will be different in the two cases. These considerations are confirmed by experience, for it has been found that the current between electrodes immersed in a flame depends to a great extent upon the metal of which the electrodes are made. Thus Pettinelli (*Acc. dei Lincei* [5], v. p. 118) found that, *ceteris paribus*, the current between two carbon electrodes was about 500 times that between two iron ones. If one electrode was carbon and the other iron, the current when the carbon was cathode and the iron anode was more than 100 times the current when the electrodes were reversed. The emission of negative particles by some metallic oxides, notably those of calcium and barium, has been shown by Wehnelt (*Ann. der Phys.* 11, p. 425) to be far greater than that of any known metal, and the increase of current produced by coating the cathodes with these oxides is exceedingly large; in some cases investigated by Tufts and Stark (*Physik. Zeits.*, 1908, 5, p. 248) the current was increased many thousand times by coating the cathode with lime. No appreciable effect is produced by putting lime on the anode.

Conduction When All the Ions Are of One Sign. *The Space Charge Effect.*—There are many important cases in which the ions producing the current come from one electrode or from a thin layer of gas close to the electrode, no ionization occurring in the body of the gas or at the other electrode. Among such cases may be mentioned those where one of the electrodes is raised to incandescence while the other is cold, or when the negative electrode is exposed to ultra-violet light. In such cases if the electrode at which the ionization occurs is the positive electrode, all the ions will be positively charged, while if it is the negative electrode the ions will all be charged negatively. The theory of this case is exceedingly simple. Suppose the electrodes are parallel planes at right angles to the axis of x; let X be the electric force at a distance x from the electrode where the ionization occurs, n the number of ions (all of which are of one sign) at this place per cubic centimetre, k the velocity of the ion under unit electric force, e the charge on an ion, and i the current per unit area of the electrode. Then we have $\frac{dX}{dx}=4\pi ne$, and if u is the velocity of the ion $neu=i$. But $u=kX$, hence we have $\frac{kX}{4\pi}\frac{dX}{dx}=i$, and since the right hand side of this equation does not depend upon x, we get $kX^2/8\pi=ix+C$, where C is a constant to be determined. If l is the distance between the plates, and V the potential difference between them,

$$V=\int_0^l Xdx=\frac{1}{i}\sqrt{\frac{8\pi}{k}}\left[(il+C)^{\frac{3}{2}}-C^{\frac{3}{2}}\right]$$

We shall show that when the current is far below the saturation value, C is very small compared with il, so that the preceding equation becomes

$$V^2 = 8\pi l^3 i/k. \tag{1}$$

To show that for small currents C is small compared with il, consider the case when the ionization is confined to a thin layer, thickness d close to the electrode: in that layer let n_0 be the value of n, then we have $q = \alpha n_0^2 + i/ed$. If X_0 be the value of X when $x = 0$, $kX_0 n_0 e = i$, and

$$C = \frac{kX_0^2}{8\pi} = \frac{i^2}{n_0^2 ke \cdot 8\pi} = \frac{\alpha}{8\pi ke^2} \cdot \frac{i^2}{q - i/ed}. \tag{2}$$

Since $\alpha/8\pi ke$ is, as we have seen, less than unity, C will be small compared with il, if $i/(eq + i/d)$ is small compared with l. If I_0 is the saturation current, $q = I_0/ed$, so that the former expression $= id/(I_0 - i)$, if i is small compared with I_0, this expression is small compared with d, and therefore *a fortiori* compared with l, so that we are justified in this case in using equation (1).

From equation (1) we see that the current increases as the square of the potential difference. Here an increase in the potential difference produces a much greater percentage increase than in conduction through metals, where the current is proportional to the potential difference. When the ionization is distributed through the gas, we have seen that the current is approximately proportional to the square root of the potential, and so increases more slowly with the potential difference than currents through metals. From equation (1) the current is inversely proportional to the cube of the distance between the electrodes, so that it falls off with great rapidity as this distance is increased. We may note that for a given potential difference the expression for the current does not involve q, the rate of production of the ions at the electrode; in other words, if we vary the ionization the current will not begin to be affected by the strength of the ionization until this falls so low that the current is a considerable fraction of the saturation current. For the same potential difference the current is proportional to k, the velocity under unit electric force of the ion which carries the current. As the velocity of the negative ion is greater than that of the positive, the current when the ionization is confined to the neighbourhood of one of the electrodes will be greater when that electrode is made cathode than when it is anode. Thus the current will appear to pass more easily in one direction than in the opposite.

Since the ions which carry the current have to travel all the way from one electrode to the other, any obstacle which is impervious to these ions will, if placed between the electrodes, stop the current to the electrode where there is no ionization. A plate of metal will be as effectual as one made of a non-conductor, and thus we get the remarkable result that by interposing a plate of an excellent conductor like copper or silver between the electrode we can entirely stop the current. This experiment can easily be tried by using a hot plate as the electrode at which the ionization takes place: then if the other electrode is cold the current which passes when the hot plate is cathode can be entirely stopped by interposing a cold metal plate between the electrodes.

A very interesting case of the space charge effect is when, as above, the ions are produced close to one electrode or are emitted by it and the pressure of the gas is so low that the motion of the ions is not affected by the presence of the gas. This includes the very important case where currents are carried through a vacuum by the electrons emitted from an incandescent electrode.

If V be the potential difference between a point P in the gas and this electrode, n the number of ions per cc. at P m the mass and e the charge on the ion, x the distance of P from the electrode. Then

$$\frac{d^2V}{dx^2} = 4\pi ne \text{ - - - -} \tag{3}$$

If V is the velocity of the ion at P, then if it starts from rest at the electrode

$$\tfrac{1}{2}mv^2 = Ve \text{ - - - -} \tag{4}$$

and if l is the current through unit area

$$l = nev \tag{5}$$

from these equations we get

$$\sqrt{\left(V \cdot \frac{d^2V}{dx^2}\right)} = 4\pi l\,(m/ze)^{\frac{1}{2}}. \tag{6}$$

A complete solution of this equation can be obtained without difficulty; the expressions for this solution are, however, somewhat complicated, and we shall confine ourselves to the special case when the current passing is small compared with the saturation current, in this case dV/dx vanishes at the electrode and the solution of (6) is

$$V = \{9i(m/u)^{\frac{1}{2}}\}^{\frac{2}{3}} \cdot x^{\frac{4}{3}} \tag{7}$$

or i the current sent by a potential difference V, when l is the distance between the electrode is given by

$$l = \frac{1}{9}\sqrt{\frac{2e}{m}} \cdot \frac{V^{3/2}}{l^2} \tag{8}$$

Thus the current produced by a given potential difference is independent of the rate at which the electrons are emitted from the electrode; this is, however, only true when the current is far from saturation.

We see from equation (3) that $\frac{d^2V}{dx^2}$ extend, therefore n are infinite when $x = o$, so that there is a great accumulation of ions close to this electrode.

The "space charge effect" has been the subject of most important investigations by Langmuir, to whom its development is mainly due.

Methods of Counting the Number of Ions.—The detection of the ions and the estimation of their number in a given volume is much facilitated by the property they possess of promoting the condensation of water-drops in dust-free air supersaturated with water vapour. If such air contains no ions, then it requires about an eightfold supersaturation before any water-drops are formed; if, however, ions are present C. T. R. Wilson (*Phil. Trans.*, 189, p. 265) has shown that a sixfold supersaturation is sufficient to cause the water vapour to condense round the ions and to fall down as raindrops. The absence of the drops when no ions are present is due to the curvature of the drop combined with the surface tension causing, as Lord Kelvin showed, the evaporation from a small drop to be exceedingly rapid, so that even if a drop of water were formed the evaporation when it was small would be so great that it would rapidly evaporate and disappear. It has been shown, however (J. J. Thomson, *Application of Dynamics to Physics and Chemistry*, p. 164; *Conduction of Electricity through Gases*, 2nd ed. p. 179), that if a drop of water is charged with electricity the effect of the charge is to diminish the evaporation; if the drop is below a certain size the effect of the charge in promoting condensation more than counterbalances the effect of the surface tension in promoting evaporation. Thus the electric charge protects the drop in the most critical period of its growth.

The effect is easily shown experimentally by taking a bulb connected with a piston arranged so as to move with great rapidity. When the piston moves so as to increase the volume of the air contained in the bulb the air is cooled by expansion, and if it was saturated with water vapour before it is supersaturated after the expansion. By altering the throw of the piston the amount of supersaturation can be adjusted within very wide limits. Let it be adjusted so that the expansion produces about a sixfold supersaturation; then if the gas is not exposed to any ionizing agents very few drops (and these probably due to the small amount of ionization which we have seen is always present in gases) are formed. If, however, the bulb is exposed to strong Röntgen rays expansion produces a dense cloud which gradually falls down and disappears. If the gas in the bulb at the time of its exposure to the Röntgen rays is subject to a strong electric field hardly any cloud is formed when the gas is suddenly expanded. The electric field removes the charged ions from the gas as soon as they

are formed so that the number of ions present is greatly reduced. This experiment furnishes a very direct proof that the drops of water which form the cloud are only formed round the ions.

This method gives us an exceedingly delicate test for the presence of ions, for there is no difficulty in detecting ten or so raindrops per cubic centimetre; we are thus able to detect the presence of this number of ions. This result illustrates the enormous difference between the delicacy of the methods of detecting ions and those for detecting uncharged molecules; we have seen that we can easily detect ten ions per cubic centimetre, but there is no known method, spectroscopic or chemical, which would enable us to detect a billion (10^{12}) times this number of uncharged molecules. The formation of the water-drops round the charged ions gives us a means of counting the number of ions present in a cubic centimetre of gas; we cool the gas by sudden expansion until the supersaturation produced by the cooling is sufficient to cause a cloud to be formed round the ions, and the problem of finding the number of ions per cubic centimetre of gas is thus reduced to that of finding the number of drops per cubic centimetre in the cloud. Unless the drops are very few and far between we cannot do this by direct counting; we can, however, arrive at the result in the following way. From the amount of expansion of the gas we can calculate the lowering produced in its temperature and hence the total quantity of water precipitated. The water is precipitated as drops, and if all the drops are the same size the number per cubic centimetre will be equal to the volume of water deposited per cubic centimetre, divided by the volume of one of the drops. Hence we can calculate the number of drops if we know their size, and this can be determined by measuring the velocity with which they fall under gravity through the air.

Stokes showed that the force required to drive a drop of water with a velocity v through a continuous fluid is equal to $6\pi\mu av$ where a is the radius of the drop and μ the viscosity of the fluid. Cunningham (*Proc. Roy. Soc.*, F3, A. p. 357) showed that this expression requires modification when the drop moves through a gas in which the mean free path of the molecules is comparable with the radius of the drop. He shows that the factor $6\pi\mu a$ must be replaced by $6\pi\mu a\left(1+1\cdot63\frac{l}{a}\right)^{-1}$ where l is the mean free path of the molecules. Since l varies inversely as the pressure, p, of the gas the factor is of the form $6\pi\mu a\left(1+\frac{B}{pa}\right)^{-1}$ where B is a constant. Milliken, assuming an expression of this form, determined the value of B by experiment. When the drop falls under gravity the force is $\frac{4}{3}\pi g a^3(\rho-\sigma)$ when ρ is the density of the drop and σ that of the gas. Since this is equal to V multiplied by a known function of a, if we measure V we can deduce the value of a.

Charge on Ion.—By this method we can determine the number of ions per unit volume of an ionized gas. Knowing this number we can proceed to determine the charge on an ion. To do this let us apply an electric force so as to send a current of electricity through the gas, taking care that the current is only a small fraction of the saturating current. Then if u is the sum of the velocities of the positive and negative ions produced in the electric field applied to the gas, the current through unit area of the gas is neu, where n is the number of positive or negative ions per cubic centimetre, and e the charge on an ion. We can easily measure the current through the gas and thus determine neu; we can determine n by the method just described, and u, the velocity of the ions under the given electric field, is known from the experiments of Zeleny and others. Thus since the product neu, and two of the factors n, u are known, we can determine the other factor e, the charge on the ion. (This method was used by J. J. Thomson, and details of the method will be found in *Phil. Mag.* [5], 46, p. 528; [5], 48, p. 547; [6], 5, p. 346). The result of these measurements shows that the charge on the ion is the same whether the ionization is by Röntgen rays or by the influence of ultra-violet light on a metal plate. It is the same whether the gas ionized is hydrogen, air or carbonic acid, and thus is presumably independent of the nature of the gas. The value of e found by this method was $3\cdot4\times10^{-10}$ electrostatic units.

H. A. Wilson (*Phil. Mag.* [6], 5, p. 429) used another method. Drops of water, as we have seen, condense more easily on negative than on positive ions. It is possible, therefore, to adjust the expansion so that a cloud is formed on the negative but not on the positive ions. Wilson arranged the experiments so that such a cloud was formed between two horizontal plates which could be maintained at different potentials. The charged drops between the plates were acted upon by a uniform vertical force which affected their rate of fall. Let X be the vertical electric force, e the charge on the drop, v_1 the rate of fall of the drop when this force acts, and v the rate of fall due to gravity alone. Then since the rate of fall is proportionate to the force on the drop, if a is the radius of the drop, and ρ its density, then

$$\frac{Xe+\frac{4}{3}\pi\rho g a^3}{\frac{4}{3}\pi\rho g a^3}=\frac{v_1}{v},$$

or

$$Xe=\tfrac{4}{3}\pi\rho g a^3(v_1-v)/v.$$

But

$$v=\tfrac{2}{9}ga^2\rho/\mu,\ \text{approximately},$$

so that

$$Xe=\sqrt{2}\cdot9\pi\sqrt{\frac{\mu^3}{g\rho}}\cdot\frac{v^{\frac{1}{2}}(v_1-v)}{v}.$$

Thus if X, v, v_1 are known e can be determined. Wilson by this method found that e was $3\cdot1\times10^{-10}$ electrostatic units. A few of the ions carried charges $2e$ or $3e$.

Townsend has used the following method to compare the charge carried by a gaseous ion with that carried by an atom of hydrogen in the electrolysis of solution. We have

$$u/\mathrm{D}=\mathrm{N}e/\pi,$$

where D is the coefficient of diffusion of the ions through the gas, u the velocity of the ion in the same gas when acted on by unit electric force, N the number of molecules in a cubic centimetre of the gas when the pressure is π dynes per square centimetre, and e the charge in electrostatic units. This relation is obtained on the hypothesis that N ions in a cubic centimetre produce the same pressure as N uncharged molecules.

We know the value of D from Townsend's experiments and the values of u from those of Żeleny. We get the following values for $\mathrm{N}e\times10^{-10}$:—

Gas	Moist gas		Dry gas	
	Positive ions	Negative ions	Positive ions	Negative ions
Air	1·28	1·29	1·46	1·31
Oxygen	1·34	1·27	1·63	1·36
Carbonic acid	1·01	·87	·99	·93
Hydrogen	1·24	1·18	1·63	1·25
Mean	1·22	1·15	1·43	1·21

Since 1·22 cubic centimetres of hydrogen at the temperature 15° C and pressure 760 mm. of mercury are liberated by the passage through acidulated water of one electromagnetic unit of electricity or 3×10^{10} electrostatic units, and since in one cubic centimetre of the gas there are 2·46 N atoms of hydrogen, we have, if E is the charge in electrostatic units, on the atom of hydrogen in the electrolysis of solutions

$$2\cdot46\mathrm{NE}=3\times10^{10},$$

or

$$2\cdot46\mathrm{NE}=3\times10^{10}.$$

The mean of the values of Ne in the preceding table is $1\cdot24\times10^{10}$. Hence we may conclude that the charge of electricity carried by a gaseous ion is equal to the charge carried by the hydrogen atom in the electrolysis of solutions. The values of Ne for the different gases differ more than we should have expected from the probable accuracy of the determination of D and the velocity of the ions: Townsend (*Proc. Roy. Soc.* 80, p. 207) has shown that when the ionization is produced by Röntgen rays some of the positive ions carry a double charge and that this accounts for the values of Ne being greater for the positive than for the negative ions. Since we know the value of e, viz., $4\cdot77\times10^{-10}$, and, also Ne, $=1\cdot24\times10^{10}$, we find N the number of molecules in a cubic

centimetre of gas at standard temperature and pressure to be equal to 2.6×10^{10}. This method of obtaining N is the only one which does not involve any assumption as to the shape of the molecules and the forces acting between them.

Another method of determining the charge carried by an ion has been employed by Rutherford (*Proc. Roy. Soc.* 81, pp. 141, 162), in which the positively electrified particles emitted by radium are made use of. The method consists of: (1) Counting the number of α particles emitted by a given quantity of radium in a known time. (2) Measuring the electric charge emitted by this quantity in the same time. To count the number of the α particles the radium was so arranged that it shot into an ionization chamber a small number of α particles per minute; the interval between the emission of individual particles was several seconds. When an α particle passed into the vessel it ionized the gas inside and so greatly increased its conductivity; thus, if the gas were kept exposed to an electric field, the current through the gas would suddenly increase when an α particle passed into the vessel. Although each α particle produces about 30 thousand ions, this is hardly large enough to produce the conductivity appreciable without the use of very delicate apparatus; to increase the conductivity Rutherford took advantage of the fact that negative ions, when exposed to a strong electric field, produce other ions by collision against the molecules of the gas through which they are moving. By suitably choosing the electric field and the pressure in the ionization chamber, the 30,000 ions produced by each α particle can be multiplied to such an extent that an appreciable current passes through the ionization chamber on the arrival of each α particle. An electrometer placed in series with this vessel will show by its deflection when an α particle enters the chamber, and by counting the number of deflections per minute we can determine the number of α particles given out by the radium in that time. Another method of counting this number is to let the particles fall on a phosphorescent screen, and count the number of scintillations on the screen in a certain time. Rutherford has shown that these two methods give concordant results.

The charge of positive electricity given out by the radium was measured by catching the α particles in a Faraday cylinder placed in a very highly exhausted vessel, and measuring the charge per minute received by this cylinder. In this way Rutherford showed that the charge on the α particle was 9.4×10^{-10} electrostatic units. Now e/m for the α particle $=5\times10^{3}$, and there is evidence that the α particle is a charged atom of helium; since the atomic weight of helium is 4 and e/m for hydrogen is 10^{4}, it follows that the charge on the helium atom is twice that on the hydrogen, so that the charge on the hydrogen atom is 4.7×10^{-10} electrostatic units.

Calculation of the Mass of the Ions at Low Pressures.—Although at ordinary pressures the ion seems to have a very complex structure and to be the aggregate of many molecules, yet we have evidence that at very low pressures the structure of the ion, and especially of the negative one, becomes very much simpler. This evidence is afforded by determination of the mass of the atom. We can measure the ratio of the mass of an ion to the charge on the ion by observing the deflections produced by magnetic and electric forces on a moving ion. If an ion carrying a charge e is moving with a velocity v, at a point where the magnetic force is H, a mechanical force acts on the ion, whose direction is at right angles both to the direction of motion of the ion and to the magnetic force, and whose magnitude is $ev\mathrm{H}\sin\theta$ where θ is the angle between v and H. Suppose then that we have an ion moving through a gas whose pressure is so low that the free path of the ion is long compared with the distance through which it moves whilst we are experimenting upon it; in this case the motion of the ion will be free, and will not be affected by the presence of the gas.

Since the force is always at right angles to the direction of motion of the ion, the speed of the ion will not be altered by the action of this force; and if the ion is projected with a velocity v in a direction at right angles to the magnetic force, and if the magnetic force is constant in magnitude and direction, the ion will describe a curve in a plane at right angles to the magnetic force. If ρ is the radius of curvature of this curve, m the mass of the ion, mv^2/ρ must equal the normal force acting on the ion, *i.e.* it must be equal to Hev, or $\rho=mv/\mathrm{H}e$. Thus the radius of curvature is constant; the path is therefore a circle, and if we can measure the radius of this circle we know the value of $mv/\mathrm{H}e$. In the case of the rapidly moving negative ions projected from the cathode in a highly exhausted tube, which are known as *cathode rays*, the path of the ions can be readily determined since they make many substances luminous when they impinge against them. Thus by putting a screen of such a substance in the path of the rays the shape of the path will be determined. Let us now suppose that the ion is acted upon by a vertical electric force X and is free from magnetic force, if it be projected with a horizontal velocity v, the vertical deflection y after a time t is $\frac{1}{2}\times et^2/m$, or if l is the horizontal distance travelled over by the ions in this time we have, since $l=vt$,

$$y=\tfrac{1}{2}\,\frac{Xe}{m}\,\frac{l^2}{v^2}.$$

Thus if we measure y and l we can deduce e/mv^2. From the effect of the magnetic force we know e/mv. Combining these results we can find both e/m and v.

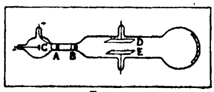

FIG. 9

The method by which this determination is carried out in practice is illustrated in fig. 9. The cathode rays start from the electrode C in a highly exhausted tube, pass through two small holes in the plugs A and B, the holes being in the same horizontal line. Thus a pencil of rays emerging from B is horizontal and produces a bright spot at the far end of the tube. In the course of their journey to the end of the tube they pass between the horizontal plates E and D, by connecting these plates with an electric battery a vertical electric field is produced between E and D and the phosphorescent spot is deflected. By measuring this deflection we determine e/mv^2. The tube is now placed in a uniform magnetic field, the lines of magnetic force being horizontal and at right angles to the plane of the paper. The magnetic force makes the rays describe a circle in the plane of the paper, and by measuring the vertical deflection of the phosphorescent patch at the end of the tube we can determine the radius of this circle, and hence the value of e/mv. From the two observations the value of e/m and v can be calculated.

Another method of finding e/m for the negative ion which is applicable in many cases, to which the preceding one is not suitable, is as follows: Let us suppose that the ion starts from rest and moves in a field where the electric and magnetic forces are both uniform, the electric force X being parallel to the axis of x, and the magnetic force Z parallel to the axis of z; then if x, y, are the coordinates of the ion at the time t, the equations of motion of the ion are—

$$m\frac{d^2x}{dt^2}=Xe-He\frac{dy}{dt},$$

$$m\frac{d^2y}{dt^2}=He\frac{dx}{dt}.$$

The solution of these equations, if x, y, dx/dt, dy/dt all vanish when $t=0$, is

$$x=\frac{Xm}{eH^2}\left\{1-\cos\left(\frac{e}{m}Ht\right)\right\}$$

$$y=\frac{Xm}{eH^2}\left\{\frac{e}{m}Ht-\sin\left(\frac{e}{m}Ht\right)\right\}.$$

These equations show that the path of the ion is a cycloid, the generating circle of which has a diameter equal to $2\mathrm{X}m/e\mathrm{H}^2$, and rolls on the line $x=0$.

Suppose now that we have a number of ions starting from the plane $x=0$, and moving towards the plane $x=a$. The particles starting from $x=0$ describe cycloids, and the greatest distance they can get from the plane is equal to the diameter of the generating circle of the cycloid, *i.e.* to $2\mathrm{X}m/e\mathrm{H}^2$. (After reaching this distance they begin to approach the plane.) Hence if a is less than

the diameter of the generating circle, all the particles starting from $x=0$ will reach the plane $x=a$, if this is unlimited in extent; while if a is greater than the diameter of the generating circle none of the particles which start from $x=0$ will reach the plane $x=a$. Thus, if $x=0$ is a plane illuminated by ultra-violet light, and consequently the seat of a supply of negative ions, and $x=a$ a plane connected with an electrometer, then if a definite electric intensity is established between the planes, *i.e.*, if X be fixed, so that the rate of emission of negative ions from the illuminated plate is given, and if a is less than $2Xm/eH^2$, all the ions which start from $x=0$ will reach $x=a$. That is, the rate at which this plane receives an electric charge will be the same whether there is a magnetic field between the plate or not, but if a *is* greater than $2Xm/eH^2$, then no particle which starts from the plate $x=0$ will reach the plate $x=a$, and this plate will receive no charge. Thus the supply of electricity to the plate has been entirely stopped by the magnetic field. Thus, on this theory, if the distance between the plates is less than a certain value, the magnetic force should produce no effect on the rate at which the electrometer plate receives a charge, while if the distance is greater than this value the magnetic force would completely stop the supply of electricity to the plate. The actual phenomena are not so abrupt as this theory indicates. We find that when the plates are very near together the magnetic force produces a very slight effect, and thus an *increase* in the rate of charging of the plate. On increasing the distance we come to a stage where the magnetic force produces a great diminution in the rate of charging. It does not, however, stop it abruptly, there being a considerable range of distance, in which the magnetic force diminishes but does not destroy the current. At still greater distances the current to the plate under the magnetic force is quite inappreciable compared with that when there is no magnetic force. We should get this gradual instead of abrupt decay of the current if some of the particles, instead of all starting from rest, started with a finite velocity; in that case the first particles stopped would be those which started from rest. This would be when $a=2Xm/eH^2$. Thus if we measure the value of a when the magnetic force first begins to affect the leak to the electrometer we determine $2Xm/eH^2$, and as we can easily measure X and H, we can deduce the value of m/e.

By these methods J. J. Thomson determined the value of e/m for the negative ions produced when ultra-violet light falls on a metal plate, as well as for the negative ions produced by an incandescent carbon filament in an atmosphere of hydrogen (*Phil. Mag.* [5], 48, p. 547) as well as for the cathode rays. It was found that the value of e/m for the negative ions was the same in all these cases, and that it was a constant quantity independent of the nature of the gas from which the ions are produced and the means used to produce them. It was found, too, that this value was more than a thousand times the value of e/M, where e is the charge carried by an atom of hydrogen in the electrolysis of solutions, and M the mass of an atom of hydrogen. We have seen that this charge is the same as that carried by the negative ion in gases; thus since e/m is more than a thousand times e/M, it follows that M must be more than a thousand times m. Thus the mass of the negative ion is exceedingly small compared with the mass of the atom of hydrogen, the smallest mass recognized in chemistry. The production of negative ions thus involves the splitting up of the atom, as from a collection of atoms something is detached whose mass is less than that of a single atom. It is important to notice in connection with this subject that an entirely different line of argument, based on the Zeeman effect (*q.v.*), leads to the recognition of negatively electrified particles for which e/m is of the same order as that deduced from the consideration of purely electrical phenomena. These small negatively electrified particles are called electrons. The latest determinations of e/m for electrons available are given in the table in the next column.

It follows from electrical theory that when the electrons are moving with a velocity comparable with that of light their masses increase rapidly with their velocity. This effect has been detected by Kauffmann (*Gött. Nach.*, Nov. 8, 1901), who used the electrons shot out from radium, some of which move with velocities only a few per cent less than that of light. Other experiments on this point have been made by Bucherer (*Ann. der Phys.* 28, p. 513).

Values of e/m

Source of ions	Observer	Date	Method of determination	Value of e/m
Radium	Kaufmann	1901–02	Magnetic and electrostatic deflection	$1{\cdot}77\times10^7$
X-rays	Bestelmeyer	1907	Magnetic and electrostatic deflection (crossed fields)	$1{\cdot}72\times10^7$
Incandescent oxide	Bestelmeyer	1911	Magnetic deflection and potential difference	$1{\cdot}767\times10^7$
Incandescent oxide	Classen	1907	Magnetic deflection and potential difference	$1{\cdot}775\times10^7$
Ultra-violet light	Alberti	1912	Magnetic deflection and potential difference	$1{\cdot}756\times10^7$ $1{\cdot}766\times10^7$
Radium	Bucherer	1909	Magnetic and electrostatic deflection (crossed fields)	$1{\cdot}763\times10^7$
Radium	Woltz	1909	Magnetic and electrostatic deflection (crossed fields)	$1{\cdot}77\times10^7$
Radium	Neumann	1914	Magnetic and electrostatic deflection (crossed fields)	$1{\cdot}765\times10^7$
..	Fortrat	1912	Zeeman effect	$1{\cdot}763\times10^7$
..	Paschen	1916	Bohr's theory	$1{\cdot}765\times10^7$

Conductivity Produced by Ultra-violet Light. (*See* PHOTOELECTRICITY.)—The electrical effects produced by light have had such great influence on our views as to the nature of light and electricity that it is desirable to consider them in some detail. The discovery by Hertz (*Wied. Ann.* 31, p. 983), in 1887, that the incidence of ultra-violet light on a spark gap facilitates the passage of a spark, led to a series of investigations by Hallwachs, Hoor, Righi and Stoletow, on the effect of ultra-violet light on electrified bodies. These researches have shown that a freshly cleaned metal surface, charged with negative electricity, rapidly loses its charge, however small, when exposed to ultra-violet light, and that if the surface is insulated and without charge initially, it acquires a positive charge under the influence of the light. The magnitude of this positive charge may be very much increased by directing a blast of air on the plate. This, as Zeleny (*Phil. Mag.* [5], 45, p. 272) showed, has the effect of blowing from the neighbourhood of the plate negatively electrified gas, which has similar properties to the charged gas obtained by the separation of ions from a gas exposed to Röntgen rays or uranium radiation. If the metal plate is positively electrified, there is no loss of electrification caused by ultra-violet light.

This has been questioned, but very careful examination of the question by Elster and Geitel (*Wied. Ann.* 57, p. 24) showed that the apparent exceptions were due to the accidental exposure to reflected ultra-violet light of metal surfaces in the neighbourhood of the plate negatively electrified by induction, so that the apparent loss of charge was due to negative electricity coming up to the plate, and not to positive electricity going away from it. The ultra-violet light may be obtained from an arc-lamp, the effectiveness of which is increased if one of the terminals is made of zinc or aluminium, the light from these substances being very rich in ultra-violet rays; it may also be got very conveniently by sparking with an induction coil between zinc or cadmium terminals. Sunlight is not rich in ultra-violet light, and does not produce anything like so great an effect as the arc-light. Elster and Geitel, who have investigated with great success the effects of light on electrified bodies, have shown that the more electropositive metals lose negative charges when exposed to ordinary

light, and do not need the presence of the ultra-violet rays. Thus they found that amalgams of sodium or potassium enclosed in a glass vessel lose a negative charge when exposed to daylight, though the glass stops the small amount of ultra-violet light left in sunlight after its passage through the atmosphere. If sodium or potassium be employed, or, what is more convenient, the mercury-like liquid obtained by mixing sodium and potassium in the proportion of their combining weights, they found that negative electricity was discharged by an ordinary petroleum lamp. If the still more electro-positive metal rubidium is used, the discharge can be produced by the light from a glass rod just heated to redness; but there is no discharge till the glass is luminous.

Elster and Geitel arrange the metals in the following order for the facility with which negative electrification is discharged by light: rubidium, potassium, alloy of sodium and potassium, sodium, lithium, magnesium, thallium, zinc. With copper, platinum, lead, iron, cadmium, carbon and mercury the effects with ordinary light are too small to be appreciable. The order is the same as that in Volta's electro-chemical series. With ultra-violet light the different metals show much smaller differences in their power of discharging negative electricity than they do with ordinary light. Elster and Geitel found that the ratio of the photo-electric effects of two metals exposed to approximately monochromatic light depended upon the wave length of the light, different metals showing a maximum sensitiveness in different parts of the spectrum. This is shown by the following table for the alkaline metals. The numbers in the table are the rates of emission of negative electricity under similar circumstances. The rate of emission under the light from a petroleum lamp was taken as unity:—

	Blue	Yellow	Orange	Red
Rb	·16	·64	·33	·039
Na	·37	·36	·14	·009
K	·57	·07	·04	·002

The table shows that the absorption of light by the metal has great influence on the photo-electric effect, for while potassium is more sensitive in blue light than sodium, the strong absorption of yellow light by sodium makes it more than five times more sensitive to this light than potassium. Stoletow, at an early period, called attention to the connection between strong absorption and photo-electric effects. He showed that water, which does not absorb to any great extent either the ultra-violet or visible rays, does not show any photo-electric effect, while strongly coloured solutions, and especially solutions of fluorescent substances such as methyl green or methyl violet, do so to a very considerable extent; indeed, a solution of methyl green is more sensitive than zinc. Hallwachs (*Wied. Ann.* 37, p. 666) proved that in liquids showing photo-electric effects there is always strong absorption; we may, however, have absorption without these effects. Phosphorescent substances, such as calcium-sulphide, show this effect, as also do various specimens of fluor-spar. As phosphorescence and fluorescence are probably accompanied by a very intense absorption by the surface layers, the evidence is strong that to get the photo-electric effects we must have strong absorption of some kind of light, either visible or ultra-violet. The photo-electric effect seems to disappear immediately the light is cut off. Stoletow, who investigated this point, could not obtain any evidence of a finite interval between the incidence of the light and the attainment of the full photo-electric effect. Laurence and Bean (*Phys. Rev.* 29, p. 904, 1927) have shown that the time lap, if any, is less than 3×10^{-9} sec. both at starting and stopping the light.

If a conductor A is placed near a conductor B exposed to ultra-violet light, and if B is made the negative electrode and a difference of potential established between A and B, a current of electricity will flow between the conductors. The relation between the magnitude of the current and the difference of potential when A and B are parallel plates has been investigated by Stoletow (*Journal de physique*, 1890, 11, p. 469), von Schweidler (*Wien., Ber.*, 1899, 108, p. 273) and Varley (*Phil. Trans. A.*, 1904, 202, p. 439). The results of some of Varley's experiments are represented in the curves shown in fig. 10, in which the ordinates are the currents and the abscissae the potentials. It will be seen that when the pressure is exceedingly low the current is independent of the potential difference and is equal to the negative charge carried off in unit time by the electrons emitted from the surface exposed to the light. At higher pressures the current rises far above these values and increases rapidly with the potential difference. This is due to the electrons emitted by the illuminated surface acquiring under the electric field such high velocities that when they strike against the molecules of the gas through which they are passing they ionize them, producing fresh ions which can carry an additional current.

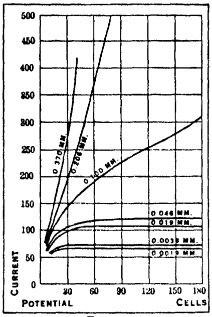

FIG. 10

The relation between the current and the potential difference in this case is in accordance with the results of the theory of ionization by collision. The electrons emitted from a body under the action of ultra-violet light start from the surface with a finite velocity. The velocity is not the same for all the electrons, nor indeed could we expect that it should be: for as Ladenburg has shown (*Ann. der Phys.*, 1903, 12, p. 558) the seat of their emission is not confined to the surface layer of the illuminated metal but extends to a layer of finite, though small, thickness. Thus the particles which start deep down will have to force their way through a layer of metal before they reach the surface, and in doing so will have their velocities retarded by an amount depending on the thickness of this layer. The variation in the velocity of the electrons is shown in the following table, due to Lenard (*Ann. der Phys.*, 1902, 8, p. 149).

	Carbon	Platinum	Aluminium
Electrons emitted with velocities between 12 and 8×10^7 cm. sec.	0·000	0·000	0·004
With velocities between 8 and 4×10^7 cm. sec.	0·049	0·155	0·151
With velocities between 4 and 0×10^7 cm. sec.	0·67	0·65	0·49
Electrons only emitted with the help of an external electric field	0·28	0·21	0·35
	1·00	1·00	1·00

If the illuminated surface is completely surrounded by an envelope of the same metal insulated from and completely shielded from the light, the emission of the negative electrons from the illuminated surface would go on until the potential difference V between this surface and the envelope became so great that the electrons with the greatest velocity lost their energy before reaching the envelope, *i.e.*, if m is the mass, e the charge on an electron, v the greatest velocity of projection, until $Ve=\frac{1}{2}mv^2$. The values found for V by different observers are not very consistent. Lenard found that V for aluminium was about 3 volts and for platinum 2. Millikan and Winchester (*Phil. Mag.*, July 1907) found for aluminium $V=\cdot738$. The apparatus used by them was so complex that the interpretation of their results is difficult.

An extremely interesting fact discovered by Lenard is that the velocity with which the electrons are emitted from the metal is independent of the intensity of the incident light. The number of electrons increases with the intensity, but the velocity of the individual electrons does not. It is worthy of notice that in other cases when negative electrons are emitted from metals, as for example when the metals are exposed to cathode rays, Canalstrahlen, or Röntgen rays, the velocity of the emitted electrons is independent of the intensity of the primary radiation which

excites them. The velocity is not, however, independent of the nature of the primary rays. Thus when light is used to produce the emission of electrons the velocity, as Ladenburg has shown, depends on the wave length of the light, increasing as the wave length diminishes. The velocity of electrons emitted under the action of cathode rays is greater than that of those ejected by light, while the incidence of Röntgen rays produces the emission of electrons moving much more rapidly than those in the cases already mentioned, and the harder the primary rays the greater is the velocity of the electrons.

The importance of the fact that the velocity and therefore the energy of the electrons emitted from the metal is independent of the intensity of the incident light can hardly be overestimated. It raises the most fundamental questions as to the nature of light and the constitution of the molecules. What is the source of the energy possessed by these electrons? Is it the light, or in the stores of internal energy possessed by the molecule? Let us follow the consequences of supposing that the energy comes from the light. Then, since the energy is independent of the intensity of the light, the electric forces which liberate the electrons must also be independent of that intensity. But this cannot be the case if, as is usually assumed in the electromagnetic theory, the wave front consists of a uniform distribution of electric force without structure, for in this case the magnitude of the electric force is proportional to the square root of the intensity.

On the emission theory of light a difficulty of this kind would not arise, for on that theory the energy in a luminiferous particle remains constant as the particle pursues its flight through space. Thus any process which a single particle is able to effect by virtue of its energy will be done just as well a thousand miles away from the source of light as at the source itself, though of course in a given space there will not be nearly so many particles to do this process far from the source as there are close in. Thus, if one of the particles when it struck against a piece of metal caused the ejection of an electron with a given velocity, the velocity of emission would not depend on the intensity of the light. There does not seem any reason for believing that the electromagnetic theory is inconsistent with the idea that on this theory, as on the emission theory, the energy in the light wave may, instead of being uniformly distributed through space, be concentrated in bundles which occupy only a small fraction of the volume traversed by the light, and that as the wave travels out the bundles get farther apart, the energy in each remaining undiminished.

Some such view of the structure of light seems to be required to account for the fact that when a plate of metal is struck by a wave of ultra-violet light, it would take years before the electrons emitted from the metal would equal in number the molecules on the surface of the metal plate, and yet on the ordinary theory of light each one of these is without interruption exposed to the action of the light. The fact discovered by E. Ladenburg (*Verh. d. deutsch. physik. Ges.* 9, p. 504) that the velocity with which the electrons are emitted depends on the wave length of the light suggests that the energy in each bundle depends upon the wave length and increases as the wave length diminishes.

This view was expressed in a very definite form by Planck, who proposed the theory that the energy of radiation is made up of units of finite size, the energy in a unit being equal to $h\nu$ where ν is the frequency of the light and h a constant, called Planck's constant, whose value in C.G.S. units is $6{\cdot}55\times10^{-27}$.

Though it was recognized from the first that the velocity of the electrons ejected by light increased with the frequency of the light it was some time before the technique of the experiments was sufficiently developed to determine whether the velocity or the energy of the electrons was a linear function of the frequency. Hughes (*Phil. Trans.* 212, p. 205, 1912) and Richardson and Compton (*Phil. Mag.* 24, p. 577, 1912) show that the second of these alternatives is the correct one and that the relation between v, the maximum velocity of the ejected electrons, and the frequency of the light

$$\tfrac{1}{2}mv^2 = k\nu - V_0e$$

where k is a constant and V_0 a potential characteristic of the substance emitting the electrons. Einstein suggested that k was equal to Planck's constant h and this was verified by Millikan in a very careful series of experiments (*Phys. Review*, 7, p. 355, 1916). So that

$$\tfrac{1}{2}mv^2 = h\nu - V_0e.$$

Thus no emission of electrons will take place unless ν is greater than ν_0 where $\nu_0 = V_0e/h$ is called the threshold frequency. The term V_0e represents the work spent in getting the electron out of the substance illuminated by the light; in the case of metals probably the bulk of this is accounted for by the attraction between the electron when just outside the surface and its image in the conducting surface; this requires an amount of work $e^2/4r$, when r is the distance of the electron from the surface, to be spent by the electron in getting away from the surface. If r equals 10^{-8} the radius of an atom, this effect would add $3{\cdot}6$ volts to V_0.

The value of the threshold wave lengths for metals in normal conditions (surfaces sand-papered but not otherwise treated) as given by Hamer (*Optical Soc. of Amer. Journal* ix. p. 251, 1924) are:

Ag.	Al.	Bi.	Graphite	Ca.	Cd.	Cu.	Fe.
3,390	3,590	2,980	2,615	4,000	3,130	2,665	2,870
Ni.	**Pb.**	**Pt.**	**Se.**	**Sn.**	**Th.**	**W.**	**Zn.**
3,050	2,980	2,780	2,670	3,180	3,460	2,615	3,420

The metals were *in valuo.*

Measurements such as those made by Pohl and Pringsheim (*Verh. d. Deutsch. Phys. Gesell.* xv. p. 173, 1913), show that the sum of the energies of the ejected electrons is but a small percentage of the energy of the light which ejects them.

The photo-electric effect is applied in the photo-electric cell to the measurement of very small intensities of light. The alkali metals have chiefly been used for this purpose and have proved very successful. The sensitiveness of these cells can be much increased by passing a slow discharge through them when a little hydrogen has been admitted into the cell. This causes the formation of a hydride, and probably turns the rest of the metal into a very sensitive colloidal form. The cell is then filled with an inert gas, such as argon, at a pressure of about 1 mm. This does not affect the surface of the metal and allows the current due to the photo-electric effect to be increased by ionization by collision.

Photo-electric Properties of Gases.—If light is able to eject electrons from the molecules of a gas it must clearly increase its conductivity, the residues of the molecules forming positive ions and the electrons being either free or attached to neutral molecules forming the negative ions. Early experiments on conductivity in this point gave rather contradictory results. It is now known that in most cases it requires light of shorter wave length to give a photo-electric effect than the majority of solids, and in consequence there is great danger of spurious effects due to electrons emitted by dust particles or by the walls of the vessel. Hughes (*Proc. Camb. Phil. Soc.* 15, 483, 1910) detected the presence of positive ions in air when it was exposed to the light emitted by an electric discharge through hydrogen if the light went through a fluorite window, though no such effect was produced if the light passed through quartz, which is not transparent for light of shorter wave length than 1,450. Palmer (*Phys. Rev.* 32, p. 1, 1911) also found ionization in air, oxygen and nitrogen from light which had passed through fluorite. Lenard and Ramsauer found that minute traces of impurities both gaseous and solid had an enormous effect on the ionization. Traces of ammonia and carbon dioxide increased the ionization for light through fluorite by 44 and 16 times respectively.

Stark (*Phys. Zeit.* x. p. 787, 1909) found marked ionization in various fluorescent vapours, such as those of anthracene, diphenylmethane, α naphthylamine and diphenylamine, by the light from a mercury lamp transmitted through quartz. This light can also ionize the vapours of the alkali metals.

Ionization by Collision.—When the ionization of the gas is produced by external agents such as Röntgen rays or ultra-violet light, the electric field produces a current by setting the positive

ions moving in one direction, and the negative ones in the opposite; it makes use of ions already made and does not itself give rise to ionization. In many cases, however, such as in electric sparks, there are no external agents to produce ionization and the electric field has to produce the ions as well as set them in motion. When the ionization is produced by external means the smallest electric field is able to produce a current through the gas; when, however, these external means are absent no current is produced unless the strength of the electric field exceeds a certain critical value, which depends not merely upon the nature of the gas, but also upon the pressure and the dimensions of the vessel in which it is contained. These variations in the electric field required to produce discharge can be completely explained if we suppose that the ionization of the gas is produced by the impact with its molecules of electrons, and in certain cases of positive ions, which under the influence of the electric field have acquired considerable kinetic energy. We have direct evidence that rapidly moving electrons are able to ionize molecules against which they strike, for the cathode rays consist of such electrons, and these when they pass through a gas produce large amounts of ionization.

Suppose, then, that we have in a gas exposed to an electric field a few electrons. These will be set in motion by the field and will acquire an amount of energy in proportion to the product of the electric force, their charge, and the distance travelled in the direction of the electric field between two collisions with the molecules of the gas. If this energy is sufficient to give them the ionizing property possessed by cathode rays, then when an electron strikes against a molecule it will detach another electron; this under the action of the electric field will acquire enough energy to produce electrons on its own account, and so as the electrons move through the gas their number will increase in geometrical progression. Thus, though there were but few electrons to begin with, there may be great ionization after these have been driven some distance through the gas by the electric field.

The number of ions produced by collisions can be calculated by the following method. Let the electric force be parallel to the axis of x, and let n be the number of electrons per unit volume at a place fixed by the co-ordinate x; then in unit time these electrons will make n/λ collisions with the molecules, if u is the velocity of an electron and λ its mean free path. When the electrons are moving fast enough to produce ions by collision their velocities are very much greater than those they would possess at the same temperature if they were not acted on by electrical force, and so we may regard the velocities as being parallel to the axis of x and determined by the electric force and the mean free path of the electrons. We have to consider how many of the nu/λ collisions which take place per second will produce ions. The ionization of a molecule will require a certain amount of energy, so that if the energy of the electron falls below this amount no ionization will take place, while if the energy of the electron exceeds this limit a collision might result in ionization. We shall suppose that a certain fraction of the number of collisions result in ionization and that this fraction is a function of the energy possessed by the electron when it collides against the molecules. This energy is proportional to $Xe\lambda$ when X is the electric force, e the charge on the electron, and λ the mean free path. If the fraction of collisions which produce ionization is $f(Xe\lambda)$ then the number of ions produced per cubic centimetre per second is $f(Xe\lambda)nu/\lambda$.

If the collisions follow each other with great rapidity so that a molecule has not had time to recover from one collision before it is struck again, the effect of collisions might be cumulative, so that a succession of collisions might give rise to ionization, though none of the collisions would produce an ion by itself. In this case f would involve the frequency of the collisions as well as the energy of the electron; in other words, it might depend on the current through the gas as well as upon the intensity of the electric field. We shall, however, to begin with, assume that the current is so small that this cumulative effect may be neglected.

Let us now consider the rate of increase, dn/dt, in the number of electrons per unit volume. In consequence of the collisions, $f(Xe\lambda)nu/\lambda$ electrons are produced per second; in consequence of the motion of the electrons, the number which leave unit volume per second is greater than those which enter it by $\frac{d}{dx}(nu)$; while in a certain number of collisions an electron will stick to the molecule and will thus cease to be a free electron. Let the fraction of the number of collisions in which this occurs be β. Thus the gain in the number of electrons is $f(Xe\lambda)nu/\lambda$, while the loss is $\frac{d}{dx}(nu)+\beta\frac{nu}{\lambda}$; hence

$$\frac{dn}{dt}=f(Xe\lambda)\frac{nu}{\lambda}-\frac{d}{dx}(nu)-\frac{\beta nu}{\lambda}.$$

When things are in a steady state $dn/dt=0$, and we have

$$\frac{d}{dx}(nu)=\frac{1}{\lambda}\{f(Xe\lambda)-\beta\}nu.$$

If the current is so small that the electrical charges in the gas are not able to produce any appreciable variations in the field, X will be constant and we get $nu=C\epsilon^{\alpha x}$, where $\alpha=\{f(Xe\lambda)-\beta\}/\lambda$. If we take the origin from which we measure x at the cathode, C is the value of nu at the cathode, *i.e.*, it is the number of electrons emitted per unit area of the cathode per unit time; this is equal to i_0/e if i_0 is the quantity of negative electricity coming from unit area of the cathode per second, and e the electric charge carried by an electron. Hence we have $nue=i_0\epsilon^{\alpha x}$. If l is the distance between the anode and the cathode, the value of nue, when $x=l$, is the current passing through unit area of the gas, if we neglect the electricity carried by negatively electrified carriers other than electrons. Hence $i=i_0\epsilon^{\alpha l}$. Thus the current between the plates increases in geometrical progression with the distance between the plates.

By measuring the variation of the current as the distance between the plates is increased, Townsend, to whom we owe much of our knowledge on this subject, determined the values of α for different values of X and for different pressures for air, hydrogen and carbonic acid gas (*Phil. Mag.* [6], 1, p. 198). Since λ varies inversely as the pressure, we see that α may be written in the form $p\phi(X/p)$ or $\alpha/X=F(X/p)$. The following are some of the values of α found by Townsend for air.

X Volts per cm.	Pressure ·17 mm.	Pressure ·38 mm.	Pressure 1·10 mm.	Pressure 2·1 mm.	Pressure 4·1 mm.
20	·24	..	..	..	..
40	·65	·34	..	..	..
80	1·35	1·3	·45	·13	..
120	1·8	2·0	1·1	·42	·13
160	2·1	2·8	2·0	·9	·28
200	..	3·4	2·8	1·6	·5
240	2·45	3·8	4·0	2·35	·99
320	2·7	4·5	5·5	4·0	2·1
400	..	5·0	6·8	6·0	3·6
480	3·15	5·4	8·0	7·8	5·3
560	..	5·8	9·3	9·4	7·1
640	3·25	6·2	10·6	10·8	8·9

We see from this table that for a given value of X, α for small pressures increases as the pressure increases; it attains a maximum at a particular pressure, and then diminishes as the pressure increases. The increase in the pressure increases the number of collisions, but diminishes the energy acquired by the electron in the electric field, and thus diminishes the chance of any one collision resulting in ionization. If we suppose the field is so strong that at some particular pressure the energy acquired by the electron is well above the value required to ionize at each collision, then it is evident that increasing the number of collisions will increase the amount of ionization, and therefore α and α cannot begin to diminish until the pressure has increased to such an extent that the mean free path of an electron is so small that the energy acquired by the electron from the electric field falls below the value when each collision results in ionization.

The value of p, when X is given, for which α is a maximum, is

proportional to X; this follows at once from the fact that α is of the form $X \cdot F(X/p)$. The value of X/p for which $F(X/p)$ is a maximum is seen from the preceding table to be about 420, when X is expressed in volts per centimetre and p in millimetres of mercury. The maximum value of $F(X/p)$ is about 1/60. Since the current passing between two planes at a distance l apart is $i_0\epsilon^{\alpha l}$ or $i_0\epsilon^{XlF(X/p)}$, and since the force between the plates is supposed to be uniform, Xl is equal to V, the potential between the plates; hence the current between the plates is $i_0\epsilon^{V \cdot F(X/p)}$, and the greatest value it can have is $i_0\epsilon^{V/60}$. Thus the ratio between the current between the plates when there is ionization and when there is none cannot be greater than $\epsilon^{V/60}$, when V is measured in volts. This result is based on Townsend's experiments with very weak currents; we must remember, however, that when the collisions are so frequent that the effects of collisions can accumulate, α may have much larger values than when the current is small. In some experiments made by J. J. Thomson with intense currents from cathodes covered with hot lime, the increase in the current when the potential difference was 60 volts, instead of being e times the current when there was no ionization, as the preceding theory indicates, was several hundred times that value, thus indicating a great increase in α with the strength of the current.

Townsend has shown that we can deduce from the values of α the mean free path of an electron. For if the ionization is due to the collisions with the electrons, then unless one collision detaches more than one electron the maximum number of electrons produced will be equal to the number of collisions. When each collision results in the production of an electron, $\alpha = 1\lambda$ and is independent of the strength of the electric field. Hence we see that the value of α when it is independent of the electric field, is equal to the reciprocal of the free path. Thus from the table we infer that at a pressure of 17 mm. the mean free path is $\frac{1}{325}$ cm.; hence at 1 mm. the mean free path of an electron is $\frac{1}{19}$ cm. Townsend has shown that this value of the mean free path agrees well with the value $\frac{1}{21}$ cm. deduced from the kinetic theory of gases for an electron moving through air. By measuring the values of α for hydrogen and carbonic acid gas Townsend and Kirby (*Phil. Mag.* [6], 1, p. 630) showed that the mean free paths for electrons in these gases are respectively $\frac{1}{11.8}$ and $\frac{1}{29}$ m. at a pressure of 1 mm. These results again agree well with the values given by the kinetic theory of gases.

If the number of positive ions per unit volume is m and v is the velocity, we have $nue + mve = i$, where i is the current through unit area of the gas. Since $nue = i_0\epsilon^{\alpha x}$ and $i = i_0\epsilon^{\alpha l}$ when l is the distance between the plates, we see that

$$nu/mv = \epsilon^{\alpha x}/(\epsilon^{\alpha l} - \epsilon^{\alpha x}),$$

$$\frac{n}{m} = \frac{v}{u} \cdot \frac{\epsilon^{\alpha x}}{\epsilon^{\alpha l} - \epsilon^{\alpha x}}.$$

Since v/u is a very small quantity we see that n will be less than m except when $\epsilon^{\alpha l} - \epsilon^{\alpha x}$ is small; *i.e.*, except close to the anode. Thus there will be an excess of positive electricity from the cathode almost up to the anode, while close to the anode there will be an excess of negative. This distribution of electricity will make the electric force diminish from the cathode to the place where there is as much positive as negative electricity, where it will have its minimum value, and then increase up to the anode.

The expression $i = i_0\epsilon^{\alpha l}$ applies to the case when there is no source of ionization in the gas other than the collisions; if in addition to this there is a source of uniform ionization producing q ions per cubic centimetre we can easily show that

$$i = i_0\epsilon^{\alpha l} + \frac{q\epsilon}{\alpha}(\epsilon^{\alpha l} - 1).$$

With regard to the minimum energy which must be possessed by an electron to enable it to produce ions by collision, Townsend (*loc. cit.*) came to the conclusion that to ionize air the electron must possess an amount of energy equal to that acquired by the fall of its charge through a potential difference of about 2 volts. This potential difference is called the ionizing potential; it has been determined by other methods for many gases. The values so obtained are very much greater than those deduced by Townsend from ionization by collision. Partysch (*Verh. deutsche. Phys. Gesell,* 14, 60, 192) has suggested that since there can be no ionization until the electron has acquired energy equal to that required to ionize the gas and that it cannot have acquired this until it has moved through a distance P/X where P is ionizing potential l in these formulae should be replaced by $l - \frac{P}{X}$.

If there is no external source of ionization and no emission of electrons from the cathode, then it is evident that even if some electrons happened to be present in the gas when the electric field were applied, we could not get a permanent current by the aid of collisions made by these electrons. For under the electric field, the electrons would be driven from the cathode to the anode, and in a short time all the electrons originally present in the gas and those produced by them would be driven from the gas against the anode, and if there was no source from which fresh electrons could be introduced into the gas the current would cease. The current, however, could be maintained indefinitely if the positive ions in their journey back to the cathode also produced ions by collisions, for then we should have a kind of regenerative process by which the supply of electrons could be continually renewed. To maintain the current it is not necessary that the ionization resulting from the positive ions should be anything like as great as that from the electrons. The mass of the positive ion is so much greater than that of an electron that in a collision between them only a very small fraction of the energy of the ion is transferred to the electron. To enable the positive ion to ionize, the electric field must be very intense, much more intense than that which experience shows is sufficient to maintain the discharge. Another method by which the current could be and is maintained is by the cathode emitting electrons under the impact of the positive ions driven against it by the electric field. J. J. Thomson has shown by direct experiment that positively electrified particles when they strike against a metal plate cause the metal to emit electrons (J. J. Thomson, *Proc. Camb. Phil. Soc.* 13, p. 212; Austin, *Phys. Rev.* 22, p. 312). If we assume that the number of electrons emitted by the plate in one second is proportional to the energy in the positive ions which strike the plate in that second, we can readily find an expression for the difference of potential which will maintain without any external ionization a current of electricity through the gas.

Two methods suggest themselves by which the electrons might be emitted from the cathode under the influence of the positive ions; the first of these is that at the cathode the positive ions are neutralized by the return of an electron; this gives rise to radiation and this radiation falling on the cathode will, by the photo-electric effect, produce an emission of electrons from the cathode. The second method is that since the positive ions possess a large amount of energy, their impact against the cathode will raise its temperature at the places where they strike and thus produce a thermionic emission. In the first method the emission of the electrons would depend primarily on the number of positive ions striking against the cathode, while in the second method it would depend upon the energy these ions possess as well as upon their number.

In addition to the effects taking place at the cathode there are other agencies which could produce the regenerative effect. The discharge through the gas produces soft X-ray radiation of much shorter wave length than any which can pass through glass or quartz, and which, in fact, is absorbed by a few millimetres of gas even at a comparatively low pressure. This radiation has the power of ionizing the gas and as it travels backwards from the electrons as well as forwards it supplies ions in the rear of the electrons and thus maintains the discharge.

We may thus divide the ionization in the self-sustained discharge into three categories:

(1) A volume ionization due to the collision of electrons.
(2) Processes taking place at the cathode.
(3) A volume ionization.

We shall consider more closely the ionization due to the collisions of electrons. If the electron is to ionize the gas it must

possess energy greater than that required to eject an electron from a molecule, let this energy be represented by Pe, where e is the charge on an electron, P is called the ionizing potential of the molecule. To be able to ionize the gas, the electron must possess energy due to a fall through a potential difference greater than P. As the energy of the electron increases, the chance of its ejecting an electron by collision does not increase indefinitely with the energy, it attains a maximum for a particular value of the energy after which it diminishes rapidly. From the theory of the transference of energy by collision it follows that the chance that an electron whose energy is measured by V should ionize on collision is proportional to

$$\frac{V-P}{1+\left(\frac{V-P}{Q}\right)^2}$$

where Q is the value of $V-P$ when the chance is a maximum, hence if ω represents the maximum chance, the chance when the energy is V is

$$\frac{2\omega\cdot\frac{V-P}{Q}}{1+\left(\frac{V-P}{Q}\right)^2} \tag{1}$$

This quantity is the one denoted by $f(Xe\lambda)$, hence by an equation previously given

$$\frac{d}{dx}nu=\frac{nu}{\lambda}\left\{\frac{2\omega\,\frac{V-P}{Q}}{1+\left(\frac{V-P}{Q}\right)^2}-\beta\right\} \tag{2}$$

$$=\theta\cdot\frac{nu}{\lambda} \tag{3}$$

where θ is written for the expression inside the bracket on the right-hand side of equation (2). The solution of equation (3) is

$$\log nu=\frac{\theta}{\lambda}x+c. \tag{4}$$

Let d be the distance between the electrodes, then when $x=d$ $nu=i/e$ where i is the current through unit area of the gas, and when $x=0$ $nu=i_0/_e$ where i_0 is the number of electrons emitted by unit area of the cathode in unit time. From these conditions we find from equation (4)

$$\log\frac{i}{i_0}=\frac{\theta d}{\lambda}. \tag{5}$$

The current carried by the positive ions at the cathode is equal to $i-i_0$, denoting this current by i, equation (5) may be written

$$\log\frac{(i_p+i_0)}{i_0}=\theta\cdot\frac{d}{\lambda} \tag{6}$$

The current i_0 is due to the impact of the positive charges, if it arises from a photo-electric effect due to the neutralization of the charges, i_0 will be a constant multiple of i_p. If each positive ion on neutralization emits radiation which ejects γ electrons from the cathode $i_0=i_p$ and (6) becomes

$$\log\frac{1+\gamma}{\gamma}=\frac{\theta d}{\lambda}. \tag{7}$$

When $V-P$ is small compared with Q, as it will be when the current through the gas is small, we see from (2) that

$$\theta=\frac{2\omega(V-P)}{Q}-\beta$$

and since $V=X\lambda$ we get from (7)

$$\log\frac{1+\gamma}{\gamma}=2\left(Xd-\frac{Pd}{\lambda}\right)\frac{\omega}{Q}-\beta\cdot$$

If E is the potential difference between the electrodes when the spark is passing $E=Xd$; hence

$$E=\frac{Q}{2\omega}\left(\log\frac{(1+\gamma)}{\gamma}+\beta\right)+\frac{Pd}{\lambda}. \tag{8}$$

Thus the potential difference required to spark across a distance d is a linear function of d/λ and cannot fall below a certain value. This is in agreement with the experimental results. It is to be noticed that d only occurs in the combination d/λ, since for the same gas λ is inversely proportional to p we see that E will be a function of dp, the quantity of gas between the electrodes is proportional to dp, hence we see that as long as this remains the same the sparking potential will be unaltered, whether we have a thin layer of gas at a high pressure or the same quantity in a thicker layer at a low pressure. This result, which holds with great accuracy, was discovered by Paschen and is known as Paschen's Law.

Let us now turn to the case of very short sparks: since the maximum value of θ is $\omega-\beta$ it follows from (7) that d/λ cannot be less than $\frac{1}{\omega-\beta}\log\frac{1+\gamma}{\gamma}$ hence if the photo-electric effect were the only agency at work it would be impossible to produce sparks shorter than a certain critical length. This would not necessarily be true if the emission of electrons from the cathode were partly thermionic for then γ would not be constant but would depend on the energy of the positive ion when it struck the cathode; this would increase with E. Let us suppose for example that γ is proportional to E, then since when γ is large

$$\log\left(\frac{1+\gamma}{\gamma}\right)=\frac{1}{\gamma}$$

the equation (7) would take the form

$$\frac{1}{\gamma}=\frac{d}{\lambda}\theta$$

or since γ is proportional to E

$$Ed\theta/\lambda=\text{a constant.}$$

Thus, though E would increase rapidly when d/λ is small there would be no critical value of d/λ below which no discharge would take place. The experiments made on short sparks seem in accordance with this view. Let us now consider the effect that would be produced by radiation excited by the discharge; if the ionization due to this per unit volume is equal to Qp when p is the density of the gas, in this case instead of equation (3) we have

$$\frac{d}{dx}(nu)=\theta\frac{nu}{\lambda}+Qp.$$

The solution when Q is constant is

$$nu=\frac{-Qp\lambda}{\theta}+C_{i_0\epsilon}\frac{\theta x}{\lambda}\cdot$$

If i is the current through the gas the electron current at the cathode, $nu=i/e$ when $x=d$ and $i_{0/e}$ when $x=0$, hence

$$\frac{i}{e}=\frac{Qp\lambda}{\theta}\left(\epsilon\frac{\theta d}{\lambda_{-1}}\right)+\frac{\omega}{\epsilon}e\frac{\theta d}{\lambda}\cdot \tag{1}$$

When there are neither photo-electric nor thermionic effects at the cathode, $i_0=0$ and

$$\frac{i}{e}=\frac{Qp\lambda}{\theta}\left(\epsilon\frac{\theta d}{\lambda_{-1}}\right) \tag{2}$$

Now $Q'p/(i\theta/e\lambda)$ is the ratio of the ionization due to radiation to that due to collisions made by the electrons and this is usually a very small quantity; let us denote it by $1/\gamma$. Then from (2)

$$\frac{\theta d}{\lambda}=\log(1+\gamma)$$

a relation of exactly the same form as that we obtained when we supposed that the only volume ionization was that due to collision, but that this was supplemented by emission of electrons from the cathode. Hence for long sparks the relation between spark potential and spark length will be the same on either theory. For very short spark lengths, we see from (2) that

$$\frac{i}{e} = Qpd \tag{3}$$

If the energy in the radiation is proportional to the work put into the discharge Q is proportional to Vi let Q$=p$Vi, then from (3)

$$V = \frac{1}{pepd}$$

Thus the potential difference required to produce a very short spark varies inversely as the spark length; we see that in this case also Paschen's law holds since V is a function of pd. Since the spark potential is infinite when the spark length is infinite and also when it is zero, there must be some length, which by Paschen's law will be inversely proportional to the pressure when the spark potential is a minimum; this potential is called the critical spark potential and the corresponding spark length the critical spark length. Since all the theories give practically the same results for long sparks it would seem that the decision between them must be made on short sparks, *i.e.*, on sparks shorter than the critical spark length.

Hitherto we have supposed that the electric force is constant between the electrodes, but it is easy to see that when the spark length is greater than the critical value the discharge in a non-uniform field might be produced by a smaller potential difference than in a uniform one.

For suppose that C represents the cathode, A the anode, B a plane whose distance from C is equal to l, the critical spark length. If a potential difference equal to the critical potential exists between C and B, then this region can furnish a continuous supply of electrons and all that is necessary to maintain the discharge is that the electric force from B to A should be great enough to remove the electrons as fast as they are produced and prevent a continuous increase in the number of electrons between B and A, which would tend to stop the discharge. The force required to do this need not be large enough to make the electrons produce other electrons by collisions, thus in consequence of the smallness of the force between B and A the potential difference may be much smaller than if the field were uniform. The potential difference between B and A may be calculated from the expression given for the space charge effect; it will be seen that the potential difference is proportional to $i^{\frac{1}{2}}$ and l where i is the current and l=AB; thus it increases more quickly with the distance than if the field were uniform. After a certain value of l the electric force will be great enough to cause ionization by collision and the field may again become uniform. The want of uniformity in the field requires in conformity with the equation $dX/dn = 4\pi\rho$ an accumulation of ions. Until these are available the field must be uniform and therefore the potential difference required to spark greater than that necessary after the ions have accumulated.

We have evidence of this in what is called the "lag" in the discharge; in many cases there is a considerable interval between the application of the electric field and the passage of the spark. This may be regarded as the time necessary for the ions to accumulate in sufficient numbers to produce the want of uniformity in the field necessary to produce the diminution in the spark potential. Warburg has shown that the lag is diminished when the cathode is illuminated by ultra-violet light, while with Röntgen rays which ionize the gas the illumination of the gas without that of the cathode has been found by Elster to diminish the lag. Warburg showed that when the ions were removed by a magnet as fast as they were produced the lag was increased very greatly. Even when the sparks are short we should expect that non-uniform field would produce the discharge with a smaller potential difference than a uniform one. For the sooner the electrons coming out of the cathode acquire enough energy to ionize by collision the more electrons will they produce before they reach the anode. From this point of view it is thus more advantageous to have the electric force larger at the cathode and smaller at the anode than to have it uniform even though the average value remains the same. This non-uniform electric force will involve a finite density of ions in the path of the discharge and therefore a finite current density, so that we should expect that when the discharge has got into a steady state and is passing with the minimum potential difference the current density must have a definite value which will increase with the pressures.

This is in accordance with the behaviour of the discharge, for if we apply to the electrodes a considerable potential difference but one not sufficient to produce a discharge at atmospheric pressure and then gradually reduce the pressure until the discharge begins to pass, as first it only comes from a very small area of the cathode as the pressure is reduced this area increases until it covers the whole of the cathode, this increase in the area decreases the current density for the total current does not increase in anything like the same proportion.

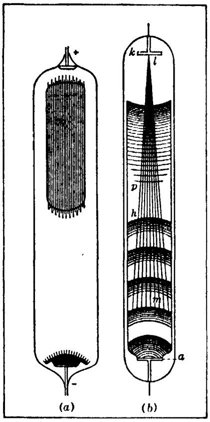

FIG. 11

Conduction Through Gases at Low Pressures.—The inequality of the electric field in the gas when a continuous discharge is passing through it is very obvious when the pressure of the gas is low. In this case the discharge presents a highly differentiated appearance of which a type is represented in fig. 11. Starting from the cathode we have a thin velvety luminous glow in contact with the surface of the metal. This glow is often called the *first cathode layer*. Next this we have a comparatively dark space whose thickness increases as the pressure diminishes; this is called the *Crookes' dark space*, or the *second cathode layer*. Next this we have a luminous position called the *negative glow* or the *third cathode layer*. The boundary between the second and third layers is often very sharply defined. Next to the third layer we have another dark space called the *Faraday dark space*. Next to this and reaching up to the anode is another region of luminosity, called the *positive column*, sometimes (as in fig. 11, *a*) continuous, sometimes (as in fig. 11, *b*) broken up into light or dark patches called *striations*. The dimensions of the Faraday dark space and the positive column vary greatly with the current passing through the gas and with its pressure; sometimes one or other of them is absent. These differences in appearances are accompanied by great differences in the strength of the electric field. The magnitude of the electric force at different parts of the discharge is represented in fig. 12, where the ordinates represent the electric force at different parts of the tube, the cathode being on the right. We see that the electric force is very large indeed between the negative glow and the cathode, much larger than in any other part of the tube. It is not constant in this region, but increases as we approach the cathode. The force reaches a minimum either in the negative glow itself or in the part of the Faraday dark space just outside, after which it increases towards the positive column. In the case of a uniform positive column the electric force along it is constant until we get quite close to the anode, when a sudden change, called the *anode fall*, takes place in the potential.

The difference of potential between the cathode and the negative glow is called the *cathode potential fall* and is found to be constant for wide variations in the pressure of the gas and the current passing through, provided the whole of the cathode is not covered with the glow. It increases, however, considerably when the current through the gas exceeds a certain critical value, just sufficient to cover the whole of the cathode with the glow, this value depends among other things on the size of the cathode. The cathode fall of potential is shown by experiment to be very approximately equal to the minimum potential difference required to produce a spark. The following table contains a comparison of the measurements of the cathode fall of potentials in various

gases made by Warburg (*Wied. Ann.*, 1887, 31, p. 545, and 1890, 40, p. 1), Capstick (*Proc. Roy. Society*, 1898, 63, p. 356); and Strutt (*Phil. Trans.*, 1900, 193, p. 377); and the measurements by Strutt of the smallest difference of potential which will maintain a spark through these gases.

Gas	Cathode fall in volts				Least potential difference required to maintain a spark
	Platinum electrodes			Aluminium electrodes	
	Warburg	Capstick	Strutt	Warburg	Strutt
Air	340–350	..	..	..	341
H_2	About 300	298	..	168	302–308
O_2	..	369	..	..	..
N_2	230 if free from oxygen	232	..	207	251
Hg vapour	340	..	..	..	..
Helium	..	..	226	..	261 326
H_2O	..	469	..	..	..
NH_3	..	582	..	..	..

Thus in the cases in which the measurements could be made with the greatest accuracy the agreement between the cathode fall and the minimum potential difference is very close. The cathode fall depends on the material of which the terminals are made, as is shown by the following table due to Mey (*Verh. deutsch. physik. Gesell.*, 1903, 5, p. 72).

Gas	Electrode										
	Pt	Hg	Ag	Cu	Fe	Zn	Al	Mg	Na	Na-K	K
O_2	369	..	..	..	..	..	..	..	..	..	..
H_2	300	..	295	280	230	213	190	168	185	169	172
N_2	232	226	..	..	..	..	..	207	178	125	170
He	226	..	..	..	..	..	..	..	80	78·5	69
Argon	167	..	..	..	..	..	100	..	..	..	..

The dependence of the minimum potential required to produce a spark upon the metal of which the cathode is made has not been clearly established, some observers being unable to detect any difference between the potential required to spark between electrodes of aluminium and those of brass, while others thought they had detected such a difference. It is only with sparks not much longer than the critical spark length that we could hope to detect this difference. When the current through the gas exceeds a certain critical value depending among other things on the size of the cathode, the cathode fall of potential increases rapidly and at the same time the thickness of the dark spaces diminishes. We may regard the part of the discharge between the cathode and the negative glow as a discharge taking place under minimum potential difference through a distance equal to the critical spark length. An inspection of fig. 12 will show that we cannot regard the electric field as constant even for this small distance.

Electric Force in Cathode Dark Space.—The cathode dark space, which is very conspicuous when the pressure of the gas is low, gives us a picture of a discharge passing with the minimum potential difference, the study of which throws a great deal of light on the mechanism of the spark discharge.

In the first place the electric force in the dark space is not constant but as we might expect is greatest close to the cathode. Aston (*Proc. Roy. Soc.*, 84A, p. 526), who has made many experiments on this point, finds that for the normal discharge the electric force at any point in the dark space is directly proportional to the distance of the point from the end of the dark space. Thus if the thickness of the dark space is d the force at a distance x from the cathode is equal to $C(d-x)$, if this is the value of force the difference of potential between the cathode and the end of the dark space is $\frac{1}{2}Cd^2$, this difference is called the cathode fall of potential, we shall denote it by K, the force at the point x is thus $2K(d-x)/d^2$. From the equation $dX/dx=4\pi\rho$ it follows that the density of the electrification in the dark space is positive and constant and equal to $K2\pi d^2$. Now d varies inversely as the pressure of the gas so that the density of the electrification varies directly as the square of the pressure.

The cathode fall of potential depends upon the material of the electrode and the nature of the gas. It is in many cases very sensitive to impurities either in the metal of the cathode or in the gas; traces of alkali metals on the cathode or of water vapour

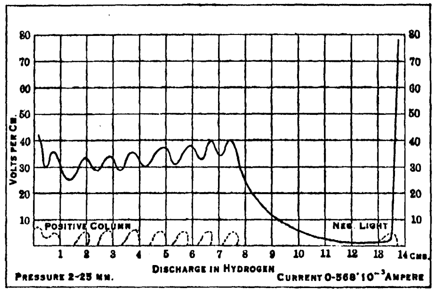

FIG. 12

in the gas produce especially large effects, and it is important in making measurements on this quantity to heat the cathode so as to free it from the layers of gas with which it may happen to be coated. The current density i_n in the normal discharge is also a quantity of fundamental importance depending on the gas and on the electrode. With plane electrodes i_n varies as the square of the pressure, with cylindrical electrodes it is proportional to the pressure.

Günter-Schultze who has made most important investigations on the dark space gives the following values for K_n in volts and for i_n in amperes per square centimetre at 1 mm. pressure (*Zeit. f. Physik.* 20, 1, 1923).

	Aluminium electrode		Iron electrode	
Gas	K_n	$i_n \times 10^6$	K	$i_n \times 10^6$
He	153	1·072	161	1·187
Ne	145	1·81	153	2·00
Ar	150	14·07	166	15·5
N	215	38·4	256	42·3
H	192	9·00	250	9·96
O	250	54·7	326	60·6

The normal current densities in the different gases vary much more than the critical potentials.

The thickness of the dark space, as long as the gas and electrode are the same, varies as long as the discharge is normal inversely as the pressure; the product pd depends however upon the gas and upon the electrode, as the following table due to Günter-Schultze shows, p being measured in millimetres of mercury and d in centimetres.

Gas	Cathode	pd.
He	Al	1·32
He	Fe	1·66
Ne	Al	·637
Ne	Fe	·722
Argon	Al	·285
Argon	Fe	·356
N	Al	·305
N	Fe	·419
H	Al	·724
H	Fe	·900

Günter-Schultze (*l.c.*) finds that the current density i, the potential fall K and the thickness of the dark space d are connected by a relation similar to that which holds for the space charge, viz.:

$$i=\frac{\sqrt{2}}{9\pi}\int\frac{e}{n}\cdot\frac{K^{\frac{3}{2}}}{d^2}$$

when M is the mass of the positive ion and e its charge. It may be pointed out that both a relation of this kind and Aston's law of force in the dark space would follow from the supposition that the ionization is constant throughout the dark space and that the current is carried by the positive ions. Günter-Schultze has shown that the values of K for different metals in the same gas are closely related to their photoelectric "threshold" potentials.

The preceding remarks apply only when the discharge is normal *i.e.*, when the cathode is large enough to permit the current to go through the tube without exceeding the normal current density and also when the space surrounding the cathode is large enough to allow the dark space to be fully developed and not interrupted by the walls of the tube. If the cathode is constricted the cathode potential fall increases rapidly just for the same reason that the spark potential increases rapidly when the spark length is reduced below the critical value. When the current is increased until the glow covers the whole of the cathode and the current density is necessarily greater than the normal, the cathode fall increases as the current increases while the thickness of the dark space diminishes. Aston (*Proc. Roy. Soc.*, 86, p. 178) gives the following empirical relations between d, the thickness of the dark space, K, the potential fall, i, the current and p, the pressure, when the discharge is not normal.

$$d=\frac{A}{P}+\frac{B}{\sqrt{i}}$$

$$K=E+\frac{F\sqrt{i}}{p}$$

where A, B, E, F are constants depending on the electrode and on the gas. Günter-Schultze gives as an empirical relation holding at constant pressure

$$K=(\text{Constant})\ i^{\frac{1}{2}}.$$

The Negative Glow.—Let us now consider the region just beyond the dark space. At the end of the dark space there will be a current of electrons some of which have started from the cathode and have acquired the energy due to the cathode fall of potential, others which have originated in the dark space itself will not have so much energy. There will thus be a stream of energy passing out into the adjacent region. This energy will be sufficient to ionize a large number of molecules without any help from outside. The local field has not to supply energy to ionize the gas but merely to give a drift to ions made without its assistance. For this a very small field will suffice and in the negative glow the field is so small that there is often not a difference of potential of a volt from one end to the other. Thus to produce a spark whose length is equal to the dark space plus the length of the negative glow requires hardly any greater potential difference than to produce one whose length is equal to the dark space.

The stream of electrons as it passes through the negative glow is continually losing energy and after going a certain distance has lost so much that it is no longer able to ionize the gas. When this occurs the electrons which come out of the glow will be moving in a region where there is no ionization and no positive ions to balance the charge on the electron. There will thus be a space charge effect and the potential will rise according to the law

$$V\alpha(ix^2)^{\frac{2}{3}}$$

where i is the current and x the distance from the negative glow. Until x is large enough to make V equal to the resonance potential (*q.v.*) of the gas there will be no luminosity. This region is the Faraday dark space; when V equals one of the resonance potentials luminosity will begin but there will be no ionization until V reaches the ionization potential of the gas. Then ionization will begin and the potential will not increase so rapidly as it did in the Faraday dark space. It may, however, still continue to increase and under certain conditions may rise considerably above the ionization potential.

In this case the electrons may have acquired so much energy that like those in the negative glow they are able to ionize with little or no further assistance from the local field and we shall have a region analogous to the negative glow where the electric force is very small. The energy of the electrons will be exhausted after passing through a certain thickness and then we shall have a region corresponding to the Faraday dark space in which the electric field increases until another negative glow is produced, and the cycle begins again. Thus in this case the discharge would consist of a regular alternation of bright and dark regions such as we have in the striated positive column.

There is, however, another way in which the charge may be maintained. The electric field instead of being variable producing a large supply of ions in some places and none in others, might be constant throughout producing just enough new electrons to supply the loss of the old ones due to combination with positive ions, attachment to molecules, diffusion to the sides of the discharge tube, and other causes.

From a previous equation we see that the chance of an electron detaching another electron by a collision is

$$\frac{2w}{Q}(X\lambda-P)$$

If the chance that the electron should from one or the other of the causes just mentioned be lost at the collision be β then if

$$\frac{2w}{Q}(X\lambda-P)=\beta$$

the losses will be balanced by the gains and a shady state maintained. Thus if

$$X=\frac{P}{\lambda}+\frac{\beta}{\lambda}\frac{Q}{2w}$$

a steady discharge is possible, the conditions now do not vary along this part of the discharge, and it would show all the characteristics of the uniform positive column.

Whether the discharge is striated or continuous will be determined by the condition that the discharge will tend to pass with the minimum potential difference; the positive column will be continuous if the potential difference is less for this type of discharge than for the striated one while if it is greater the discharge will be striated. So many factors have to be taken into account that the problem of determining which of these forms of discharge might be expected to give the smaller potential difference is an exceedingly complicated one. We shall only give some quite general considerations to show that we might expect the advantage to change from one form to the other under certain changes in the conditions. The criterion which determines whether the discharge is striated or continuous is whether the change from the striated to the continuous form would increase or decrease the potential difference on a given length of the column, or what amounts to the same thing whether the force in the continuous column is less or greater than the average force in the striated one. The conditions which might be expected to increase the force in the continuous column relatively to that in the striated may be deduced by the consideration of equation (7).

We shall confine ourselves to the effect of the term represented by β for changes in λ would affect the striated column in the same direction though not necessarily to the same extent. The term in β is proportional to the loss of electrons in various ways; some of these ways, such as the loss by the diffusion of electrons which, as it is larger in small tubes than in large, makes the electric force necessary to sustain the discharge greater in small tubes than in large, will affect the striated discharge in the same way. It will make the potential due to the space charge effect increase more rapidly with the distance when electrons diffuse to the sides as those which remain will have to be speeded up to carry the same current. There is, however, another source of loss of electrons which is greater in the continuous discharge than in the striated one, for along the continuous discharge there are as many positive ions as electrons and thus there is a very considerable loss of electrons due to their recombination with the positive ions. This does not occur to the same extent in the striated discharge as in the Faraday dark spaces which form part of the

striated discharge. There are under certain conditions no positive ions and thus no loss of electrons from recombination. Thus we see that there are certain features in the striated discharge which may under special circumstances compensate for the potential in this type of discharge having to increase beyond the minimum required to produce ionization, and thus cause the discharge to pass in the striated form.

The positive column is often by far the most conspicuous part of the discharge, the thickness of Crookes' dark space, and of the negative glow do not depend on the distance between the cathode and anode in the discharge tube and if this is great practically the whole length of the discharge may consist of the positive column. Thus for example when a spark passes through air at atmospheric pressure the dark space and the negative glow do not extend beyond a fraction of a millimetre, all the rest of the spark is positive column.

In one very interesting form of discharge known as the electrodeless ring discharge the positive column constitutes the whole of the discharge; there is no dark space, and no negative glow. This type of discharge may be produced by pulling a cylindrical tube containing gas at a low pressure inside a solenoid through which rapidly alternating currents such as those produced by discharging a Leyden jar are passing. These alternating currents produce by electromagnetic induction electric forces in the exhausted tubes; the direction of these forces is tangential to circles having their centres along the axis of the solenoid and their planes at right angles to it. Thus the lines of electric force through the rarefied gas form closed circles round which the electrons circulate. No regenerative effect, such as occurs at the cathode in the ordinary type of discharge is required as the electrons are not taken out of the gas. Ionization by electronic-collision alone is thus sufficient to maintain the discharge. The discharge under these circumstances forms a brightly luminous ring which is in general of uniform luminosity. J. J. Thomson has shown that in hydrogen this ring sometimes shows well marked striations, and also that under certain conditions large currents may pass through the gas without showing more than a mere trace of luminosity.

The connection between the potential difference and the spark length has been made the subject of a large number of experiments. The first measurements were made by Lord Kelvin in 1860 (*Collected Papers on Electrostatics and Magnetism*, p. 247); subsequent experiments have been made by Baille (*Ann. de chimie et de physique*, 5, 25, p. 486), Liebig (*Phil. Mag.* [5], 24, p. 106), Paschen (*Wied. Ann.* 37, p. 79), Peace (*Proc. Roy. Soc.*, 1892, 52, p. 99), Orgler (*Ann. der Phys.* 1, p. 159), Strutt (*Phil. Trans.* 193, p. 377), Bouty (*Comptes rendus*, 131, pp. 469, 503), Earhart (*Phil. Mag.* [6], 1, p. 147), Carr (*Phil. Trans.*, 1903), Russell (*Phil. Mag.* [5], 64, p. 237), Hobbs (*Phil. Mag.* [6], 10, p. 617), Kinsley (*Phil. Mag.* [6], 9, 692), Ritter (*Ann. der Phys.* 14, p. 118). The results of their experiments show that for sparks considerably longer than the critical spark length, the relation between the potential difference V and the spark length l may be expressed when the electrodes are large with great accuracy by the linear relation $V=c+blp$, where p is the pressure and c and b are constants depending on the nature of the gas. When the sparks are long the term blp is the most important and the sparking potential is proportional to the spark length. Though there are considerable discrepancies between the results obtained by different observers, these indicate that the production of a long spark between large electrodes in air at atmospheric pressure requires a potential difference of 30,000 volts for each centimetre of spark length. In hydrogen only about half this potential difference is required, in carbonic acid gas the potential difference is about the same as in air, while Ritter's experiments show that in helium only about one-tenth of this potential difference is required. From a previous equation the coefficient of l in the expression for the spark potential is P/λ where P is the potential of the gas and λ the free path of the electron. A very complete account of the various determinations of P is given in K. T. Compton and Mohler's report on Critical Potentials (*Bulletin National Research Council*, U.S.A. Sept. 1924). P is about 16 volts for H_2 and O_2, 17 for N_2 and 25 for H_e. Since experiments on the spark potential give P/λ when P is known, λ can be deduced.

When the electric field is not uniform, as for example when the discharge takes place between spherical electrodes, Russell's experiments show that the discharge takes place as soon as the maximum electric force in the field between the electrodes reaches

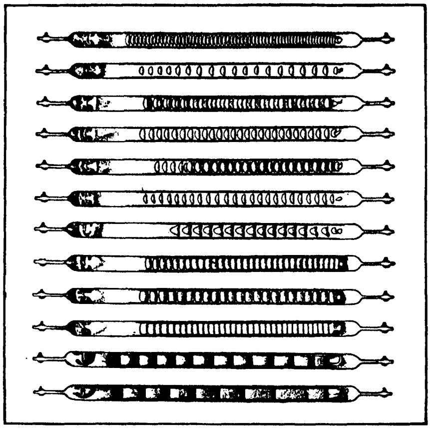

FIG. 13

a definite value, which he found was for air at atmospheric pressure about 38,000 volts per centimetre.

Striated Discharge.—We have already described the general appearance of the discharge through gases at low pressures. (*See* p. 259.) The striated form of discharge is, however, so striking and beautiful that it deserves more detailed consideration. Some forms of this are represented in fig. 13, which is taken from a paper by De la Rue and Müller (*Phil. Trans.*, 1878, Pt. 1). This type of discharge only occurs when the current and the pressure of the gas are between certain limits. It is most beautifully shown when a Wehnelt cathode is used and the current is produced by storage cells, as this allows us to use large currents and to maintain a steady potential difference between the electrodes. The striations are in consequence very bright and steady. The facts which have been established about these striations are as follows: The distance between the bright parts of the striations is greater at low pressures than at high; it depends also upon the diameter of the tube, increasing as the diameter of the tube increases. If the discharge tube is wide at one place and narrow in another the striations will be closer together in the narrow parts than in the wide. The distance between the striations depends on the current through the tube. The relation is not a very simple one, as an increase of current sometimes increases while under other circumstances it decreases the distance between the striations. (*See* Willows, *Proc. Camb. Phil. Soc.* 10. p. 302.) The electric force is not uniform along the striated discharge, but is greater in the bright than in the dark parts of the striation.

An example is shown in fig. 16, due to H. A. Wilson, which shows the distribution of electric force at every place in a striated discharge. In experiments made by J. J. Thomson (*Phil. Mag.*, Oct., 1909), using a Wehnelt cathode, the variations in the electric force were more pronounced than those shown in fig. 12. The electric force in this case changed so greatly that it actually became negative just on the cathode side of the bright part of the striation. Just inside the striation on the anode side it rose to a very high value, then continually diminished towards the bright side of the next striation when it again increased. This distribution of electric force implies that there is great excess of negative elec-

tricity at the bright head of the striation, and a small excess of positive everywhere else. The temperature of the gas is higher in the bright than in the dark parts of the striations. Wood (*Wied. Ann.*, 49, p. 238), who has made a very careful study of the distribution of temperature in a discharge tube, finds that in those tubes the temperature varies in the same way as the electric force, but that this temperature (which it must be remembered is the average temperature of all the molecules and not merely of those which are taking part in the discharge) is by no means high; in no part of the discharge did the temperature in his experiments exceed 100° C.

Aston (*Proc. Roy. Soc.*, 80, p. 45, 1908; 84, p. 531, 1911), has discovered in helium and hydrogen a second dark space close to the cathode of much smaller thickness than the Crookes' dark space; it is especially noticeable in helium. Unlike the Crookes' space the thickness of this does not change with the pressure, but it increases when the current through the tube diminishes.

Distribution of Luminosity in the Discharge.—As will be gathered from the preceding account the amount of visible light given out by the discharge varies very much from one part to another, although all the parts are traversed by the same current. Though the dark spaces do not emit much visible light they do emit radiation though this is of much smaller wave length than that in the visible part of the spectrum. Again Seeliger and his colleagues have shown that even in the Crookes' dark space some lines due to the gas in the tube may be present even at some distance from the negative glow. The emission of visible light is not a necessary consequence of ionization; we can have ionization without appreciable luminosity and we can also have bright luminosity without ionization. The greater part of the light in the visible part of the discharge seems to arise not from atoms or molecules which have been ionized but from those which have received some energy from electrons which though it is not sufficient to detach an electron from the atom is sufficient to displace the electron to a new position of equilibrium in the atom, and it is the return from the old to the new which is responsible for the emission of light.

The question of luminosity in the discharge is one which is primarily concerned with the mechanism of radiation and is most appropriately considered under spectroscopy.

Short Sparks.—Some very interesting experiments on the potential difference required to produce exceedingly short sparks have been made by Earhart, Hobbs and Kinsley; the length of these sparks was comparable with the wave length of sodium light. With sparks of these lengths it was found that it was possible to get a discharge with less than 330 volts, the minimum potential difference in air. The results of these observers show that there is no diminution in the minimum potential difference required to produce discharge until the spark length gets so small that the average electric force between the electrodes amounts to about one million volts per centimetre. When the force rises to this value a discharge takes place even though the potential difference is much less than 330 volts; in some of Earhart's experiments it was only about 2 volts. This kind of discharge is determined not by the condition that the potential difference should have a given value, but that the electric force should have a given value. Another point in which this discharge differs from the ordinary one is that it is influenced entirely by the nature of the electrodes and not by the nature or pressure of the gas between them, whereas the ordinary discharge is in many cases not affected appreciably by changes in the metal of the electrodes, but is always affected by changes in the pressure and character of the gas between them. Kinsley found that when one of these small sparks passed between the electrodes a kind of metallic bridge was formed between them, so that they were in metallic connection, and that the distance between them had to be considerably increased before the bridge was broken. Almy (*Phil. Mag.*, Sept. 1908), who used very small electrodes, was unable to get a discharge with less than the minimum spark potential even when the spark length was reduced to one-third of the wave length of sodium light. He suggests that the discharges obtained with larger electrodes for smaller voltages are due to the electrodes being dragged together by the electrostatic attraction between them.

Experiments bearing on this point have recently been made by Lilienfeld (*Zeit. f. Phys.* xv., p. 46, 1923); Millikan and Eyring (*Phys. Review*, xxvii., p. 51, 1926); Rother (*Ann. der Phy.* 81, p. 317, 1926); De Bruyne (*Phil. Mag.*, 5 p. 574, 1928); and del Rosario (*Journal Franklin Society* 203, p. 243) who have experimented with very high vacua (at pressures less than 10^{-6} mm.) and with cathodes carefully freed from gas. When the electron force at the cathode is of the order of a million volts per centimetre currents flow from the cathode. Lilienfeld and De Bruyne attribute them to electrons being torn from the metal by the strong electric field, del Rosario to the presence of residual gas. It would seem that even if the electrons could not be dragged out of the metal by the electric force an electric current should be able to pass across a vacuum if the potential difference between the electrodes were very large. For suppose there was a casual electron between the electrodes, this would be driven by the electric field against the anode, the impact would produce Röntgen rays, those falling on the cathode would produce an emission of electrons by the photoelectric effect. If the energy given to the electron by the field were great enough to make the Röntgen rays cause the emission of one or more electrons the discharge would be self-sustained. This effect would depend on the potential difference between the electrodes while the extraction of electrons by the electric force would depend on the electric force at the cathode.

The Arc Discharge.—The discharges we have hitherto considered have been characterized by large potential differences and small currents. If the current through the discharge tube is gradually increased starting from a small value the following stages are passed through: at first, when the current is so small that the cathode is not wholly covered with glow the current density at the cathode and the cathode fall of potential are constant. When the current reaches the value when the cathode is covered with glow both the current density and the cathode fall increase rapidly with the current. When the current density reaches a certain value the appearance suddenly changes, there is a sudden jump in the current density, a large fall in the potential difference at the cathode, the dark space disappears, and the electrodes get very hot. This is the arc discharge. In the arc discharge we get very large currents with comparatively small potential differences. We may get the arc discharge by taking a battery of cells large enough to give a potential difference of 60 to 80 volts, and connecting the cells with two carbon terminals,

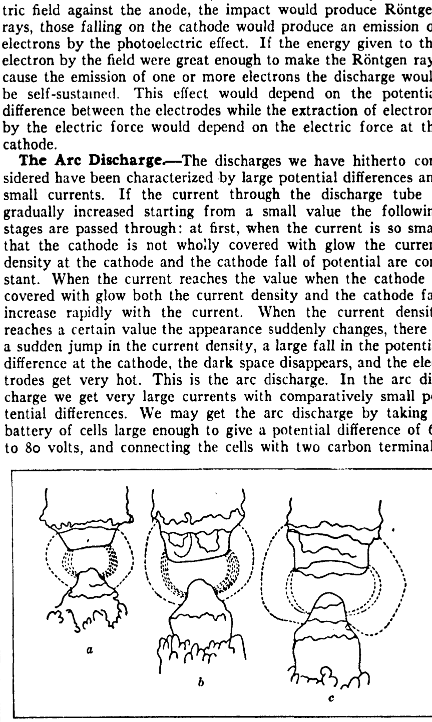

FIG. 14

which are put in contact, so that a current of electricity flows round the circuit. If the terminals, while the current is on, are drawn apart, a bright discharge, which may carry a current of many amperes, passes from one to the other. This arc discharge, as it is called, is characterized by intense heat and by the brilliant luminosity of the terminals. This makes it a powerful source of light. The temperature of the positive terminal is much higher than that of the negative. According to Violle (*Comptes Rendus*, 115, p. 1273) the temperature of the tip of the former is about 3,500° C, and that of the latter 2,700° C. The temperature of the

arc itself he found to be higher than that of either of its terminals. As the arc passes, the positive terminal gets hollowed out into a crater-like shape, but the negative terminal remains pointed. Both terminals lose weight.

The appearance of the terminals is shown in fig. 14, given by Mrs. Ayrton (*Proc. Inst. Elec. Eng.* 28, p. 400); *a, b* represent the terminals when the arc is quiet, and *c* when it is accompanied by a hissing sound. The intrinsic brightness of the positive crater does not increase with an increase in the current; an increased current produces an increase in the area of the luminous crater, but the amount of light given out by each unit of area of luminous surface is unaltered. This indicates that the temperature of the crater is constant; it is probably that at which carbon volatilizes. W. E. Wilson (*Proc. Roy. Soc.* 58, p. 174; 60, p. 377) has shown that at pressures of several atmospheres the intrinsic brightness of the crater is considerably diminished.

The connection between V, the potential difference between the terminals, and l, the length of the arc, is somewhat analogous to that which holds for the spark discharge. Fröhlich (*Electrotech. Zeit.* 4, p. 150) gives for this connection the relation $V=m+nl$, where m and n are constants. Mrs. Ayrton (*The Electric Arc*, chap. iv.) finds that both m and n depend upon the current passing between the terminals, and gives as the relation between V and l, $V=\alpha+\beta l+\gamma+\frac{\delta l}{I}l$, where $\alpha, \beta, \gamma, \delta$ are constants and I the current. With this relation VI is a linear function of I so that the graph representing the relation between Watts and current is a straight line which does not pass through the origin. The relation between current and potential difference was made the subject of a series of experiments by Ayrton (*Electrician*, I., p. 319; xi. p. 418), some of whose results are represented in fig. 15. For

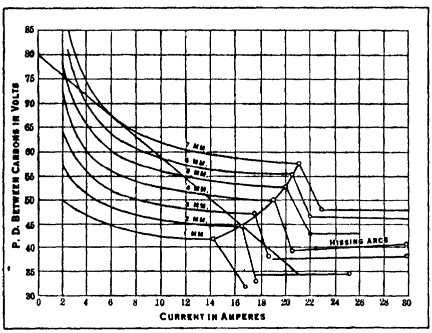

FIG. 15

a quiet arc an increase in current is accompanied by a fall in potential difference, while for the hissing arc the potential difference is independent of the current.

Many determinations have been made of the constants for different electrodes and different gases. Tables I. and II. give some idea of their values. Table I. refers to the values for different electrodes in air at atmospheric pressure and Table II. to carbon electrodes in different gases.

TABLE I.

Electrode	α	β	γ	δ		Observer
Carbon	38·88	2·0	16·64	10·54	Cooled	Ayrton
	39·6	1·7	15·5	11·5	elec-	Duddell
	45·75	3·3	35·7	19·31	trodes	Palmer and Wäyrynen
Copper	26·61	2·22	32·49	18·6	Cooled	Palmer and Wäyrynen
	15·24	10·69	21·38	3·02	elec-	Guye and Zebrikoff
Silver	19·01	11·36	14·19	3·64	trodes	,, ,, ,,
Iron	15·01	9·44	15·73	2·52		,, ,, ,,

TABLE II.

Gas	α	β	γ	δ	Observer
Air (stagnant)	35·7	3·0	11·46	1·8	Kohn and Guckel
Air (current)	44·1	2·6	17·8	1·8	,, ,, ,,
Argon	24·8	0·9	10·2	0·0	,, ,, ,,
CO_2	44·5	1·7	18·2	8·7	,, ,, ,,
N_2	48·2	2·6	23·3	5·3	,, ,, ,,

The values of α β δ change only slowly with the pressure; γ changes more rapidly.

According to Kohn and Guckel, the anode fall of potential is $\frac{4}{5}\alpha+\frac{\gamma}{2i}$ the cathode fall $\frac{\alpha}{5}+\frac{\gamma}{2i}$ and the potential gradient in the arc $\beta+\frac{\delta}{i}$. It is shown that when the discharge is passing through a gas it will not be stable unless

$$\frac{dV}{d^3}+R>0$$

where R is the resistance of the leads.

Applying this to Ayrton's relation between V and I we find that the smallest current which will give a stable arc is given by

$$I_{\min}=\sqrt{\frac{\gamma+\delta l}{R}}$$

the maximum resistance that will give a stable arc is

$$R=\frac{\gamma+\delta l}{I^2}.$$

Nottingham (*Phys. Review* 28, p. 764, 1926) has shown that the relation $V=A-B/l^n$ where A and B are quantities which depend upon the length of the arc and the pressure, is very closely satisfied provided the anode is at a very high temperature. The value of n depends upon the boiling point of the metal of the anode; if this in absolute measures is T

$$n=2{\cdot}62\times10^{-4}T$$

for copper $n=0{\cdot}67$.

In comparing values in Tables I. and II., it is important to remember that Lecher has shown that with Fe or Pt terminals the arc discharge is intermittent. Arons has shown that this is also the case with Hg terminals, but no intermittence has been detected with terminals of C, Ag or Cu. The preceding measurements refer to mean potentials, and no conclusions as to the actual potential differences at any time can be drawn when the discharge is discontinuous, unless we know the law of discontinuity. The ease

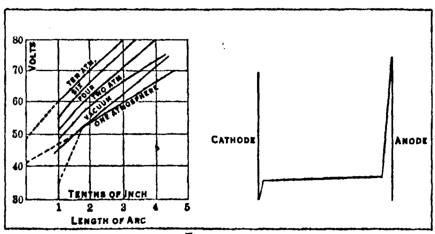

FIG. 16 & 17

with which an arc is sustained depends greatly on the nature of the electrodes; when they are brass, zinc, cadmium, or magnesium it is exceedingly difficult to get the arc.

The potential difference between the terminals is affected by the pressure of the gas. The most extensive series of experiments on that point is that made by Duncan, Rowland and Tod (*Electrician*, 31, p. 60), whose results are represented in fig. 16. We see from these curves that for very short arcs the potential difference increases continuously with the pressure, but for longer ones there is a critical pressure at which the potential difference

is a minimum, and that this critical pressure seems to increase with the length of arc.

The nature of the gas also affects the potential difference. The magnitude of this effect may be gathered from the following values given by Arons (*Ann. der Phys.* 1, p. 700) for the potential difference required to produce an arc 1·5 mm. long, carrying a current of 4·5 amperes, between terminals of different metals in air and pure nitrogen.

Terminal	Air	Nitrogen	Terminal	Air	Nitrogen
Ag . .	21	?	Pt . .	36	30
Zn . .	23	21	Al . .	39	27
Cd . .	25	21	Pb . .	..	18
Cu . .	27	30	Mg . .	..	22
Fe . .	29	20			

Thus, with the discharge for an arc of given length and current, the nature of the terminals is the most important factor in determining the potential difference. The effects produced by the pressure and nature of the surrounding gas, although quite appreciable, are not of so much importance, while in the spark discharge the nature of the terminals is of small importance, compared with the nature and pressure of the gas.

The potential gradient in the arc is very far from being uniform. With carbon terminals Luggin (*Wien. Ber.* 98, p. 1192) found that, with a current of 15 amperes, there was a fall of potential of 33·7 close to the anode, and one 8·7 close to the cathode, so that the curve representing the distribution of potential between the terminals would be somewhat like that shown in fig. 17, though the change of potential at the electrodes is much more abrupt than that represented in the figure. We have seen that a somewhat analogous distribution of potential holds in the case of conduction through flames, though in that case the greatest drop of potential is in general at the cathode and not at the anode. The difference between the changes of potential at the anode and cathode is not so large with Fe and Cu terminals as with carbon ones; with mercury terminals, Arons (*Wied. Ann.* 58, p. 73) found the anode fall to be 7·4 volts, the cathode fall 5·4 volts.

The case of the arc when the cathode is a pool of mercury and the anode a metal wire placed in a vessel from which the air has been exhausted is one which has attracted much attention, and important investigations on this point have been made by Hewitt (*Electrician,* 52, p. 447); Wills (*Electrician,* 54, p. 26); Stark, Retschinsky and Schnaposnikoff (*Ann. der Phys.* 18, p. 213); and Pollak (*Ann. der Phys.* 19, p. 217). In this arrangement the mercury is vaporized by the heat, and the discharge which passes through the mercury vapour gives an exceedingly bright light, which has been largely used for lighting factories, etc. The arrangement can also be used as a rectifier, for a current will only pass through it when the mercury pool is the cathode. Thus if such a lamp is connected with an alternating current circuit, it lets through the current in one direction and stops that in the other, thus furnishing a current which is always in one direction.

The Singing Arc.—Unlamped vibrations of a circuit containing self-induction and capacity can be obtained by inserting in the oscillating circuit an arc discharge produced by a constant potential difference between carbon electrodes. The energy required to maintain these vibrations comes from the arc and the action is as follows. When the current from the oscillating circuit passes through the arc in the same direction as the arc current the current through the arc is increased. If i is the current through the arc, I that round the oscillating circuit, the potential difference between the terminals of the arc is increased by $\frac{dV}{di}I$ when the oscillating current goes through it. In the arc discharge if dV/di is negative so that the passage of I through the arc reduces the potential difference between its terminals, this reduction is equal to $-IdV/di$. The effect of this on the oscillating circuit is the same as if an electromotive force equal to this reduction acted on the oscillating circuit in the direction tending to increase the current; this communicates energy to the oscillating circuit at the rate $-I^2dv/de$. The rate at which this circuit loses energy due to its resistance is rI^2 where r is its resistance, hence if

$$-I^2\frac{dV}{di} > rI^2$$

or

$$-\frac{dV}{di} > r$$

the circuit will get enough energy from the arc to balance its losses and the oscillations will be maintained. This condition was given by Duddell (*Electrician* 46. pp. 269–310, 1900) who made very important investigations on this subject. When the magnitude of the currents in the oscillating circuit are small compared with the arc current, they will not be able to produce great changes in the potential difference between the terminals of the arc. When however the oscillating currents approach in magnitude the arc current they will quench the arc when they flow in the opposite direction to these currents. The stoppage of the current will produce a great increase in the potential difference between the arc terminals, this will be communicated to the plates of the condenser and in this may start vibrations of great amplitude and energy.

Theory of the Arc Discharge.—An incandescent body such as a piece of carbon, even when at a temperature far below that of the terminals in an arc, emits electrons at a rate corresponding to a current of the order of 1 ampere per square centimetre of incandescent surface, and as the rate of increase of emission with the temperature is very rapid, it is probably at the rate of many amperes per square centimetre at the temperature of the negative carbon in the arc. If then a piece of carbon were maintained at this temperature by some external means, and used as a cathode, a current could be sent from it to another electrode whether the second electrode were cold or hot. If, however, these electrons did not produce other ions either by collision with the gas through which they move or with the anode, the spaces between cathode and anode would have a negative charge, which through the space charge effect would tend to stop the electrons leaving the cathode and would require a large potential difference between anode and cathode to produce any considerable current. If, however, there is ionization either in the gas or at the anode, the positive ions will diffuse into the region of the discharge until they are sensibly equal in number to the negative ions. When this is the case the back electromotive force is destroyed and the same potential difference will carry a much larger current. The arc discharge may be regarded as analogous to the discharge between incandescent terminals, the only difference being that in the arc the terminals are maintained in the state of incandescence by the current and not by external means. On this view the cathode is bombarded by positive ions which heat it to such a temperature that electrons sufficient to carry the current are emitted by it. These electrons bombard the anode and keep it incandescent. They ionize also, either directly by collision or indirectly by heating the anode, the gas and vapour of the metal of which the anode is made, and produce in this way the supply of positive ions which keep the cathode hot.

There is still considerable uncertainty as to how the ionization of the gas in the arc discharge is produced. In some cases such as mercury vapour, neon and helium arcs have been observed when the potential difference between the electrodes is less than the ionizing potential of the gas. This has led to various suggestions, *e.g.,* that the ionization is not due to a single collision but to the accumulation of the effects of two or more consecutive ones, it has also been suggested that the ionization is not due directly to collisions but is a thermal dissociation produced by the high temperature of the gas. It ought however in this connection to be remembered that the potential difference between the electrodes is not always the greatest potential difference in the field, for an extreme instance of this is an experiment made by J. J. Thomson (*Phil. Mag.* 18, p. 449, 1909) when a fully developed discharge with cathode fall of potential, dark space, and striations, was produced between two electrodes in metallic connection.

Though the potential fall at the cathode in the arc discharge is much smaller than the normal cathode fall in the glow discharge

it is very much more abrupt. We have no direct measurements of the thickness of the larger in the arc next the cathode in which the cathode potential fall is developed, we know however that it is exceedingly small, possibly at atmospheric pressure of the order of 10^{-5} centimetres. The smaller it is the greater the electric force at the cathode; if it were 10^{-5} cm. this force would be of the order of a million volts per centimetre. Langmuir has suggested that under such forces electrons may be extracted from the cathode and that this might supplement or even replace the thermionic emission. We have seen in this article that there is some evidence from other sources of the extraction of electrons from metals by forces comparable with a million volts per centimetre. This may help us to understand how it is that from a metal like mercury with a low boiling point there may be an emission of electrons so large that if it were thermionic in origin the temperature of the metal must be very much higher than the boiling point.

Discharge from a Point.—A very interesting case of electric discharge is that between a sharply pointed electrode, such as a needle, and a metal surface of considerable area. At atmospheric pressures the luminosity is confined to the immediate neighbourhood of the point. If the sign of the potential of the point does not change, the discharge is carried by ions of one sign—that of the charge on the pointed electrode. The velocity of these ions under a given potential gradient has been measured by Chattock (*Phil. Mag.* 32, p. 285), and found to agree with that of the ions produced by Röntgen or uranium radiation, while Townsend (*Phil. Trans.* 195, p. 259) has shown that the charge on these ions is the same as that on the ions streaming from the point. If the pointed electrode be placed at right angles to a metal plane serving as the other electrode, the discharge takes place when, for a given distance of the point from the plane, the potential difference between the electrodes exceeds a definite value depending upon the pressure and nature of the gas through which the discharge passes; its value also depends upon whether, beginning with a small potential difference, we gradually increase it until discharge commences, or, beginning with a large potential difference, we decrease it until the discharge stops. The value found by the latter method is less than that by the former.

According to Chattock's measurements the potential difference V for discharge between the point and the plate is given by the linear relation $V=a+bl$, where l is the distance of the point from the plate and a and b are constants. From v. Obermayer's (*Wien. Ber.* 100, 2, p. 127) experiments, in which the distance l was greater than in Chattock's, it would seem that the potential for larger distances does not increase quite so rapidly with l as is indicated by Chattock's relation. The potential required to produce this discharge is much less than that required to produce a spark of length l between parallel plates; thus from Chattock's experiments to produce the point discharge when $l=\cdot 5$ cm. in air at atmospheric pressure requires a potential difference of about 3,800 volts when the pointed electrode is positive, while to produce a spark at the same distance between plane electrodes would require a potential difference of about 15,000 volts. Chattock showed that with the same pointed electrode the value of the electric intensity at the point was the same whatever the distance of the point from the plane. The value of the electric intensity depended upon the sharpness of the point.

Determinations of the electric force and potential difference required to produce discharge from pointed electrodes have been made by Chattock (*Phil. Mag.* 20, p. 273, 1910); Chattock and Tyndall (*Phil. Mag.* 120, p. 285, 1910); Edmunds (*Phil. Mag.* 28. p. 234, 1914); and Zeleny (*Phys. Review* 3, p. 69, 1914; 16. 102. 1920) who has made a very interesting series of experiments on this subject using not only metallic points, but also points made of minute drops of water, glycerine, and methyl alcohol. He found but little difference between the electric force required to spark from a metal point and that from a metallic one of the same radius. He obtained as an empirical formula for the connection between f the electric force at the point, and the radius of the point and p the pressure of the gas

$$fV=Apr+B\sqrt{pr}$$

a form which had been suggested previously by Edmunds. For air, Zeleny finds $A=0{\cdot}955$; $B=5{\cdot}6$; f being measured in electrostatic units, r in centimetres, and p in centimetres of mercury. The potential difference V in volts required to produce a spark to a plate at a given distance from the point, is given by

$$V=a\sqrt{r}+b$$

when a is a quantity depending on the pressure. For air b is 340 volts, agreeing very closely with the minimum potential required to produce a spark in that gas. He found too that the lag in time between the application of the forces and the passage of the spark was especially pronounced in liquid electrodes, he attributes this lag to a non-conducting layer, perhaps of gas over the surface of the liquid which has to be pierced before the spark can pass. Warburg (*Wied. Ann.* 67, 69, 1899, showed that the current due to a potential difference V is proportional to v $(V-U)$ where U is the potential required to start the spark.

The value of the electric intensity at the pointed electrode is much greater than its value at a plane electrode for long sparks; but we must remember that at a distance from a pointed electrode equal to a small multiple of the radius of curvature of its extremity the electric intensity falls very far below that required to produce discharge in a uniform field, so that the discharge from a pointed electrode ought to be compared with a spark whose length is comparable with the radius of curvature of the point. For such short sparks the electric intensity is very high. The electric intensity required to produce the discharge from a gas diminishes as the pressure of the gas diminishes, but not nearly so rapidly as the electric intensity for long sparks. Here again the discharge from a point is comparable with short sparks, which, as we have seen, are much less sensitive to pressure changes than longer ones. The minimum potential at which the electricity streams from the point does not depend upon the material of which the point is made; it varies, however, considerably with the nature of the gas. The following are the results of some experiments on this point. Those in the first two columns are due to Röntgen, those in the third and fourth to Precht:—

Gas	Discharge potential. Point +		Pressure 760	
	Pressure 205	Pressure 110	Point +	Point −
	Volts	Volts	Volts	Volts
H_2	1,296	1,174	2,125	1,550
O_2	2,402	1,975	2,800	2,350
CO	2,634	2,100	..	..
CH_4	2,777	2,317	..	..
NO	3,188	2,543	..	..
CO_2	3,287	2,655	3,475	2,100
N_2	..	..	2,600	2,000
Air	..	..	2,750	2,050

We see from this table that in the case of the discharge from a positively electrified point the greater the molecular weight of the gas the greater the potential required for discharge. Röntgen concluded from his experiments that the discharging potential from a positive point in different gases at the same pressure varies inversely as the mean free path of the molecules of the gas. In the same gas, however, at different pressures the discharging potential does not vary so quickly with the pressure as does the mean free path. In Precht's experiments, in which different gases were used, the variations in the discharging potential are not so great as the variations in the mean free path of the gases.

The current of electrified air flowing from the point when the electricity is escaping—the well-known "electrical wind"—is accompanied by a reaction on the point which tends to drive it backwards. This reaction has been measured by Arrhenius (*Wied. Ann.* 63, p. 305), who finds that when positive electricity is escaping from a point in air the reaction on the point for a given current varies inversely as the pressure of the gas, and for different gases (air, hydrogen and carbonic acid) inversely as the square root of the molecular weight of the gas. The reaction when negative electricity is escaping is much less. The proportion between

the reactions for positive and negative currents depends on the pressure of the gas. Thus for equal positive and negative currents in air at a pressure of 70 cm. the reaction for a positive point was 1·9 times that of a negative one, at 40 cm. pressure 2·6 times, at 20 cm. pressure 3·2 times, at 10·3 cm. pressure 7 times, and at 5·1 cm. pressure 15 times the reaction for the negative point. Investigation shows that the reaction should be proportional to the quotient of the current by the velocity acquired by an ion under unit potential gradient. Now this velocity is inversely proportional to the pressure, so that the reaction should on this view be directly proportional to the pressure. This agrees with Arrhenius' results when the point is positive.

Again, the velocities of an ion in hydrogen, air and carbonic acid at the same pressure are approximately inversely proportional to the square roots of their molecular weights, so that the reaction should be directly proportional to this quantity. This also agrees with Arrhenius' results for the discharge from a positive point. The velocity of the negative ion is greater than that of a positive one under the same potential gradient, so that the reaction for the negative point should be less than that for a positive one, but the excess of the positive reaction over the negative is much greater than that of the velocity of the negative ion over the velocity of the positive. There is, however, reason to believe that a considerable condensation takes place around the negative ion as a nucleus after it is formed, so that the velocity of the negative ion under a given potential gradient will be greater immediately after the ion is formed than when it has existed for some time. The measurements which have been made of the velocities of the ions relate to those which have been some time in existence, but a large part of the reaction will be due to the newly-formed ions moving with a greater velocity, and thus giving a smaller reaction than that calculated from the observed velocity.

With a given potential difference between the point and the neighbouring conductor the current issuing from the point is greater when the point is negative than when it is positive, except in oxygen, when it is less. Warburg (*Sitz. Akad. d. Wissensch. zu Berlin*, 1899, 50, p. 770) has shown that the addition of a small quantity of oxygen to nitrogen produces a great diminution in the current from a negative point, but has very little effect on the discharge from a positive point. Thus the removal of a trace of oxygen made a leak from a negative point 50 times what it was before. Experiments with hydrogen and helium showed that impurities in these gases had a great effect on the current when the point was negative, and but little when it was positive. This suggests that the impurities, by condensing round the electrons as nuclei, seriously diminish their velocity.

If a point is charged up to a high and rapidly alternating potential, such as can be produced by the electric oscillations started when a Leyden jar is discharged, then in hydrogen, nitrogen, ammonia and carbonic acid gas a conductor placed in the neighbourhood of the point gets a negative charge, while in air and oxygen it gets a positive one. There are two considerations which are of importance in connection with this effect. The first is the velocity of the ions in the electric field, and the second the ease with which the ions can give up their charges to the metal point. The greater velocity of the negative ions would, if the potential were rapidly alternating, cause an excess of negative ions to be left in the surrounding gas. This is the case in hydrogen. If, however, the metal had a much greater tendency to unite with negative than with positive ions, such as we should expect to be the case in oxygen, this would act in the opposite direction, and tend to leave an excess of positive ions in the gas.

The Characteristic Curve for Discharge Through Gases.—When a current of electricity passes through a metallic conductor the relation between the current and the potential difference is the exceedingly simple one expressed by Ohm's law; the current is proportional to the potential difference. When the current passes through a gas there is no such simple relation. Thus we have already mentioned cases where the current increased as the potential increased although not in the same proportion, while as we have seen in certain stages of the arc discharge the potential difference diminishes as the current increases. Thus the problem of finding the current which a given battery will produce when part of the circuit consists of a gas discharge is much more complicated than when the circuit consists entirely of metallic conductors. If, however, we measure the potential difference between the electrodes in the gas when different currents are sent through it, we can plot a curve, called the "characteristic curve," whose ordinates are the potential differences between the electrodes in the gas and the abscissae the corresponding currents. By the aid of this curve we can calculate the current produced when a given battery is connected up to the gas by leads of known resistance.

For let E_0 be the electromotive force of the battery, R the resistance of the leads, i the current, the potential difference between the terms in the gas will be E_0-Ri. Let ABC (fig. 18) be the "characteristic curve," the ordinates being the potential difference between the terminals in the gas, and the abscissae the current. Draw the line LM whose equation is $E=E_0-Ri$, then the points where this line cuts the characteristic curves will give possible values of i and E, the current through the discharge tube and the potential difference between the terminals. Some of these points may, however, correspond to an unstable position and be impossible to realize. The following method gives us a criterion by which we can distinguish the stable from the unstable positions. If the current is increased by δi, the electromotive force which has to be overcome by the battery is $R\delta i+\frac{dE}{di}\delta i$. If $R+dE/di$ is positive there will be an unbalanced electromotive force round the circuit tending to stop the current. Thus the increase in the current will be stopped and the condition will be a stable one. If, however, $R+dE/di$ is negative there will be an unbalanced electromotive force tending to increase the current still further; thus the current will go on increasing and the condition will be unstable. Thus for stability $R+dE/di$ must be positive, a condition first given by Kaufmann (*Ann. der Phys.* 11, p. 158). The geometrical interpretation of this condition is that the straight line LM must, at the point where it cuts the characteristic curve, be steeper than the tangent to characteristic curve. Thus of the points ABC where the line cuts the curve in fig. 18, A and C correspond to stable states and B to an unstable one. The state of things represented by a point P on the characteristic curve when the slope is downward cannot be stable unless there is in the external circuit a resistance greater than that represented by the tangent of the inclination of the tangent to the curve at P to the horizontal axis.

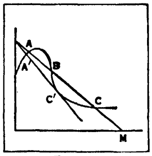

FIG. 18

If we keep the external electromotive force the same and gradually increase the resistance in the leads, the line LM will becаme steeper and steeper. C will move to the left so that the current will diminish; when the line gets so steep that it touches the curve at C′, any further increase in the resistance will produce an abrupt change in the current; for now the state of things represented by a point near A′ is the only stable state. Thus if the BC part of the curve corresponded to a luminous discharge and the A part to a dark discharge, we see that if the electromotive force is kept constant there is a minimum value of the current for the luminous discharge. If the current is reduced below this value, the discharge ceases to be luminous, and there is an abrupt diminution in the current.

Cathode Rays.—When the gas in the discharge tube is at a very low pressure some remarkable phenomena occur in the neighbourhood of the cathode. These seem to have been first observed by Plücker (*Pogg. Ann.* 107, p. 77; 116, p. 45) who noticed on the walls of the glass tube near the cathode a greenish phosphorescence, which he regarded as due to rays proceeding from the cathode, striking against the sides of the tube, and then travelling back to the cathode. He found that the action of a magnet on these rays was not the same as the action on the part of the discharge near the positive electrode. Hittorf (*Pogg. Ann.* 136, p. 8) showed that the agent producing the phosphorescence was intercepted by a solid, whether conductor or insulator,

placed between the cathode and the sides of the tube. He regarded the phosphorescence as caused by a motion starting from the cathode and travelling in straight lines through the gas. Goldstein (*Monat. der Berl. Akad.*, 1876, p. 24) confirmed this discovery of Hittorf's, and further showed that a distinct, though not very sharp, shadow is cast by a small object placed near a large plane cathode. This is a proof that the rays producing the phosphorescence must be emitted almost normally from the cathode, and not, like the rays of light from a luminous surface, in all directions, for such rays would not produce a perceptible shadow if a small body were placed near the plane. Goldstein regarded the phosphorescence as due to waves in the ether, for whose propagation the gas was not necessary. Crookes (*Phil. Trans.*, 1879, pt. i. p. 135; pt. ii. pp. 587, 661), who made many remarkable researches in this subject, took a different view. He regarded the rays as streams of negatively electrified particles projected normally from the cathode with great velocity, and, when the pressure is sufficiently low, reaching the sides of the tube, and by their impact producing phosphorescence and heat. The rays on this view are deflected by a magnet, because a magnet exerts a force on a charged moving body.

These rays striking against glass make it phosphorescent. The colour of the phosphorescence depends on the kind of glass; thus the light from soda glass is a yellowish green, and that from lead glass blue. Many other bodies phosphoresce when exposed to these rays, and in particular the phosphorescence of some gems, such as rubies and diamonds, is exceedingly vivid. The spectrum of the phosphorescent light is generally continuous, but Crookes showed that the phosphorescence of some of the rare earths, such as yttrium, gives a spectrum of bright bands, and he founded on this fact a spectroscopic method of great importance. Goldstein (*Wied. Ann.* 54, p. 371) discovered that the haloid salts of the alkali metals change colour under the rays, sodium chloride, for example, becoming violet. The coloration is a surface one, and has been traced by E. Wiedemann and Schmidt (*Wied. Ann.* 54, p. 618) to the formation of a subchloride. Chlorides of tin, mercury and lead also change colour in the same way. E. Wiedemann (*Wied. Ann.* 56, p. 201) discovered another remarkable effect, which he called thermo-luminescence; he found that many bodies after being exposed to the cathode rays possess for some time the power of becoming luminous when their temperature is raised to a point far below that at which they become luminous in the normal state.

Substances belonging to the class called by van 't Hoff solid solutions exhibit this property of thermo-luminescence to a remarkable extent. They are formed when two salts, one greatly in excess of the other, are simultaneously precipitated from a solution. A trace of $MnSO_4$ in $CaSO_4$ shows very brilliant thermo-luminescence. The impact of cathode rays produces after a time perceptible changes in the glass. Crookes (*Phil. Trans.* pt. ii. 1879, p. 645) found that after glass has been phosphorescing for some time under the cathode rays it seems to get tired, and the phosphorescence is not so bright as it was initially. Thus, for example, when the shadow of a Maltese cross is thrown on the walls of the tube as in fig. 19, if after the discharge has been going on for some time the cross is shaken down or a new cathode used whose line of fire does not cut the cross, the pattern of the cross will still be seen on the glass, but it will now be brighter instead of darker than the surrounding portion. The portions shielded by the cross, not being tired by being made to phosphoresce for a long time, respond more vigorously to the stimulus than those portions which have not been protected.

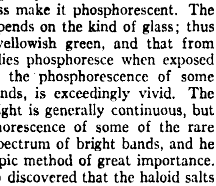

FIG. 19

Skinner (*Proc. Camb. Phil. Soc.* ix. p. 371) and Thomson found on the glass which had been exposed to the rays gelatinous filaments, apparently silica, resulting from the reduction of the glass. A reducing action was also noticed by Villard (*Journ. de phys.* 3, viii. p. 140) and Wehnelt (*Wied. Ann.* 67, p. 421). It can be well shown by letting the rays fall on a plate of oxidized copper, when the part struck by the rays will become bright. The rays heat bodies on which they fall, and if they are concentrated by using as a cathode a portion of a spherical surface, the heat at the centre becomes so great that a piece of platinum wire can be melted or a diamond charred. Measurements of the heating effects of the rays have been made by Thomson (*Phil. Mag.* [5], 44, p. 293) and Cady (*Ann. der Phys.* 1, p. 678). Crookes (*Phil. Trans.*, 1879, pt. i. p. 152) showed that a vane mounted as in a radiometer is set in rotation by the rays, the direction of the rotation being the same as would be produced by a stream of particles proceeding from the cathode. The movement is not due to the momentum imparted to the vanes by the rays, but to the difference in temperature between the sides of the vanes, the rays making the side against which they strike hotter than the other.

Effect of a Magnet.—The rays are deflected by a magnet, so that the distribution of phosphorescence over the glass and the shape and position of the shadows cast by bodies in the tube are altered by the proximity of a magnet. The laws of magnetic deflection of these rays have been investigated by Plücker (*Pogg. Ann.* 103, p. 88), Hittorf (*Pogg. Ann.* 136, p. 213), Crookes (*Phil. Trans.*, 1879, pt. 1, p. 557), and Schuster (*Proc. Roy. Soc.* 47, p. 526). The deflection is the same as that of negatively electrified particles travelling along the path of the rays. Such particles would in a magnetic field be acted on by a force at right angles to the direction of motion of the particle and also to the magnetic force, the magnitude of the force being proportional to the product of the velocity of the particle, the magnetic force, and the sine of the angle between these vectors. In this case we have seen that if the particle is not acted on by an electrostatic field, the path in a uniform magnetic field is a spiral, which, if the magnetic force is at right angles to the direction of projection of the particle, becomes a circle in the plane at right angles to the magnetic force, the radius being mv/He, where m, v, e are respectively the mass, velocity and charge on the particle, and H is the magnetic force. The smaller the difference of potential between the electrodes of the discharge tube the greater the deflection produced by a magnetic field of given strength, and as the difference of potential rapidly increases with diminution of pressure, after a certain pressure has been passed, the higher the exhaustion of the tube the less the magnetic deflection of the rays.

Birkeland (*Comptes rendus*, 1896, p. 492) has shown that when the discharge is from an induction coil the cathode rays produced in the tube at any one time are not equally deflected by a magnet, but that a narrow patch of phosphorescence when deflected by a magnet is split up into several distinct patches, giving rise to what Birkeland calls the "magnetic spectrum." Strutt (Lord Rayleigh) (*Phil. Mag.* 48, p. 478) has shown that this magnetic spectrum does not occur if the discharge of a large number of cells is employed instead of the coil. Thomson (*Proc. Camb. Phil. Soc.* 9, p. 243) has shown that if the potential difference between the electrodes is kept the same the magnetic deflection is independent of the nature of the gas filling the discharge tube; this was tested with gases so different as air, hydrogen, carbonic acid and methyl iodide.

Charge of Negative Electricity Carried by Cathode Rays.—We have seen that the rays are deflected by a magnet, as if they were particles charged with negative electricity. Perrin (*Comptes rendus*, 121, p. 1130) showed by direct experiment that a stream of negative electricity is associated with the rays. A modification made by Thomson of Perrin's experiment is sketched in fig. 20 (*Phil. Mag.* 48, p. 478).

The rays start from the cathode A, and pass through a slit in a solid brass rod B fitting tightly into the neck of the tube. This rod is connected with earth and used as the anode. The rays after passing through the slit travel through the vessel C. D and E are two insulated metal cylinders insulated from each other, and each having a slit cut in its face so as to enable the rays to pass into the inside of the inner cylinder, which is connected with an electrometer, the outer cylinder being connected with the earth. The two cylinders are placed on the far side of the vessel, but

out of the direct line of fire of the rays. When the rays go straight through the slit there is only a very small negative charge communicated to the inner cylinder, but when they are deflected by a magnet so that the phosphorescent patch falls on the slit in the outer cylinder the inner cylinder receives a very large negative charge, the increase coinciding very sharply with the appearance of the phosphorescent patch on the slit. When the patch is so much deflected by the magnet that it falls below the slit, the negative charge in the cylinder again disappears. This experiment shows that the cathode rays are accompanied by a stream of negative electrification.

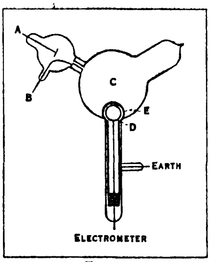

FIG. 20

The same apparatus can be used to show that the passage of cathode rays through a gas makes it a conductor of electricity. For if the induction coil is kept running and a stream of the rays kept steadily going into the inner cylinder, the potential of the inner cylinder reaches a definite negative value below which it does not fall, however long the rays may be kept going. The cylinder reaches a steady state in which the gain of negative electricity from the cathode rays is equal to the loss by leakage through the conducting gas, the conductivity being produced by the passage of the rays through it. If the inner cylinder is charged up initially with a greater negative charge than corresponds to the steady state, on turning the rays on to the cylinder the negative charge will decrease and not increase until it reaches the steady state. The conductivity produced by the passage of cathode rays through a gas diminishes rapidly with the pressure. When rays pass through a gas at a low pressure, they are deflected by an electric field; when the pressure of the gas is higher the conductivity it acquires when the cathode rays pass through it is so large that the potential gradient cannot reach a sufficiently high value to produce an appreciable deflection.

Thus the cathode rays carry a charge of negative electricity; the experiment described on page 252 (fig. 9) shows that they are deflected by an electric field as if they were negatively electrified, and are acted on by a magnetic force in just the way this force would act on a negatively electrified body moving along the path of the rays. There is therefore every reason for believing that they are charges of negative electricity in rapid motion. By measuring the deflection produced by magnetic and electric fields we can determine the velocity with which these particles moved and the ratio of the mass of the particle to the charge carried by it.

We may conclude from the experiments that the value of $\frac{m}{e}$ for the particles constituting the cathode rays is of the order $1/1{\cdot}7\times10^7$, and we have seen that m/e has the same value in all the other cases of negative ions in a gas at low pressure for which it has been measured—viz., for the ions produced when ultra-violet light falls on a metal plate, or when an incandescent carbon filament is surrounded by a gas at a low pressure, and for the β particles given out by radio-active bodies. We have also seen that the value of the charge on the gaseous ion, in all cases in which it has been measured—viz., the ions produced by Röntgen and uranium radiation, by ultra-violet light, and by the discharge of electrification from a point—is the same in magnitude as the charge carried by the hydrogen atom in the electrolysis of solutions. The mass of the hydrogen alone is, however, 10^{-4} times this charge, while the mass of the carriers of negative electrification is only $1/1{\cdot}7\times10^7$ times the charge; hence the mass of the carriers of the negative electrification is only $\frac{1}{1,700}$ of the mass of the hydrogen atom. We are thus, by the study of the electric discharge, forced to recognize the existence of masses very much smaller than the smallest mass hitherto recognized.

Direct determinations of the velocity of the cathode rays have been made by J. J. Thomson (*Phil. Mag.* 38, p. 358), who measured the interval between the appearance of phosphorescence on two pieces of glass placed at a known distance apart, and by Maiorana (*Nuovo Cimento*, 4, 6, p. 336) and Battelli and Stefanini (*Phys. Zeit.* 1, p. 51), who measured the interval between the arrival of the negative charge carried by the rays at two places separated by a known distance. The values of the velocity got in this way are much smaller than the values got by the indirect methods previously described: thus J. J. Thomson at a fairly high pressure found the velocity to be 2×10^7 cm./sec. Maiorana found values ranging between 10^7 and 6×10^7 cm./sec., and Battelli and Stefanini values ranging from 6×10^6 to $1{\cdot}2\times10^7$. In these methods it is very difficult to eliminate the effect of the interval which elapses between the arrival of the rays and the attainment by the means of detection, such as the phosphorescence of the glass or the deflection of the electrometer, of sufficient intensity to affect the senses.

New light has been thrown on the nature of the cathode rays by experiments made by G. P. Thomson (*Proc. Roy. Soc.* A. 117, p. 600; 119, p. 65) and others by Davisson and Germer (*Phys. Review*, 30, p. 705, 1927), G. P. Thomson found that when a thin pencil of cathode rays is sent through an exceedingly thin film of metal or celluloid and then received on a photographic plate the image of the central spot is surrounded by a series of concentric rings, the radii of the rings are in the same ratio as the radii of rings formed when a pencil of Röntgen rays passes through the metal. The molecules of the metal form a crystalline grating and the rings formed by the Röntgen rays are due to the diffraction of the waves of which the rays consist by the grating. Thomson used several metals, gold, silver, platinum and aluminium and found that for each of these the rings formed by the cathode rays followed the same law as the Röntgen ray rings. That the rings formed by the cathode rays were due to the impact of the electrons against the photographic plate and not to secondary Röntgen rays produced by the impact of the electrons against the metal, was proved by the fact that they were deflected by a magnet placed near the photographic plate and far away from the thin film. The electronic waves are of extremely high frequency, never less than $1{\cdot}2\times10^{20}$, a frequency only equalled by that of the hardest γ rays. The wave length of these waves depends upon the velocity of the electron, varying inversely at this velocity. The connection between the velocity u and the wave length λ is expressed by the relation

$$\lambda u = 7{\cdot}5\sqrt{\left(1-\frac{u^2}{c^2}\right)}.$$

Thus when the velocity of the cathode ray is 10^{10} the wave length of the waves which accompany it is 7×10^{-10}. These experiments show that a moving electron cannot be regarded as merely a moving point charge of negative electricity; it includes in addition a train of waves whose wave length varies inversely as the velocity of the electron, when these waves are deflected, *e.g.*, by diffraction the electron follows the waves. Thus the waves may be regarded as guiding the electron along its path.

Davisson and Germer investigated the scattering of a homogeneous pencil of electrons incident upon a crystal of nickel, and they found that under certain conditions sharply defined beams of electrons issue from the crystal and that these for the most part coincide in direction with the beams of Röntgen rays which would be emitted if these rays were incident at the same angle as the beam of electrons.

Transmission of Cathode Rays Through Solids. *Lenard Rays.*—It was for a long time believed that all solids were absolutely opaque to these rays, as Crookes and Goldstein had proved that very thin glass, and even a film of collodion, cast intensely black shadows. Hertz (*Wied. Ann.* 45, p. 28), however, showed that behind a piece of gold-leaf or aluminium foil an appreciable amount of phosphorescence occurred on the glass, and that the phosphorescence moved when a magnet was brought near. A most important advance was next made by Lenard (*Wied. Ann.* 51, p. 225), who got the cathode rays to pass from the inside of a discharge tube to the air outside. For this purpose he used

a tube like that shown in fig. 21. The cathode K is an aluminium disc 1·2 cm. in diameter fastened to a stiff wire, which is surrounded by a glass tube. The anode A is a brass strip partly surrounding the cathode. The end of the tube in front of the cathode is closed by a strong metal cap, fastened in with marine glue, in the middle of which a hole 1·7 mm. in diameter is bored, and covered with a piece of very thin aluminium foil about ·0026 mm. in thickness. The aluminium window is in metallic contact with the cap, and this and the anode are connected with the earth. The tube is then exhausted until the cathode rays strike against the window. Diffuse light spreads from the window into the air outside the tube, and can be traced in a dark room for a distance of several centimetres. From the window, too, proceed rays which, like the cathode rays, can produce phosphorescence, for certain bodies phosphoresce when placed in the neighbourhood of the window. This effect is conveniently observed by the platino-cryanide screens used to detect Röntgen radiation. The properties of the rays outside the tube resemble in all respects those of cathode rays; they are deflected by a magnet and by an electric field, they ionize the gas through which they pass and make it a conductor of electricity, and they affect a photographic plate and change the colour of the haloid salts of the alkali metals. McClelland (*Proc. Roy. Soc.*, 61, p. 227) showed that they carry a charge of negative electricity. As, however, it is convenient to distinguish between cathode rays outside and inside the tube, we shall call the former *Lenard* rays. In air at atmospheric pressure the Lenard rays spread out very diffusely. If the aluminium window, instead of opening into the air, opens into another tube which can be exhausted, it is found that the lower the pressure of the gas in this tube the farther the rays travel and the less diffuse they are. By filling the tube with different gases Lenard showed that the greater the density of the gas the greater is the absorption of these rays. Thus they travel farther in hydrogen than in any other gas at the same pressure. Lenard showed, too, that if he adjusted the pressure so that the density of the gas in this tube was the same—if, for example, the pressure when the tube was filled with oxygen was $\frac{1}{16}$ of the pressure when it was filled with hydrogen—the absorption was constant whatever the nature of the gas.

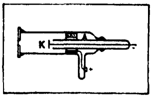

FIG. 21

Becker (*Ann. der Phys.* 17, p. 381) has shown that this law is only approximately true, the absorption by hydrogen being abnormally large, and by the inert monatomic gases, such as helium and argon, abnormally small. The distance to which the Lenard rays penetrate into this tube depends upon the pressure in the discharge tube; if the exhaustion in the latter is very high, so that there is a large potential difference between the cathode and the anode, and therefore a high velocity for the cathode rays, the Lenard rays will penetrate farther than when the pressure in the discharge tube is higher and the velocity of the cathode rays smaller. Lenard showed that the greater the penetrating power of his rays the smaller was their magnetic deflection, and therefore the greater their velocity; thus the greater the velocity of the cathode rays the greater is the velocity of the Lenard rays to which they give rise. For very slow cathode rays the absorption by different gases departs altogether from the density law, so much so that the absorption of these rays by hydrogen is greater than that by air (Lenard, *Ann. der Phys.* 12, p. 732). Ramsauer (*Ann. d. Phys.* 64, 513 [1921]; 66, 546 [1921]; 72, 345, 1923) discovered the very interesting fact that the absorption of cathode rays by the inert gases shows a remarkable diminution when the velocity of the rays is reduced below a certain value. Thus in argon the absorption when the velocity is that corresponding to a fall through one volt is only about $\frac{1}{10}$ of that when the velocity is due to ten volts, when the absorption is a maximum. The shape of the curves indicates that the absorption would be still less if the speed were yet further reduced. Thus the atoms of the inert gases seem almost transparent to very slow rays. Lenard (*Wied. Ann.*, 56, p. 255) studied the passage of his rays through solids as well as through gases, and arrived at the very interesting result that the absorption of a substance depends only upon its density, and not upon its chemical composition or physical state; in other words, the amount of absorption of the rays when they traverse a given distance depends only on the quantity of matter they cut through in the distance. The production of Lenard rays has been carried out on the grand scale by Coolidge in the laboratory of the General Electric Company, U.S.A. By the use of potential differences of half-a-million volts beams of rays several inches long at atmospheric pressure are produced and very interesting chemical effects observed.

Diffuse Reflection of Cathode Rays.—When cathode rays fall upon a surface, whether of an insulator or a conductor, cathode rays start from the surface in all directions. This phenomenon, which was discovered by Goldstein (*Wied. Ann.* 62, p. 134), has been investigated by Starke (*Wied. Ann.* 66, p. 49; *Ann. der Phys.* 111, p. 75), Austin and Starke (*Ann. der Phys.* 9, p. 271), Campbell-Swinton (*Proc. Roy. Soc.* 64, p. 377), Merritt (*Phys. Rev.* 7, p. 217) and Gehrcke (*Ann. der Phys.* 8, p. 81); it is often regarded as analogous to the diffuse reflection of light from such a surface as gypsum, and is spoken of as the diffuse reflection of the cathode rays. According to Merritt and Austin and Starke the deviation in a magnetic field of these reflected rays is the same as that of the incident rays. The experiments, however, were confined to rays reflected so that the angle of reflection was nearly equal to that of incidence. Gehrcke showed that among the reflected rays there were a large number which had a much smaller velocity than the incident ones. According to Campbell-Swinton the "diffuse" reflection is accompanied by a certain amount of "specular" reflection. Lenard, who used slower cathode rays than Austin and Starke, could not detect in the scattered rays any with velocities comparable with that of the incident rays; he obtained copious supplies of slow rays whose speed did not depend on the angle of incidence of the primary rays (*Ann. der Phys.* 15, p. 485). The discovery that cathode rays are accompanied by electronic waves throws a great deal of light on these effects. These waves as in Davisson and Germer's experiments cause some of the incident cathode rays to be scattered without loss of velocity in certain definite directions depending on the structure of the reflecting surface, one of their directions whatever be their structure will be that where the angle of reflection is equal to the angle of incidence. In addition to the scattering the incident beam produces secondary cathode rays of much smaller velocity. When the angle of incidence is very oblique the surface struck by the rays gets positively charged, showing that the secondary rays are more numerous than the primary.

Repulsion of Two Cathode Streams.—Goldstein discovered that if in a tube there are two cathodes connected together, the cathodic rays from one cathode are deflected when they pass near the other. Experiments bearing on this subject have been made by Crookes and Wiedemann and Ebert. The phenomena may be described by saying that the repulsion of the rays from a cathode A by a cathode B is only appreciable when the rays from A pass through the Crookes' dark space round B. This is what we should expect if we remember that the electric field in the dark space is far stronger than in the rest of the discharge, and that the gas in the other parts of the tube is rendered a conductor by the passage through it of the cathode rays, and therefore incapable of transmitting electrostatic repulsion.

Scattering of the Negative Electrodes.—In addition to the cathode rays, portions of metal start normally from the cathode and form a metallic deposit on the walls of the tube. The amount of this deposit varies very much with the metal. Crookes (*Proc. Roy. Soc.* 50, p. 88) found that the quantities of metal torn from electrodes of the same size, in equal times, by the same current, are in the order Pd, Au, Ag, Pb, Sn, Pt, Cu, Cd, Ni, In, Fe. . . . In air there is very little deposit from an Al cathode, but it is abundant in tubes filled with the monatomic gases, mercury vapour, argon or helium. The scattering increases as the density of the gas diminishes. No scattering takes place unless the potential fall at the cathode exceeds a certain value which is greater than the normal fall. The particles of metal are at low pressures deflected by a magnet, though not nearly to the same extent as

the cathode rays. The evidence as to whether the particles are charged or not is contradictory. From spectroscopic evidence V. Hippel (*Ann. der Phys.* 80, 672, 1926) concludes that the particles are uncharged *atoms* of the metal. Günter-Schultze (*Zt. f. Phys.* 38, 575) also comes to the same conclusion. According to Grandquist, the loss of weight of the cathode in a given time is proportional to the square of the current; it is therefore not, like the loss of the cathode in ordinary electrolysis, proportional to the quantity of current which passes through it.

Positive Rays or "Canal-strahlen."—Goldstein (*Berl. Sitzungsb.* 39, p. 691) found that with a perforated cathode certain rays occurred behind the cathode which were not appreciably deflected by a magnet; these he called *Canal-strahlen,* but we shall, for reasons which will appear later, call them "positive rays."

Their appearance is well shown in fig. 22, taken from a paper by Wehnelt (*Wied. Ann.* 67, p. 421) in which they are represented at B. Goldstein found that their colour depends on the gas in which they are formed, being gold-colour in air and nitrogen, rose-colour in hydrogen, yellowish rose in oxygen, and greenish grey in carbonic acid.

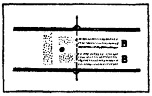

FIG. 22

The colour of the luminosity due to positive rays is not in general the same as that due to cathode rays; the difference is exceptionally well marked in helium, where the cathode ray luminosity is blue while that due to the positive rays is red. The luminosity produced when the rays strike against solids is also quite distinct. The cathode rays make the body emit a continuous spectrum, while the spectrum produced by the positive rays often shows bright lines. Thus lithium chloride under cathode rays gives out a steely blue light and the spectrum is continuous, while under the positive rays the salt gives out a brilliant red light and the spectrum shows the red lithium line. It is remarkable that the lines on the spectra of the alkali metals are much more easily produced when the positive rays fall on the oxide of the metal than when they fall on the metal itself. Thus when the positive rays fall on a pool of the liquid alloy of sodium and potassium the specks of oxide on the surface shine with a bright yellow light while the untarnished part of the surface is quite dark.

The method given previously for measuring the value of e/m for the cathode rays has been used by W. Wien and J. J. Thomson to determine the value of the same quantity for the positive rays. The theory of the method is as follows: AB and CD (fig. 23) are two equal horizontal plates connected to a battery of cells s that a constant potential difference maintained between this produces a vertical electric force X between the plates. M and N are the poles of an electromagnet, producing a vertical magnetic force H between the plates. A thin pencil of positive rays coming from a discharge tube containing gas at a low pressure passes horizontally between the metal plates and then strikes against a photographic plate, P. While passing between the metal plates the particles are deflected vertically by the electric force and transversely at right angles to the plane of the diagram by the magnetic forces. The vertical deflection x of the spot where the particle strikes the photographic plate by the electric field is given by the equation

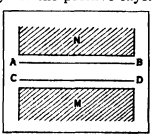

FIG. 23

$$x = \frac{Xe}{mv^2} l \left(L + \frac{l}{2}\right)$$

where l is the length of the metal plates and L the distance of the ends A and C of these from the photographic plate, v is the velocity of the particles the transverse deflection y due to the magnetic force H is, if the electric and magnetic fields are coterminous, given by

$$y = \frac{He}{mv} l \left(L + \frac{l}{2}\right).$$

If all the particles had the same velocity and the same value of e/m, the electric and magnetic forces would just deflect the spot from its position when these forces are absent to another position. If however the particles are not homogeneous as to velocity and the value of e/m the orginal spot will, under the electric and magnetic forces, be drawn out into a series of curves. Since

$$\frac{y^2}{x} = \frac{H^2}{X} \frac{e}{m} l \left(\frac{l}{2} + L\right)$$

an expression which does not involve v but does involve e/m, if the particles were of the same kind but had different velocities, y^2/x would be constant so that the spot would be drawn out into a parabola, and by measuring the parameter of this we can determine e/m.

We see from the expressions for x and y that they cannot vanish unless mv^2 and mv are infinite. Since $mv^2/2 = Ve$ when V is the potential difference through which the particles have fallen, mv^2 cannot be greater than $2Ve$ where V is the potential difference between the electrodes of the discharge tube, hence x cannot be less than

$$\frac{Xl}{V}\left(L + \frac{l}{2}\right).$$

Thus the minimum value of x will not depend on e/m and will be the same whatever may the mass of the carrier of the positive charge. When there is only one value of e/m as in the cathode rays there will be only one parabola and the value of e/m deduced from the parabolas for these rays is $1{\cdot}78 \times 10$. With the positive rays the results are quite different, as will be seen from figs. 24 and 25, taken from J. J. Thomson's *Rays of Positive Electricity.* These are reproductions of the curves found on the photographic plate when the positive rays went through electric and magnetic fields—the horizontal deflection in due to the electric force, the vertical to the magnetic, for one-half of the exposure the magnetic force was in one direction for the other half in the opposite. It will be seen that instead of there being only one parabola there are many. The measurement of these shows that the greatest value of e/m is 10^4 which is the value of e/m for an atom of hydrogen; there is another parabola for which e/m is $\frac{1}{2} \times 10^4$ which is due to the molecule of hydrogen, another with $e/m = \frac{1}{12} \times 10^4$ due to the carbon atom, for the smallest parabola $e/m = \frac{1}{200} \times 10^4$. It is due to atoms of mercury vapour coming from the pump. This shows that the carriers of positive electricity are the atoms and molecules of the gases in the discharge tube;

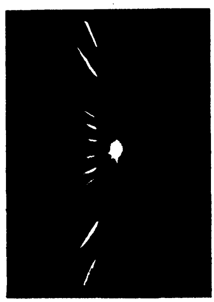
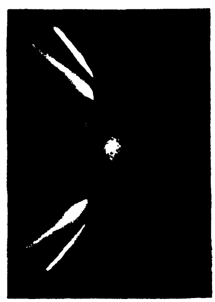

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FIG. 24 FIG. 25

no carrier with a smaller mass than that of an atom of hydrogen has been discovered. It is to be noticed that atoms as well as molecules are always found among the carriers of positive electricity, and that when a compound gas is in the tube there is not only a parabola for the molecule of the compound, but one for each of the atoms of which the compound is composed, thus showing that the discharge is accompanied by a great amount of dissociation.

Some of the atoms occur with a double positive charge as well as with a single one, others may occur with one, two or three

charges, while the atom of mercury may have any number of charges from one to six. Many kinds of atoms show multiple charges, but these are very rare indeed on molecules.

In addition to the particles deflected in the direction corresponding to the positive charge there are some (*see* fig. 1) which are deflected in the opposite direction, and which are, therefore, charged negatively. These are particles which, after leaving the discharge tube and before arriving at the electric and magnetic fields, have lost their positive charge and acquired a negative one. It is remarkable that while every kind of atom can acquire a positive charge, the atoms of many elements seem incapable of doing so. The atoms of hydrogen, carbon, oxygen, chlorine are frequently found with negative charges, but a negative charge has never been found on atoms of nitrogen, helium, neon or argon. Again, it is very rarely that a molecule carries a negative charge, the only cases recorded are the molecules of oxygen and some hydro-carbons.

Retrograde Rays.—Thus, after the positive rays leave the discharge tube, some of them get a negative charge while others are found to be unchanged, so that the penal of positive rays has negative and uncharged particles mixed with it. An analogous effect occurs in the pencil of cathode rays streaming from the cathode. J. J. Thomson (*Proc. Camb. Phil. Soc.* ix., p. 243; *Phil. Mag.* xiv., p. 359, 1907), and Villard (*C.R.* 143, p. 673, 1906), have shown that the stream of cathode rays does not consist entirely of electrons; mixed with these are particles which are not nearly so much deflected by a magnet as the electrons; some are not deflected at all and are presumably uncharged; others are deflected in a direction indicating a negative charge; others in one indicating a positive one. These rays are called *retrograde rays*. J. J. Thomson measured the value of e/m for these rays and found that they consisted of positively electrified atoms and molecules of hydrogen, and atoms of oxygen and negatively electrified atoms of hydrogen and oxygen.

Use of Positive Rays for Chemical Analysis and for the Determination of Atomic Weights.—Positive rays supply a very powerful method of chemical analysis, for each kind of atom or molecule in the discharge tube produces a separate parabola and the measurement of these parabolas gives the value of e/m, and therefore of m. Thus the study of the photographs gives the atomic weight of the gases in the discharge. We can analyse a gas by putting a small quantity of it in a discharge tube and taking a photograph of the positive rays. This method of analysis has great advantages, for substances which can be obtained in the gaseous state it only requires a very small quantity of the substance and if a new gas is in the tube it is indicated by a new parabola; the presence of this not only shows that a new gas is present, it enables us to determine its atomic weight. By this means J. J. Thomson discovered the existence of H_3 and an isotope of neon.

Very great improvement in the accuracy of the determination of atomic weight has been made by modifications of the method made by Aston; he has made it by far the most accurate method of measuring atomic weights. He has obtained results of fundamental importance with regard to the relation between the atomic weight of the different elements, and has detected and measured the atomic weights of the isotopes of a large number of elements; an account of this work is given in the article ISOTOPES.

The positive rays show, when the pressure is not very low, the line spectrum of the gas through which they pass. An exceedingly valuable set of observations on this point have been made by Stark and his pupils (*Physik. Zeit.* 6, p. 892; *Ann. der Phys.* 21, pp. 40, 457). Stark has shown that in many gases, notably hydrogen, the spectrum shows the Doppler effect, and he has been able to calculate in this way the velocity of the positive rays.

Anode Rays.—Gehrcke and Reichenhein (*Ann. der Phys.* 25, p. 861) have found that when the anode consists of a mixture of sodium and lithium chloride raised to a high temperature either by the discharge itself or by an independent heating circuit, very conspicuous rays come from the anode when the pressure of the gas in the discharge tube is very low, and a large coil is used to produce the discharge. The determination of e/m for these rays showed that they are positively charged atoms of sodium or lithium, moving with very considerable velocity; in some of Gehrcke's experiments the maximum velocity was as great as $1{\cdot}8\times10^7$ cm./sec. though the average was about 10^7 cm./sec. These velocities are less than those of the positive rays whose maximum velocity is about 2×10^8 cm./sec. (J. J. TH.)

ELECTRICITY COMMISSIONERS. The Electricity Commissioners (Great Britain) were established in 1920 under the provisions of the Electricity Supply Act, 1919, for the purpose of promoting, regulating and supervising the supply of electricity in the United Kingdom (limited to Great Britain in 1922 on the transfer of Irish services). The objects of the Act, which was largely based on the findings of the Electric Power Supply Committee of the Board of Trade, were to secure improvement in the organization for the supply of electricity and to consolidate the administration of the then existing acts and orders relating to such supply.

The Act provided for the setting up of Electricity Commissioners not exceeding five in number responsible to the minister of Transport, with powers and duties which are indicated later; and for the transfer to the minister of the functions of the Board of Trade under prior acts, orders, etc., relating to electricity supply. It enabled the minister to exercise any of such functions through the commissioners, and provided that the minister should refer to the commissioners for their advice all matters connected with the exercise of the functions transferred to him, subject to certain exceptions.

The annual expenses of the commissioners, in accordance with an estimate prepared by them and approved by the minister, are defrayed by a levy upon the authorized electricity undertakings in the country, the expenses being apportioned on the basis of the number of units sold by each undertaking.

The principal functions of the commissioners are: (*a*) The preparation of technical schemes for the concentration of generation and the provision of main transmission systems, to be carried out by the Central Electricity Board constituted by the Act of 1926; and where necessary, the formation of electricity districts for the reorganization of supply therein under joint electricity authorities; (*b*) The sanctioning of the borrowing of money for such schemes by the Central Electricity Board, joint electricity authorities and municipal supply authorities; (*c*) The giving or withholding of consent to the erection of any new or the extension of any existing generating station other than a private station; (*d*) The granting of orders to authorize the supply of electricity in specific areas, the compulsory acquisition of land, etc.; (*e*) The framing of Regulations relating to the supply of electricity; (*f*) The prescribing of annual statements of account for all supply authorities, the collection of statistics, etc.

The commissioners advise the minister of Transport in the exercise of his powers connected, *inter alia,* with the granting of consents to the erection of overhead lines; the revising of maximum prices for electricity; the revocation of electricity powers in case of default, etc.; and reports to parliament on the provisions of private bills relating to the supply of electricity.

ELECTRICITY SUPPLY: COMMERCIAL ASPECTS. The conditions influencing the supply of electricity in Great Britain have undergone a number of important changes since the legislative foundation of the industry in 1882. The position now, nearly half a century later, considered in the light of subsequent legislation, presents some interesting phases of rhythmic evolution. The events may be grouped in three periods. The first was one of varying activities instrumented by trial and error—technically, commercially, politically. The second was one of fatigue and recuperation followed by splendid performance during the World War. The third is one of re-organization by the Electricity Commissioners. As a consequence, we reach the emergent conclusions that electricity can be transmitted more easily than coal, it can be sub-divided and applied more effectively than steam, and is more controllable than other forms of motive power. The industry offers scope for enterprise, for investment of capital, for employment of labour, which cannot be estimated

without appearance of exaggeration.

First Period.—The first of the three periods referred to covers about 25 years and deals with restrictive legislative conditions amid technical and financial difficulties which characterized the early struggles for survival of a young industry competing against firmly established gas interests, and later maintaining a defensive attitude against foreign competition developed under far-seeing encouragement. Public opinion in Great Britain in the latter part of the 19th century was adverse to the creation of further monopolies, the general belief being that railway, water and gas companies had received valuable concessions on terms which did not safeguard the interests of the community sufficiently. At the same time municipal institutions were given wider functions. These legislative measures were not uniformly successful; some proved injurious to the public, others discouraging to investors. One of these measures was the Tramways act (1870), which twelve years later was followed with the same political outlook by the first Electric Lighting act, imposing onerous conditions of expropriation. Stagnation during many years was the consequence, and recovery was slow. The aggregate capacity of the electrical plants installed in the United Kingdom in 1906 (24 years after the passing of the first Electric Lighting act) was only one million kw. The average load factor of all the British electricity stations was 14·5%. The average capital expenditure was about £80 per kw. of plant. The units sold were 530 millions. The average cost of generation and distribution, excluding depreciation and interest, was 2s. 3d. per unit.

With advances in technical practice the advantages of generation on a large scale, of distribution over wide areas at high voltages, and of application of electricity in various industries, were demonstrated in other countries, but in Great Britain special Acts of Parliament had to be promoted to authorize effect to be given to these principles. Before this could be done education of public opinion was necessary because strong opposition arose on the part of local authorities, who feared that municipally-owned electrical undertakings would be prejudiced. A joint committee of both houses of Parliament was appointed in 1898, with Lord Cross as Chairman, to consider the bills promoted by enterprising pioneers. This committee recommended that powers should be given for the supply of electrical energy over areas including the districts of several local authorities, and suggested that the then legislative conditions did not apply to such undertakings. While the Electric Power acts passed in 1900 were more consistent with economical development than the provisional orders granted under the acts of 1882 and 1888, the exclusion of the large towns from the acts, coupled with other restrictive provisions, disabled most of the Power act companies from raising the requisite capital, and progress under these special acts was at first very slow and difficult, because the sound policy of supplying cheap electricity in bulk had to be deferred. Successive bills were drafted by the Board of Trade to remove the obstacles, and eventually the Electric Lighting act (1909) was passed. It conferred wider facilities upon undertakers in minor matters, but the traditional attitude of restraining private enterprise in deference to views in favour of municipal trading permeated the measure, and afforded very little assistance towards building up a comprehensive system of supply. The conspicuous feature in this phase of electrical history is the hundreds of comparatively small generating stations, scattered and isolated throughout the country, supplying in restricted areas, and pursuing the uneconomic policy of independent development.

Second Period.—The second period (1909–19) presented during the first part the effects of disappointment due to unavailing struggles in the face of flourishing industrial conditions abroad. During this period Dr. S. Z. de Ferranti was president of the Institution of Electrical Engineers for two successive years. In his presidential address, Nov. 1910 (*Journal Inst. E.E.*, vol. 46) he expounded the "all-electric idea" of making an abundant and cheap supply of electricity available by a supply of electricity distributed over the country, with a view to coal conservation, production of home-grown food, and the better utilization of labour. This address is a sign-post indicating the main road of electrical progress which the present generation is treading, which in all probability will be followed not only by electrical engineers as pioneers, but by the whole army of British industrialists during the present century. In other addresses he made audible the demand within the industry for a "broader policy" in favour of better organized and more effective solidarity of the technical, commercial and political interests. The remarkable improvements which followed the adoption of this policy are best seen by a comparison of the contents of the *Journal Inst. E.E.* before and after the year 1913 (vol. 52).

The transition from a state of depression in the industry was hastened by the outbreak of the World War, followed by unprecedented demands for electric power in connection with production of war material. The war changed entirely the general aspects of the industry and initiated radical modifications in the legislative standpoint. The exigencies of the war revealed electricity as a vital agent of industrial production; they brought out sharply the defects in the legislative situation, by which co-operation in production and distribution was impracticable, and isolated development was fostered. The interconnection of generating stations, desirable with a view to economy in plant, coal and other items of cost, was urged upon electricity undertakers by a Board of Trade circular in May, 1916, and a special department was formed under the Ministry of Munitions to organize the supply of electric power. Despite chaotic conditions the great efforts made by the industry to cope with the urgent and practically unlimited call for power were generally successful. The four years of war were equivalent in electrical growth to that of the previous 35 years. The proof afforded of the great national importance of electricity supply led the educated public to think electrically. The following committees were appointed: coal conservation sub-committee of the reconstruction committee (Cd. 8880, 1917); electrical trades committee (Board of Trade Cd. 9072, 1918); electric power supply committee (Board of Trade Cd. 9062, 1918); committee of chairmen of the advisory council of the Ministry of Reconstruction (Cd. 93, 1919). These reports led to the passing of the Electricity Supply act, 1919 (amended by the Act of 1922). As originally drafted the bill met with much opposition, directed chiefly against its compulsory nature and what was regarded in many quarters as a distinct bias towards nationalization in its financial provisions. The contentious clauses were withdrawn, and provision was made for the creation of joint electricity authorities empowered to acquire generating stations and main transmission lines by agreement, but not otherwise. The act provided for the appointment of five electricity commissioners. Their general duties are defined as "promoting, regulating and supervising the supply of electricity." Their first specific duty was to determine provisionally "electricity districts," and consider schemes for improving the existing organization for the supply of electricity. Such schemes might provide for the establishment of joint electricity authorities representative of authorized undertakers, within the electricity district, either with or without the addition of representatives of county councils, local authorities, large consumers of electricity, and other interests within the district, and for the exercise by those authorities of the powers of the authorized undertakers. The machinery of the act was of a voluntary nature. The act as passed inspired confidence in the future of the industry; it broke down many prejudices, municipal, political and official; it simplified the procedure for extensions of supply areas, and in the general view constituted the one statesmanlike piece of legislation bestowed on the electrical industry. The appointment of electricity commissioners was in itself a salutary revolution. Their annual reports, the first to March 31, 1921, the seventh to March 31, 1927, are full and interesting records of important events and of beneficial work done.

Third Period.—The third stage covers the period from 1919 to the present time (1928). The year 1920 was not favourable to the task of embarking upon extensive schemes of industrial reorganization. The commissioners recognized the fact that "even if the problem could be reduced to engineering considerations alone, the financial stress would constitute a barrier to the speedy

development of schemes in different parts of the country." Not only was capital dear and rates of wages high, but prices of plant, materials and fuel were rising. The industry was faced also with the urgent problem of plant replacement. It was the policy of the commissioners not to consent to the establishment of new stations or the installation of additional plant, unless the proposals were technically and financially sound. But the needs were so urgent that often the commissioners found no alternative but to consent to the extension of uneconomical stations, in order that demands upon the undertaking might be met without failure of supply. The knowledge gained by manufacturers during the war had been so well assimilated that even during the time of acute trade depression, which succeeded the period of inflation, and notwithstanding labour troubles—which included prolonged disputes in the coalfields, culminating in the general strike (May 1926)—replacement and extension proceeded continuously. An appreciable portion of the work put in hand was expedited expressly for the purpose of stimulating the revival of trade and relieving unemployment, and in a number of such cases financial assistance was given by the Government to company undertakings by way of loans guaranteed by H.M. Treasury under the Trade Facilities acts. With similar objects in view advances were made (mainly to local authority undertakers) by the unemployment grants committee. As a further encouragement the Local Authorities (Financial Provisions) act was passed in 1921 to enable local authorities to suspend sinking fund payments on moneys borrowed for the construction or extension of revenue-producing works, while such works remained unremunerative, subject to a maximum period of 5 years.

In 1920–26 upwards of 100 (64 non-statutory) new generating stations were sanctioned, including four hydro-electric schemes in Scotland authorized by special acts. The largest of the new stations was of 100,000 kw. capacity, while 79 others were of smaller capacity than 250 kw. each. The figures of the smaller stations are of interest, inasmuch as they represent the inauguration of supplies in about 80 new localities, to which no alternative source of supply was available. This increase of generating facilities has been accompanied by a certain amount of concentration in large stations. The aggregate capacity of generating plant of authorized undertakers in 1927 was practically twice the capacity installed in 1920, but the actual number of stations in operation shows only a small decrease. The process of modernization has been marked by a notable improvement in the efficiency of generating machinery, due to advances in design and manufacture; by an increase in the size of units; and by change-over from direct current to alternating current.

Modern units ranging from 10,000kw. to over 30,000kw. now constitute a considerable proportion of the generating plant in operation, and nearly 90% consists of steam turbo-alternators. The combination of change of type and enlargement of units, coupled with improvements in steam-raising plant and advances in furnace practice, has effected important economies in the utilization of fuel. The lowest fuel consumption recorded at any steam station in 1926 was 1·36 lb. per unit, and the highest thermal efficiency 21·51%. Both figures relate to the Barton station of the Manchester corporation. The average consumption of fuel, coal, coke and oil, at steam stations was 2·43 lb. per unit, to which figure it has progressively declined from the 3·42 lb. per unit recorded in 1920.

The Growth of Supplies.—A conspicuous feature of post-war development has been the large extension of distribution areas, as many as 329 special orders having been granted during the period under review. The corresponding result in a view of the period as a whole, is seen in a progressive and substantial increase in the consumption of electricity. The sales of electricity by authorized undertakers in 1926 (excluding sales by non-statutory undertakings and the output of traction and private industrial plants) amounted to 5,723 million units. A hindrance to fuller development of the load is experienced in some areas by the practice in the past (which in some instances still prevails) of laying mains of a size too small to carry the increased demands now made upon them. The commissioners issued a memorandum on the subject in May, 1927.

For the purpose of ascertaining what steps were being taken to encourage and extend the use of electricity for domestic purposes; the relative effectiveness of such steps; and what further steps could be taken to bring about increased consumption, an advisory committee was appointed by the electricity commissioners in April, 1925. The committee's Report was published in Oct. 1926. It refers to the increasing use of electricity for domestic purposes, emphasizing the great potential demand and the value of the load to the supply undertaking, on account of its high "diversity factor," and includes an interesting and useful analysis of various multi-part tariffs at present in use. The committee formed the opinion that none of the latter could be recommended as standard for exclusive adoption.

Statistical Summary, 1926.—The industrial position of electricity supply in 1926 may now be statistically recorded. There were, in Great Britain, 623 separate undertakers holding statutory powers and owning between them 479 generating stations (264 local authorities and 215 companies) with an installed plant capacity aggregating 4,422,000 kw. (practically twice the capacity installed in 1920). The units sold to consumers were 5,724 millions, representing about 130 units per head of population. These figures relate to authorized undertakers only, but, including non-statutory undertakings, there are altogether 816 electricity supply undertakings with an aggregate capital of 283 million pounds (141 millions in respect of local authorities and 142 millions in respect of companies). The average return on the capital invested in the companies (debenture and shares) fluctuated between 5·58% in 1920 and 6·51% in 1925. For 1926, which was an abnormal year owing to the coal strike, the return fell to 6·21%. These figures reveal substantial expansion; nevertheless the progress made since the act of 1919, though considerable, was small compared with the potentialities of the industry and with progress in other countries.

The "Weir" Report.—The electricity commissioners in their annual reports made several references to the engineering, financial, administrative and legal obstacles to progress, and in their fourth report (Aug. 1924) they stated that though the powers vested in the commissioners had enabled progress to be made in securing co-ordinated development, it had become apparent that a real organization which would adequately serve the requirements of the country could only be achieved on the voluntary basis of the act of 1919, by a radical change in the attitude of authorized undertakers in general, and that, failing the early disappearance of the obstacles, the whole position would call for review. All parties in the legislature showed alacrity to deal with the problem, and in Jan. 1925 the Government appointed a committee consisting of Lord Weir of Eastwood (Chairman), Lord Forres and Sir E. Hardman Lever, Bart., with Sir John Snell as technical adviser, to consider the general question of the immediate and future electrical development of the country. The committee's report was presented to the minister of transport in May 1925, but was not published until March 1926, when a Government bill, based largely on the findings of the committee, was introduced in the House of Commons. The report recommended the establishment of a comprehensive network of transmission mains (called the "Gridiron") interconnecting all selected stations (43 existing ones and 15 new ones proposed) where generation would be concentrated, entailing the closing down of local generation at 432 existing stations. It further recommended the creation of a new body, termed the Central Electricity Board, with powers to construct, own and operate the proposed "Grid" system of high tension transmission lines; that selected stations should be operated by the owners under the directions of the board; and that all high tension energy generated by authorized undertakers in the country after a certain date should be generated under control in accordance with a technical scheme for the country, and sold through the board to all authorized undertakers at cost price. It proposed "not a change of ownership, but the partial subordination of vested interests in generation to that of a new authority for the benefit of all, and this only under proper safeguards and in a manner which will preserve the value of the incentive of private

enterprise." The report contains a picture of what should be aimed at to secure efficient generation of high tension energy in 1940 compared with the year 1925. The salient comparisons are given in the following table:

	Position (1925)	Position in 1940 or when the consumption has reached 500 units per head
Units sold per head of population	110	500
Maximum load	1,844,000 kw.	8,135,000 kw.
Kw. installed	3,096,000 kw.	10,000,000 kw.
Spare plant	68%	25%
Units sold	4,016,000,000	21,385,000,000
Load factor	24·9%	30%
Total capital:		
Generation	£73,680,000	£127,000,000
"Gridiron" transmission	..	£29,000,000
Distribution	£88,070,000	£243,500,000
Total revenue	£34,256,000	£88,100,000
Average price per unit	2·047d.	1d. or under

The Act of 1926.—The Government Bill framed to give effect to the recommendations of the "Weir" report was exposed to very keen criticism during its progress through Parliament. It is remarkable that whenever the industry is confronted by a serious crisis, it is not purely technical; not wholly industrial; not alone financial; but essentially political in its character. The opponents of the bill were not opposed to "super-power" developments. They agreed that standardization and systematic grouping, interconnection of existing power systems, generation on a large scale in efficient power stations, and transmission in bulk at high voltage to local distributors, would enable differential outputs to be adjusted, with beneficial results making for increased output, greater efficiency and economy; but they contended that these results could be better secured by other means and without the novel administrative system of control and economic methods proposed; and the owners of company electricity supply undertakings were nervous lest the proposed legislation should again inflict grievous financial and confiscatory burdens upon them. With considerable amendments of details the measure was finally passed and received the royal assent on Dec. 15, 1926 (16 and 17 Geo. 5. Ch. 51). By its enactment a radical change in legislative conditions affecting the organization of the electricity supply industry was brought about. A memorandum summarizing its provisions mainly from the standpoint of the powers, duties and obligations of authorized undertakers was issued by the electricity commissioners in Feb. 1927.

In order to secure the concentration of generation in a selected and limited number of stations, all interconnected and operated under one control, the act discards the principle of co-operative action on a voluntary basis (which was the principle embodied in the act of 1919) and substitutes a compulsory basis through the medium of a new body—the Central Electricity Board. This board, whose functions may be briefly described as the reorganization and control of generation, is established as an authorized undertaker for the whole of Great Britain, within the meaning of the Electricity (Supply) acts 1882–1922. The ultimate object in view is that all authorized undertakers shall obtain their supplies of electricity in bulk from the board, either directly or indirectly. For this purpose certain generating stations will be "selected" and interconnected, and operated by the owners on behalf and under the control of the board, who will purchase all the output of such stations at a price (being the cost of production) to be ascertained in accordance with prescribed rules. Distribution and commercial development is left in the hands of the undertakers as heretofore, who will purchase from the board the supplies they require (within specified limits) at a price, unless otherwise agreed, equal to the cost of production as ascertained and adjusted, plus a proper proportion of the board's expenses or according to the tariff fixed under the act, whichever is the lower. In the case of non-selected stations, the owners (being authorized undertakers) may demand a supply of electricity from the board, in which case they may be required to close down their local generating stations and take the whole of their supplies from the board. There are other circumstances in which the owners of a non-selected station may be required (by an order of the electricity commissioners) to close down local generation, namely when the Board notify that they are in a position to supply the full requirements of the undertaking at a cost below the then prevailing cost of generation at the station in question. The act does not contemplate the construction or operation, or the transfer of any generating stations to the board itself, except as a last resource, when they are unable to enter into an arrangement with any authorized undertakers or other company or person to operate such stations, or extend, alter or construct such stations as the case may be. The act contains various clauses for the protection of undertakers, but the commercial and, it is feared, the legal interpretations, are very involved. The board has power to borrow money with the consent of the commissioners and subject to regulations made by the minister of transport with the approval of the Treasury up to a maximum of £33,500,000, which money may be raised by the issue of central electricity stock, but power may be conferred on the board by special order to borrow in excess of that amount. The act makes provision for the preparation, adoption and carrying out of schemes of technical development ultimately covering the whole country. The Central Electricity Board consists of a chairman and seven other members appointed by the minister of transport "after consultation with representatives of local government, electricity, commerce, industry, transport, agriculture and labour." (Sir Andrew R. Duncan [chairman], Sir James Devonshire, K.B.E., Frank Hodges, Sir James Lithgow, Bart., W. Walker, Sir Duncan Watson, W. K. Whigham and Lt.-Col. the Hon. Vernon Willey, C.M.G.) The chief engineer and manager is Mr. Archibald Page (formerly an electricity commissioner). The secretary is Sir John R. Brooke, C.B.

Four schemes under the act have already been drawn up by the electricity commissioners and published by the Central Electricity Board. The first was transmitted by the commissioners to the central board and published by the board on May 11, 1927. It dealt with central Scotland, covering an area of about 4,980 sq.m. with a population of 3¾ millions, including roughly the whole of the industrial, shipbuilding and coalfield areas of Scotland. At the present time there are 42 authorized undertakers in the area, owning between them 36 generating stations. Under the scheme ten existing stations will be selected and operated for the board. The scheme contemplates the erection of two new stations of not less than 100,000 kw. each by the year 1938. The transmission system is designed in a series of ring mains, so that there will be alternative routes to points of supply. The primary line voltage adopted is 132,000 volts. The scheme involves a large measure of standardization of frequency—no fewer than eleven undertakings and five generating stations will have to be altered from 25 to 50 cycles. The scheme, with certain modifications, was adopted by the central board on July 1, 1927. The second scheme was transmitted on Sept. 29, 1927. It deals with south-east England, covers an area of 8,828 sq.m. including the London and home counties electricity district, and extends from Peterborough in the north to Brighton in the south, with a population of over 11 millions. The third scheme is for Central England and the fourth is known as the north-west England and north Wales scheme. Other schemes dealing with south-west England and south Wales are being prepared.

In the opinion of the commissioners the improvements in the organization for the supply of electricity which have taken place during the post-war period, will serve to facilitate the transition to the new régime laid down by the act of 1926. This important industry of nearly 50 years' standing is now for the first time placed under authorities able to deal authoritatively with technical, commercial and financial problems of the industry on their merits, in the national interests, in a large measure freed from local administrative restrictions. It is emerging from a state of bare existence to the full enjoyment of its life, with energies directed to rendering valuable services to the community. It has

an ill-advised inheritance of legislation, but a naturally strong constitution which enables it to regard difficulties and adversity as normal antecedents to technical success and commercial prosperity. As a matter of historical interest 12 years hence, it may be said that though the objections to many of the provisions of the 1926 act are valid, it is generally agreed that loyal and co-operative effort on the part of undertakers to make the operation of the act successful, is now more important to the realization of the all-electric idea than adverse criticism of the legislative machinery. The complementary condition of this consummation is all-round confidence that justice will be done in the difficult adjustments of rights, duties and interests between investors and workers on the one hand, and consumers on the other, having regard to past sacrifices and future services of the former and the paramount demand by the latter for cheap electricity as an essential to maintenance of national welfare.

The London Position.—After many years of controversy the problem of electricity supply in London is in process of solution. The limitations of the early electric lighting acts were sufficiently difficult in relation to provincial undertakings, but they were accentuated when applied to the metropolis. "London" is an agglomeration of towns and local authorities, and in the sense of the Electric Lighting acts the boundaries of a borough constituted the limits of an electric lighting area. Moreover, the generating station had to be erected within the municipal area of supply. The history of attempted reform of the London position dates back to 1905, and is summarized in *Garcke's Manual*, 1915–16, vol. xix., pp. 16–19, and 1926–27, vol. xxx., pp. 596–8 and 611–5. *See* also *4th, 5th, 6th and 7th Annual Reports of the Electricity Commissioners.* Nothing tangible was achieved until the London Electric Supply acts 1908 and 1910 were passed. Under these acts the powers to purchase the undertakings of the companies in the administrative county of London, which would otherwise have been exercisable for the most part in the year 1923 by the metropolitan borough councils, were modified, *inter alia* by extension of tenure to 1931, and transferred to the London County Council. Under the Electricity (Supply) act, 1919, the London and home counties joint electricity authority was established as from July 29, 1925. The district of the joint authority includes the whole of the counties of London and Middlesex, and parts of the counties of Herts., Essex, Kent, Surrey, Bucks. and Berks. The local government areas comprised in the district include the City of London, the City of Westminster, 27 metropolitan boroughs, 3 county boroughs, 16 municipal boroughs and a large number of urban and rural districts. The population at census of 1921 was 8,178,766; the assessable value on April 6, 1925, £75,926,030. The total number of authorized distributors is 89, namely, 44 local authorities and 45 companies. The position of the company undertakings was wholly altered by the London Electricity (No. 1) and (No. 2) acts, 1925, and the London and Home Counties Electricity district order, 1925. Under these the London companies secured an extension of the tenure of their undertakings until 1971, when such undertakings will be transferred to the London and home counties joint electricity authority. Prices to be charged for electricity and dividends to be paid to shareholders will be regulated by a sliding scale, and sinking funds will be set up by the operation of which the existing assets of the companies will be transferred to the joint electricity authority in 1971 free of cost, and new assets will be transferred at cost price less depreciation. Under the powers conferred by the London Electricity (No. 1) act, the promoters, namely, the City of London, county of London, south London, and south metropolitan companies, have prepared a scheme subject to approval by the electricity commissioners, under which the operation of the generating stations of the four companies would be directed by a joint committee. These generating stations have been joined by interconnecting cables. The remaining ten companies which promoted the No. 2 act have formed a new company now called the London Power Company, Limited, the board of which consists of a representative of each of the ten companies. This company has taken over the generating stations and main transmission lines of the ten companies, and these, retaining their full and complete rights as authorized distributors, now purchase in bulk from the London power company the whole of the electricity which they require for supply in the county of London.

Transmission and Distribution.—The present practice is to generate electricity at pressures of from 5,500 volts upwards to 66,000 volts, and to transmit the energy to sub-stations situated at convenient points of the low pressure distribution network where, in the case of alternating current supplies, it is transformed to the low distribution pressure for use by the consumers, and in some cases is converted to direct current of similar low pressure, ranging from 230 to 250 volts. The distribution network is provided with apparatus for isolating sections automatically or at will. From this low pressure distribution network the small service connections are made to individual premises for lighting, heating, cooking and other uses. In the case of factories and other industrial purposes the supply is provided at extra high pressure on the 3-phase system in the same manner as to the sub-stations, the consumer installing the transformers for reducing the voltage suitable to requirements. In the case of motors of a greater h.p. than 250, high pressure current up to 11,000 volts is often used without transformation. In the larger distribution areas the 3-phase system alternating 50-periods per second is now becoming standard. In thickly populated districts the standard practice is to employ cables with conductors insulated by paper impregnated with oil, surrounded by a lead sheath which, in many cases, is further externally protected by steel wire or tape binding, this system being employed for both high and low pressure cables. These cables are either laid direct in the ground or drawn into earthenware conduits at a depth of 2′ 6″ to 3′ 0″ below the surface. The alternative method of distributing electricity is to carry the conductors overhead.

The cost of providing cables underground is approximately three times that of overhead conductors of similar current-carrying capacity. In congested areas the density of the demand may justify the increased cost of underground cables, but the problem of distributing electricity in rural districts is now receiving attention; and to enable these services to be given at prices which the consumers can pay, the cost of distribution must be kept down, because the distribution network in rural areas is large in relation to number of consumers. Overhead lines outside the more congested centres of population are being increasingly adopted, but not sufficiently, if the rural load is to develop to the large extent which the potential demand indicates. The subject is closely bound up with questions of way-leaves and pole rentals, and the standard of construction demanded under the commissioners' 1923 code of regulations. A revised code of Overhead Line Regulations was issued by the Commissioners in April 1928 (El. C. 53). The high cost of construction imposes a handicap on development, particularly with low voltage lines. A memorandum on electrical development in rural areas was issued by the electricity commissioners in Aug. 1927, inviting the active support of local authorities, landowners and others able to afford facilities in connection with overhead lines and way-leaves. Further steps were taken in Nov. 1927 by a conference of various bodies interested in different aspects of rural electrification, to review the whole position. A report was issued by the Electricity Commissioners in July 1928. The Overhead Lines Association was formed in Oct. 1927 at the suggestion of Mr. R. Borlase Matthews, M.I.E.E., to co-ordinate experience and special knowledge of the subject.

Rural electrification points to ruralization of industries, with electricity distributed economically to factories on relatively cheap land. Decentralization of large composite works and segregation of factories for production of standard parts are easily conceivable developments. The social effects are not at present calculable, as many factors are still indeterminate, but the beneficial influence of these impending changes upon the relations between labour and capital, and upon the problems of unemployment, cannot be overlooked. The important point to note is that there is no national monopoly in electricity; it is an all-world development, with economic potentialities difficult to measure, with social and ethical probabilities interesting to contemplate. A few words on the subject of electricity in agriculture are apposite. Electro-farming is

an important recent development. As farms employ more power, in the aggregate, than all other industries put together, the capture of the farming load is most interesting from the point of view of the electrical engineer, and the fact that probably over a million of the world's farmers are using electricity (including 750 in this country) points to further advances. This new service has its own journals in Britain, America and Sweden, and a recently collected bibliography reveals the fact that over 600 authoritative articles, pamphlets and books have been written upon it, over 20% of which deal with electro-culture. In Great Britain, the most advanced electro-farming areas are Fifeshire, Ayrshire, south Wales, north Wales, Shropshire, Somerset and Cheshire, while near East Grinstead is an all-electric farm of 650 acres, where some 67 of the 200 known applications of electricity to agriculture are installed. In cities the annual consumption of electricity is based on units (kilowatt-hours) per square mile, but in rural areas it should be based on units (kw.hr.) per mile of distributor. On this basis, rural electrification compares very favourably with statistics available for suburban areas.

Manufacture.—The electrical manufacturing industry has experienced exceptional difficulties and undergone many vicissitudes. In its early days the various departments which are now developed as separate industries were closely allied. Thus the manufacturer was linked by various bonds, especially that of finance, with the inventor and *entrepreneur*, the parliamentary promoter of public utility undertakings, and the constructor of works, for he could not obtain employment for his factory unless he was interested in the initiation of enterprises. But during the World War the manufacturers gained experience in mass-production, and diverse industrial functions were segregated and became specialized. Subsequently in the post-war period of transient inflation, kindred businesses were again united by allied finance rather than in coalescence, and large combines of separate but interconnected companies were created for the furtherance of common interests and execution of large composite contracts. During the pre-war period when the industry was involuntarily inert, owing to impeded growth, manufacturers in America and in Germany, who had the encouragement of growing demand for apparatus, devoted their resources to the development of efficient selling organizations at home and abroad; with the result that they were able to take advantage of the system of free imports to secure orders in Great Britain for plant and machinery. The British electrical industry has been reproached for being in a backward condition, but the wonder is that it has got so far forward. Under changed surroundings after the war the electrical manufacturing branch recovered rapidly as compared with other branches of the engineering industry. Since the 1907 census of production the electrical output has increased from 13 million pounds to an estimated output of 80 millions in 1927, an increase of 500%, which is considerable in relation to the figures for general engineering products for the same period. The conspicuous progress of the industry is not by any means merely a quantitative increase. As Mr. Dunlop, the director of the British Electrical and Allied Manufacturers Association has shown, side by side with the growth in volume has proceeded a progressive improvement in quality and efficiency, the result of intensive research work for which the manufacturer had no funds under pre-war conditions. In the case of generating machinery, for example, fuel consumption has been reduced within the last five years by nearly 30%. Recent figures of exports indicate an advance relatively to other nations. In 1913 Germany dominated the electrical export trade of the world. In 1927, however, Britain has moved into the first place among electrical exporting countries. "The displacement of trading strength," says Sir Hugo Hirst, "justifies the assumption that the technical and manufacturing efficiency of British firms now stands at a higher point than at any previous time. In quality as apart from mass production their superiority can scarcely be challenged." It can be assumed, he says, that of the total production of electrical apparatus at least four-fifths represent direct and indirect wages paid. This means that the industry gives employment to probably 600,000 workers, or 320,000 in addition to the 280,000 it employs directly. The electrical manufacturer therefore is fighting for more than his own industry, and there are few industries in this position, at least of the same importance. The fact that an improved margin of profit has been earned need not be regarded as an effect of co-operation to keep prices above an economic level. As a matter of fact, the moderate improvement in net profits of electrical manufacture during the post-war period has been accompanied by substantial reductions in selling prices of electrical goods in relation to altered money values, cost of living, wages and other economic factors which enter into determination of price levels. An international comparison of prices in relation to costs of production is, however, rendered excessively difficult by variable classifications of manufactured goods, and by lack of information as to debit and credit items making up the effective costs for purposes of foreign competition. The history of the British electrical industry demonstrates in an accentuated form the truism that unrestricted competition leads to inability of an industry to do justice to essential interests of producer, consumer and community. Unduly low prices mean reduction and perhaps even elimination of profit, and this deters capital required for improvements, extensions and research, and produces disturbing conditions owing to fear of wage reductions; while consumers and users suffer in quality of commodities supplied and services rendered.

The following are financial figures relating to manufacturing undertakings in the three typical periods of the electrical industry:

Year	*Number of companies*	*Capital*
1910	265	£41,693,000
1920	280	£63,908,000
1926	365	£89,291,000

The average rates of net profits earned by such of the companies and firms whose accounts are published are for the year 1910, 5·22%; for 1920, 9·98%; for 1926, 7·73%.

The aggregate subscribed capital and loans authorized in 1926 of 1633 British electrical undertakings of all kinds amount to over £818 millions.

These undertakings are classified as follows:—

	£
Telegraph Companies	50,165,000
Telephone, Companies	9,251,000
Telephone, Government and Municipal Expenditure	72,735,000
Electricity Supply, Companies	142,470,000
Electricity Supply Municipalities, Loans authorized	140,568,000
Electric Traction, Companies	181,866,000
Electric Traction Municipalities, Loans authorized	89,686,000
Manufacturing	89,291,000
Miscellaneous	42,720,000
	£818,752,000

Research Work.—Following the rapid expansion of the industry during the war, it became evident that co-operative research was necessary for continued technical and commercial progress. An electrical research committee was formed in 1917, and a few years later this committee was reconstituted as the British Electrical and Allied Industries Research Association (E.R.A.) under the scheme of the department of scientific and industrial research which was established in 1918, the Government placing at the disposal of the department one million sterling to enable it to encourage the industries of the country to undertake scientific research. It is estimated that the membership of the E.R.A. represents about 85% of the capital employed in manufacture in the industry. The work of the E.R.A. now covers a large part of the field of research in the industry. The results are embodied in technical reports issued to members of the association, and about one-third of the reports have been published for the general benefit of the industry, mostly through the *Journal of the Institution of Electrical Engineers.* There are many problems which show great promise but which have to be postponed for lack of adequate funds, notwithstanding that the solutions are urgently needed. It must be added that large sums are being spent on research by individual firms; and that brilliant achievements are recorded in the field of theoretical physics, which, however, lead to further technical investigations for their practical application. In 1925 the electricity commissioners addressed representative sections of the industry with the view of enlisting active support for the work of the association.

Standardization.—Recognition of the principle of standardization arises early in the organization of every industry, but until a considerable degree of prosperity and solidarity is attained, by which individual interests and jealousies are merged in collective interests, its growth is slow. The first edition of the *I.E.E. Wiring Rules* was issued as early as in 1882, but it required many years before rival manufacturers could agree on standardizing even such small things as switches, plugs and lamps. In 1901 the British Engineering Standards Association (then called the Engineering Standards Committee) appointed a sub-committee for standardization of electrical plant. In 1906 Colonel R. E. Crompton founded the International Electrotechnical Commission, and the British National Committee was appointed to co-operate in this work. One of the many objects was to discourage the use of varying specifications by individual engineers when one specification would serve the purpose. The B.E.S.A. has now 70 committees preparing electrical specifications. The I.E.C. by its various committees is itself directly engaged in important co-operative standardization, and committees considering questions of electrical standards (mostly for reference to the B.E.S.A.) exist within various sectional electrical associations, while practically every industrial and scientific body in the electrical industry lends its active support to the work. In 1919 a Government inter-departmental committee was set up to co-ordinate the electrical requirements of the Government departments, and this committee works in close co-operation with the B.E.S.A. In 1925 the membership of the B.E.S.A. was made available to all connected with the industry on payment of an annual fee. The B.E.S.A. has endeavoured to set up standards of quality in materials and apparatus. Those standards are not confined to technical requirements, but are of value also on the commercial side, as is seen in the I.E.E. Model Conditions of Contract. Conditions of employment have also been standardized to a certain extent in the electrical industry. Probably one of the most valuable pieces of work brought to completion is the *British Standard Glossary of Terms used in Electrical Engineering.* The increase in production and the rapid spread of distribution of electric power on a large scale have created many new problems of standardization, for the consideration of which reference may be made to articles by Mr. P. Good in the *I.E.E. Journal*, vol. 64, April 1926, vol. 65, Jan. 1927, vol. 66, Jan. 1928.

Growth of Associated Effort.—Compared with the almost entire absence of solidarity in the industry previous to the adoption in 1912 and 1913 of "the broader policy" by the I.E.E. and various other bodies representative of electrical interests, there is now a marked improvement in the general organization for the promotion and protection of collective interests, and for collaboration on matters calling for joint examination and action. There are no fewer than 50 different associations, institutions and societies representing or concerned with diverse electrical affairs. There is not space to mention all; a full list appears in the *Manual of Electrical Undertakings.*

WORLD ASPECTS

From the standpoint of production and distribution, the pre-war progress of electricity in old countries was not commensurate with the advance and potentialities of the science. A study of the causes shows that the main deterrent factors are to be found in the complexity of the industrial organism and the social conditions of the particular country and period. The industries in general were firmly established on a steam-using basis; plant efficiency was high, and fuel cheap. Central power stations were therefore dependent for the most part on the advent of new industries or on a combination of circumstances in old factories which justified the conversion of steam to electrically-driven equipment, and the concomitant sacrifice of capital in the discarded installation. The element necessary for the economical generation of electricity, namely, a large and diversified demand for power, was absent or available only in a small degree. The standard of wages, too, precluded a considerable section of the people from adopting electricity for domestic purposes in preference to gas, the mains for which were laid in all the streets, whereas electrical distribution mains were, by reason of their almost prohibitive cost in relation to inadequacy of demand for current, confined to the principal thoroughfares and the better-class residential districts. But a new orientation has arisen: the adaptation during the war period of so many factories to electrical operation, the greatly increased cost of fuel which has deflected the scale against private steam plants, and the higher standard of living and domestic needs, constitute conditions which will enable the science of electricity to exercise a determining influence upon the future industrial and social development of European countries.

In new countries the door to electrical development was open from the outset; the field for enterprise was ready for exploration. Industries were few and of small extent. Gas, where supplied, was dear. Oil and candles were the mainstay for illuminating purposes. Legislation, if any, was benevolent. In a comparatively short space of time, communities, even those remote from the arteries of communication, contrived to harness the local streams and to enjoy the benefits of electricity supply. In the case of America, the virile genius of the people quickly surmounted initial difficulties standing in the way of obvious benefits to be secured; by the end of the nineteenth century a few large central stations had displaced many small stations, and electric current for all purposes was available over wide areas. The primary need was capital for new steam and hydro-electric undertakings and extensions of existing stations. The funds at command nationally were relatively meagre. European money, mainly British, was available, but in amount too small to meet the needs. Nevertheless, the progress in the United States was considerable. Electricity supply had opened up a vista of cheaper manufacture of commodities imported from overseas. The industrial instinct of the nation was awakened. Heavy, if not prohibitive, import duties were imposed. And thus, step by step, the United States emerged from an agricultural country into an industrial state with vast potentialities for home and export trade. By fertile combination of natural resources, growing population, intellect unhampered by national tradition, and with freedom from anxiety for conservation of capital investments in obsolete plants—all these causes, conjoined with the rapid accretion of wealth, have enabled the United States to occupy a place far ahead of any other nation in the domain of electricity supply, inasmuch as its installed generating plant capacity of 22 million kw. equals that of all the European countries combined. Canada, inspired by the example of its prosperous neighbour, made strenuous efforts towards development through the agency of its beneficent water powers; and not unsuccessfully, for with a population of only 9 million it has already installed more than 2½ million kw. of generating plant, whose output is largely utilized by the pulp and paper, mining and other industries which have contributed so much to the country's welfare. Other constituent parts of the British Empire—Australia and New Zealand, South Africa, India, the Crown Colonies and Mandated Territories—are markedly active in the development of their civic and industrial life by means of electricity supply derived from water powers, coal, oil, and plantation refuse respectively to local conditions. The great republics of South America, stimulated by the influx of foreign capital, have schemes for electricity supply throughout their territories, and bid fair to become large producers of current and users of electrical plant. Japan continues steadily to westernize its industries, and has an installed generating plant capacity exceeding 2½ million kw., and an estimated annual expenditure on electrical goods equivalent to £21 millions.

France, despite its war wounds, is forging ahead with ambitious electrical schemes, including networks of transmission lines and super-power steam stations in the industrial districts in the north, and hydro-electrical developments in the south. It possesses an installed plant capacity of over 4½ million kw. Belgium, with revived industrial activity, uses about 1½ million kw. of generating plant. Germany before the war, under the guidance and influence of its Government and the sustained assistance of its financial institutions, held a prominent, if not pre-eminent, position in the hierarchy of producers of electrical plant, and is again striving to recover supremacy. It has an installed plant capacity of about 6 million kw. 80% of the output of its public generating

stations is utilized for industrial purposes, or the same percentage as in the case of France; while the corresponding figure for Britain and the United States is only 65%. Scandinavia has over 2½ million kw. of generating plant installed, and Switzerland 6,900 hydro-electric undertakings operating 1½ million kw. of plant. The engineers of these countries enjoy a high reputation, and water turbines and generators of Swiss and Swedish manufacture are found in many of the principal hydro-electric installations in North America. The industrial position attained by both these countries demonstrates the enormous value of electricity in overcoming the handicaps of mountainous terrain and absence of coal deposits. Switzerland has the distinction of producing 750 kw. hours of electricity per inhabitant per annum, or more than that of any other nation. Italy has nearly 2,400,000 kw. of steam and hydro-electric plant in service, of which about 90% is used for industrial purposes; while a government commission is engaged (1928) in elaborate investigations of the country's resources and markets for electricity supply. Russia has rehabilitated its generating stations and erected many new ones, but awaits capital resources for industrial expansion. Spain has large existing and projected installations in the Pyrenean zone. The Netherlands, Czecho-Slovakia, and other countries of Europe also furnish evidence of substantial electrical progress.

The conference on the world's power resources held at the British Empire Exhibition at Wembley, London (June–July, 1924), under the aegis of the British Electrical and Allied Manufacturers' Association, and the patronage of the British Government, was epochal in the annals of electricity supply and of international relations. The conference was attended by representatives—technical, commercial, financial and legal—of foreign governments and of many electricity supply undertakings throughout the world. Papers were read by experts of no less than 22 different nationalities, who contributed to the dissemination of information calculated to further the progress of electricity supply in all its ramifications throughout the civilized world. The *Transactions of the Conference* (5 volumes, Lund, Humphries and Company, Ltd., London) rank among the most valuable contributions of modern times to applied science.

The following figures, extracted from publications by the B.E.A.M.A., indicate approximately the magnitude of the electrical industry in the principal countries of the world:—

Total Production of Electrical Goods	£600 million
Internal Consumption of Electrical Goods	£528 million
Exports (less Imports) of Electrical Goods	£ 72 million
Capacity of Generating Plant installed	53 million kw.
Output of Electricity	141,000 millions of units (kw. hours).

(E. Gar.)

UNITED STATES

Electric central station service in the United States is available in every city of 5,000 population or more; in 97% of all communities between 1,000 and 5,000; in 50% of all communities between 250 and 1,000; and in 25% of all hamlets of less than 250 inhabitants.

The electric utility industry, by which is meant the production, transmission and distribution of electric current by companies formed for that purpose and serving the general public without discrimination, had its birth in 1882 when Thomas A. Edison established the first central station in the world in New York City. This little Pearl Street station started with a few score customers in an area of 12 city blocks, and had a total generating capacity of 1,200 horse power. Current was used only for lighting, in electric arcs and the recently invented carbon-filament incandescent lamps.

In 1927, less than half a century later, the electric utility industry in the United States had a total of 21,694,000 customers, reaching about 80,000,000 of the population, and an installed generating capacity of nearly 40,000,000 horse power.

There are in the United States 4,400 electric utility enterprises, including both those privately and municipally owned. These represent an investment of more than 9½ billions of dollars, and require about one billion of new capital a year for maintenance, expansion and development.

Following the demonstrated success of the Pearl Street station, electric utility plants were built in city after city and town after town in rapid succession. Water-power at this early period began to be used to drive dynamos to generate electricity, though the difficulties of transmitting current over long distances made only favourably located water-power sites available for this purpose. The first hydro-electric central station was established at Appleton, Wis., in 1882, closely followed by the harnessing of Niagara Falls for the production of current for sale to the public. As late as 1891 the art of transmission was so little known that it was considered impossible to transmit power from Niagara Falls to Buffalo, 16 m. away. Niagara Falls now produces more than one million continuous horse power, part of which is transmitted 200 miles.

Growth and Control of the Industry.—The history of the electric utility industry through the remaining years of the century is a story of tumultuous but steady growth. Central station plants were built in increasing numbers, and since there was at this time no governmental control, fierce competition existed. Rival companies for the same city or district fought each other, and rates were cut until one company absorbed the other or they mutually ruined themselves, while the public demand for electric service steadily grew. Out of this early chaos came, State by State, the recognition that electric service was essential to the public well-being; that electric utilities were "affected with a public interest"; and that, for the benefit of the public, as well as of the companies, competition must give way to a State-regulated monopoly. Various kinds of regulation were tried, and from these has evolved the typical public service commission now in operation in every State but Delaware. Members of public service commissions are usually appointed by the governor of the State for a period of years, and serve as representatives of the public in the supervision and regulation of all public utilities, not electric companies alone. Water supply, gas, electricity, street railway, bus, express, telephone and telegraph companies are generally listed among public utilities.

The economic theory underlying regulation of public utilities is one of reciprocal benefit; in return for an exclusive privilege to serve a given territory and make use of public property, such as streets, the State assumes the right to supervise and regulate utility rates and standards of service for the benefit of the public.

Public service commissions have as their main function the assurance to the public of safe and adequate service at fair and reasonable rates. To this end they are given broad powers over accounting, financing, rates and service. Since it is equally in the public interest that a utility be able to maintain, improve and enlarge its service as the demand increases, it is also a function of public service commissions to see that properly managed companies are permitted to charge rates which will provide a reasonable return upon capital invested in furnishing the service.

It is under this general form of State regulation of private enterprise that the electric utility industry of the United States has made its extraordinary record of growth during the present century, to a point where the country uses nearly as much electricity as all the rest of the world.

The total cost of Federal and State regulation of public utilities and railroads in the United States is estimated to be about $12,000,000 a year, whereas the electric utility industry alone pays taxes aggregating more than 150 million dollars.

During the early years of the electric service industry numerous municipally owned and operated central stations were built. In many cases these were established in smaller communities, into which private capital was fearing to venture. The number of municipal enterprises increased from 815 in 1902 to a peak of 2,581 in 1922. Of this number, 1,820 operated generating plants, and the remainder purchased current for distribution. Privately owned enterprises in this same period increased from 2,805 to 3,615. Between 1922 and 1927 the number of municipal establishments decreased by more than one-fifth, and between 1917 and 1927 it is estimated that approximately 900 municipal electric enterprises throughout the United States were abandoned or put under private operation. Municipal electric companies in 1927

supplied less than 5% of the customers of the industry. The nationwide trend toward the consolidation of electric generating plants into interconnected, or so-called "superpower," systems has been an outstanding factor in the elimination of the small isolated unit. This development has applied peculiarly to municipal plants, which in the United States has tended to serve a restricted area only.

The relative economic merits of municipal and private operation of electric service systems is discussed in the 1927 report of the committee on public ownership and operation of the National Association of Railroad and Utilities Commissioners.

Quoting a detailed study of electric utilities under private and public operation made by the chamber of commerce of the United States, the report says, "In every count the advantage is with the private concern. Excluding taxes, operating expenses in the public plants exceeded those of the private plants by 20%. In the manufacture of current the cost to the public plant was found to be 33% more per kilowatt-hour than to the privately owned plants. The distribution of current cost 20% more. Labour costs were 53% more, and costs of fuel 13% more. The labour efficiency of the public plant was 26% below that of the private concern, while the loss of current through leakage showed an advantage in favour of the private business of 31%. As a general thing, utilities owned and operated by the public furnish inferior service to that furnished by privately owned and operated utilities. United States conditions thus present a direct contrast to British statistics.

An outstanding feature in the growth of the electric service industry in the United States has been the development, largely since 1914, of interconnected, or "superpower," systems, whereby transmission lines covering vast areas, sometimes several States, form great power pools, fed by a number of generating stations, both steam and water-power. These may belong to different utility companies, and may be widely separated. Increased reliability of service and economies of operation result from interconnection, while the widespread network of transmission lines makes service available to many communities otherwise without it, or ill-served by small and isolated plants. Electric utilities in the United States have built more than 135,000 miles of transmission lines.

Through the consolidation of smaller enterprises by interconnection, and the abandonment of uneconomic isolated plants in many parts of the country, the number of individual electric systems decreased 33% between 1922 and 1928, whereas the number of communities served by them increased by 5,000 or about 37%. The ultimate destiny of the United States is to be covered with a network of interconnected transmission systems fed by strategically located generating plants and reaching every community.

Output.—In 1927 125 electric utility systems produced 100 million kilowatt-hours or more of current each, and, of these, 18 produced a billion kilowatt-hours or more each. One single system, at Niagara Falls, generated nearly 4½ billion kilowatt-hours during the year, the largest individual production in the world. These 125 systems supplied more than four-fifths of the nation's electric power generated by utilities, and with additional current purchased by them for distribution, supplied 97%.

Increasing size of generating units, *i.e.*, steam turbines and high-pressure boilers, has continued, and whereas in 1910 a 10,000 kilowatt unit was considered large, 150,000 kilowatt units are now in service, and one of 200,000 kilowatts was recently constructed. With the construction of larger and more efficient plants, the coal required to generate one kilowatt-hour had decreased from more than 3 lb. in 1919 to less than 2 lb. as a national average in 1928.

The present installed capacity of all the central stations of the United States is approximately 36,000,000 horse power, of which 24,000,000 horse power are in fuel-burning plants, and 11,720,000 horse power in water-power plants.

The conservation of coal resulting from increased thermal efficiency in electric utility plants, as compared with 1919, was in 1927 about 5% of all the coal used in the country. And if the electrical energy used to drive industrial motors in 1927 had been generated by small factory plants instead of being purchased from the water-power and high-efficiency steam plants of the utilities, it is estimated that 40,000,000 tons of coal more than were used would have been burned. The average efficiency of the country's steam generating stations in 1927 was 40% higher than in 1919, and while the production of electricity from fuel has increased 107% since 1919, the actual consumption of fuel increased but 19%. The U.S. Geological Survey states: "In 1927 the operators of the public utility power-plants performed the remarkable feat of generating 2½ billion *more* kilowatt-hours of electricity with the use of 150,000 tons *less* fuel than in the previous year."

In 1925 the United States generated 40% of all the electricity produced in the world, but in yearly *per caput* use of current ranked only fifth among the countries, according to figures presented at the Economic Conference, in Geneva, covering that year.

Norway, with a *per caput* consumption of 2,200 kilowatt-hours a year, led the world. Second came Canada, with 1,150 kilowatt-hours. Switzerland was in third place with 990 kilowatt-hours. Others countries, in the order of their *per caput* use, were Germany, France, Great Britain, Italy and Japan.

In production of electricity the United States had almost three times that of the next country, which was Germany, their totals being respectively 66 and 22 billion kilowatt-hours. Great Britain in 1925 produced 11 billion, and was followed by Canada, France, Italy, Japan, and Norway, in that order. The figures for the United States and Canada cover only electric utility plant output, while for the other countries all generating plants are included.

Of a total production by electric companies in the United States in 1927 of 75,116,000,000 kilowatt-hours, about two-thirds was produced by fuel burning plants, and one-third by water-power.

There is available for development in the United States water-power totaling approximately 50 million horse power, but it must be pointed out that a large part of the still undeveloped water-power is not economically feasible under existing conditions of construction costs and markets and the severe competition of modern steam generating plants.

California ranks first among the States in public utility water-power installations, with nearly two million horse power. New York, with 1,528,000 h.p., is second and the State of Washington, with 663,490 h.p., is third.

Use of Electricity.—The growth of interconnection and improvements in the art of electrical transmission and distribution is making electric service available to a steadily increasing number of villages and rural districts throughout the country. This flow of power is profoundly affecting American life, economically, socially and industrially.

For a number of years after the establishment of the first central station, electricity was used almost exclusively for lighting purposes. The earliest recorded use of an electric motor driven by central station power to do commercial work is about 1883, when a small motor is reported to have been set up in a grocery shop near the Pearl Street station and used to grind coffee. In 1927 electricity furnished 70%, or nearly three-fourths, of all the 41,000,000 h.p. used in American industry, and provided more than three horse power for every wage-earner. In 1900 there had been available only one-tenth of one h.p. per worker.

Between 1913 and 1928 the total electrical energy generated by the utilities of the country increased six times; the energy used for lighting increased six times, and that used for power increased eight times. Nearly 75% of the current produced is generated in the Atlantic and North Central States.

Despite the fact that the United States uses nearly as much electricity as the rest of the world, that country ranks only fifth in proportion of homes equipped for electric service. Switzerland is first, with 96.5% of her homes electrified. Japan, Denmark and Canada follow in that order, followed by the United States with 62% of her homes so equipped. Each of the countries leading the United States has large hydro-electric resources and relatively short transmission distances to contend with, and most

of their homes are in compact areas. There are more than 17½ million electrified homes in the United States, approximately as many as in the rest of the world, but tremendous areas of sparsely settled country have retarded the development of electric service therein. New York State has the largest number of electrified homes, with 2,550,000, or more than 91% of the total number. Illinois and Pennsylvania follow, with about 1,450,000 each, and California is third, with 1,336,000.

Twelve per cent of the electricity generated by American utility companies is used for domestic purposes. This branch of the service produces approximately 30% of the gross revenue of the electric utilities, but while the average domestic rate is 3.28 times the commercial rate, it is to be considered that the average commercial customer is a wholesale purchaser, using more than 30 times as much as the average home.

Following the development of the electric incandescent lamp and the widespread establishment of central stations in the United States, small motors were perfected and the use of electric household labour-saving appliances began. It is impossible to obtain exact figures on the numbers of such appliances in use, but the following estimates, for 1927, are below rather than above the actual totals:

Electric irons	13,500,000
Vacuum cleaners	11,000,000
Clothes washers	4,750,000
Electric fans	4,600,000
Toasters	4,500,000
Heaters	2,300,000
Electric ranges	600,000
Electric refrigerators	500,000
Ironing machines	350,000

These are the more widely used appliances for the home. A complete list would include dishwashers, radiators, sewing-machines, percolators, violet-ray outfits, heating pads, waffle-irons, hot plates, floor polishers, hair curlers, radio sets and many others.

High wages and increased purchasing power have made the American home the greatest user of electric appliances of any in the world. To the 17½ million homes equipped for electric service, additional homes are being added at a rate of about 1½ million yearly.

Rural Electrification.—The adoption by agriculture of electric power is a relatively recent development in the United States, and is playing a twofold part: first, by providing the farmer with a reliable, flexible source of power for farm work; and second, by providing the farm home with electric light and other mechanical comforts hitherto available only in towns.

The increasing interconnection of utility systems, with their far-reaching transmission lines, has been a notable factor in rural electrification, in addition to which thousands of miles of rural lines have been built in farming districts. It is estimated that in 1928 there were 400,000 farms taking electric service from utility companies in the United States, about 6% of the total number of farms. Between 1923 and 1926 the number of electrified farms increased by 86.6%, at which rate there will be one million such farms in the country at the end of 1932.

California, where electric power is widely used for irrigation, leads the other States, having 62,000 farms served by the companies. New York, with 44,000, is second, and the State of Washington, with 21,000, third.

Electricity in the farm home is used as in the urban dwelling, for light and to drive labour-saving appliances. Electric power for farm work is being economically used for a wide variety of purposes, among them: automatic water systems, baling presses, bone grinders, milk bottle washers, brooders, churns, cider mills, clippers and shearers, concrete mixers, corn shellers, cream separators, drills, fanning mills, feed grinders, hay hoists, incubators, limestone grinders, milking machines, potato graders, milk refrigerators, saws, shredders, silo fillers, sorghum mills, sprayers, threshers and others.

Rural electrification in the United States is being hastened by the combined efforts of the utility companies, national and State Governments, through farm experiment stations and agricultural colleges, and other organizations. This work falls into two general divisions: first, the application of electrical energy to present farming practices, and second, the development of new practices and farm equipment for which electricity may be peculiarly suited. Seventeen experimental rural lines have been built in as many States, and are serving as field laboratories. Information derived from their operation by utility companies, equipment manufacturers and agricultural experts is used both to avoid costly errors and to speed rural electrification to a sound and productive development.

Electricity in Industry.—It is probable that the application of electric power to industry in the United States has been the single most important contributing factor in the past quarter-century to the country's material prosperity. Increased individual production, greater efficiency, higher wages and higher standards of living have followed this phase of electrical development, and it is estimated that the American worker had in 1927 a real wage nearly double that of any in Europe.

Between 1914, when the demand for war material stimulated American industry of every sort, and 1925, the output of American factories, mills, and other plants increased by 70%. During the same period the power used increased by 61%, virtually the entire increase being electrical. In this time the number of workers increased only 21%, indicating the greatly augmented output per worker.

Significant changes in industrial operation appear in recent industrial electrification. Between 1919 and 1925 the use of primary power in the United States increased 22%, from 29,300,000 to 35,775,000 horse-power. There was in this period almost no increase in boilers and engines installed in plants. The increase of more than 6 million horse-power was practically all in electric motors driven by power furnished by electric utility companies.

It is estimated that there are installed in American industrial plants electric motors which in 1927 consumed more than 38 billion kilowatt-hours of energy, as compared to less than 20 billion kilowatt-hours in 1920. The cost of all power and fuel, the latter including fuel used to produce heat as well as power, is about 6½% of the "value added by manufacture," and about 2½% of the total value of the finished products.

Interconnection and the wide distribution of electric service has had a further effect upon American industry in liberating the manufacturing plant in its choice of location. The factory no longer has to go to a power source; power comes to it. With electric service to be had nearly everywhere, factories have been made free to consider other elements such as transportation facilities, markets, availability of raw materials and labour. Thus small towns are increasingly often chosen as factory sites because of the better living conditions for the workers. Decentralization of American industry is becoming an actuality. The use of electric motors and power purchased from the utility companies obviates investment in boilers and engines by factories, and so releases large sums of capital for other purposes, and facilitates the establishment of new factories.

The most recent authentic figures upon the electrification of industry are those for 1925, completed by the U.S. Census of Manufactures. These indicate the following percentage of electric power used, in relation to all power, in various industries: machinery manufacture 95·7; transportation equipment, including automobiles, 95·1; rubber products, 91·7; non-ferrous metals, 89·6; tobacco products, 87·1; leather products, 83·3; stone, clay, glass, etc., 80·4; textiles and their products, 74·6; food and kindred products, 65·7. The average for the 16 major industries examined was 70% of electrification, a proportion which has since then materially increased. These industries had installed motors aggregating more than 25 million horse-power, of which nearly 16 million horse-power were supplied by energy purchased from the electrical utilities, and the rest by generators in the plants.

Finance.—Electric service rates in the United States are based upon the value of property "used and useful" provided by the company to furnish the service. It is held that upon such a valuation the utility is entitled to earn a "fair and reasonable

return."

The increasing efficiency in generating and transmitting current, and the economies achieved in the operation of large, modern plants, and interconnected systems, have produced a virtually uninterrupted downward trend in electric rates in the United States, particularly in domestic rates. These, in 1928, averaged for the country as a whole 15% less than in 1913, and were the only item on the Government's cost-of-living list to show a decrease to a point below pre-war averages. In 1882 the price paid by household users was 20 cents a kilowatt-hour. In 1926 it was 7·4 cents. In 1913 "cost-of-living" dollars, based on figures of the Bureau of Labor Statistics, this latter price was equivalent to 4·2 cents a kilowatt-hour. Thus domestic rates have been reduced not only relatively, but absolutely. No other industry, it is believed, can show a similar record.

The electric service industry of the United States represented in 1927 an investment of $9,500,000,000. To maintain and expand the service, approximately $1,000,000,000 of new capital is required yearly. In 1926 American electric utilities sold securities of the value of $1,390,000,000, a total which was more than one-fourth of the country's entire security sales for that year. Of this sum, $370,000,000 were used for refunding purposes, and the remainder for improvements and extensions to meet increasing demands for service. (The sale of electric utility securities in 1926 was greater than those of the railroads, iron, steel, copper, coal, automobile, oil, rubber and shipping industries combined.)

In 1927 the electric service companies raised $2,100,000,000 and expended $760,000,000 for additional facilities. Their 1928 budget was more than $900,000,000. Savings-banks, insurance companies, universities, colleges and other organizations are among the heaviest purchasers of electric company securities. American savings-banks alone have invested more than 300 million dollars, and insurance companies nearly a billion dollars in this industry. Nineteen states have passed laws permitting savings-banks to purchase utility bonds.

A feature in the financing of electric service companies, and to a lesser degree other utilities, has been the development chiefly since 1914 of "customer-ownership," *i.e.*, the direct sale of their securities, chiefly stocks, by individual companies to the people using their service and to their employees. It is estimated that in 1926 there were nearly 1½ million customer-owners of the electric service industry, holding more than 13 million shares of stock. To these were added in 1927 the investment of $240,000,000, through 344,000 individual sales, an average of about $700. Nearly 1½ billion dollars' worth of electric utility stock has been sold to customers and employees since 1920. A single issue of stock sold on this plan showed purchasers in 57 trades or occupations, and included bakers, barbers, bricklayers, butchers, carpenters, domestics, dressmakers, janitors, mail carriers, mechanics, nurses, plasterers, plumbers, policemen, railroad men and seamen; also artists, bankers, dentists, doctors, lawyers and clergymen.

The capitalization of American electric utilities has increased from about 600 million dollars in 1900 to more than 9½ billions in 1928, about evenly divided between stocks and bonds. Upon this investment the industry in 1927 had a gross income of $1,783,000,000, indicating an investment of nearly five dollars for each dollar of gross income. The net income was $1,017,000,000. Of the total income, about $1,075,000,000 was paid by lighting customers; $517,000,000 by power customers; $60,000,000 by electric railways. Intersales between utility companies accounted for $129,000,000. This last item reflects the effects of interconnection and the flexibility of the power supply over large transmission systems. Sales of current between companies doubled from 1923 to 1928, and in amount constitute about one-fifth of all the energy generated. In spite of these very large inter-company sales, less than 10% of the current produced by American electric utilities is sent across State boundaries.

Electric service companies in the United States, with other utilities and the steam railroads, pay a higher percentage of their gross receipts in taxes than any other corporate group. (This does not include municipal or Government owned central stations, which are virtually tax-exempt.)

For each dollar of gross income, electric utilities pay more than nine cents in the form of Federal, State, county and local taxes. This is a tax rate which has risen steadily from 3½ cents in 1902. In 1927 the electric utilities contributed to Federal, State and local Governments taxes aggregating more than $150,000,000. Of this sum, approximately one-third was collected by the Federal Government and two-thirds by the State, county and municipal Governments. The ramification and variety of taxes appear in the following list of 11 taxes paid by one New York State company:

Name of tax	*Assessed by*
Gross earnings tax	State
Excess dividend tax	State
Real estate tax	Cities, towns, villages
Franchise tax	Cities, towns, villages
Auto and chauffeur license	Municipality
Street sprinkling, snow removal, etc.	City
Improvement taxes	City
Capital stock tax	Federal Gov't
Federal income tax	Federal Gov't
Excise taxes	State Gov't
Bond interest withheld	Federal Gov't

The growth and development of the electric utilities in the United States have been almost unparalleled in the history of industry. In capital invested it ranks fifth, the four larger industries being agriculture, the largest, railroads, automobile manufacturing, and construction, in the order named. In value of products, electric utilities industry ranks 13th, and in number of employees the same.

Peculiar Uses of Electricity.—Electrical energy, in the form of light and power, has been applied to thousands of different tasks. Many of them are familiar to nearly everyone, while others are known only to the specialists who are using them. A few of the curious and interesting things done by electricity are here listed.

A new electric signal system stops machinery at the cry of "Help." This is done by wireless waves and a microphone so selective that it reacts only to the key-words chosen.

An electric arc burning in neon gas has been developed which glows with a brilliant red light and has the power to pierce fog.

A single tank, heated by electricity, melts 45 tons of zinc at one time, for galvanizing.

Electric lights of specific colours are being used to attract insect pests of different sorts in orchards and gardens.

Rays from ultra-violet lamps are being used to sterilize the water in indoor swimming-pools.

An automatic electric welder welds 150 ft. of seam an hour on steel pressure tanks without guidance or assistance.

Fish are "shocked" away and saved from turbine wheels of hydro-electric plants by a pair of electrodes which set up an electric field in the water nearby.

Wheat has been grown to maturity, entirely by electric light, in 13 weeks, the grain being put in jars of water containing the necessary food elements.

An electric motor has been built no taller than a housefly, weighing a quarter of an ounce and consisting of 58 parts. It develops 400 revolutions a minute.

Violet rays from electric lamps are being used on cows and chickens to produce better milk and more fertile eggs.

Bullets in flight are photographed by means of an electric spark in a dark chamber.

Electricity weighs a moving web of paper as it is produced, through a tuned radio circuit. The paper passes between two metal plates and any variation in thickness affects the response of the circuit. The variation is recorded on a meter. (M. S. S.)

ELECTRICITY SUPPLY: TECHNICAL ASPECTS.

The supply of electricity may be either (1) a private supply on a small scale for electric lighting in an isolated country house, hotel, institution or ship, or else on a large scale by a railway company or local authority for purposes of lighting, traction, or power for their own use; or it may be (2) a public supply by a limited company, corporation, local authority or government for general supply of electric current to the public for light, heat, power or other purposes. In the latter case the commodity sold is

energy in the form of electric current supplied for a certain time at a specified voltage or pressure and reckoned and charged for at a certain price per kilowatt-hour or Board of Trade unit. (B.T.U.).

The invention of the carbon filament, electric incandescent lamp in 1880 and 1881 by T. A. Edison, J. W. Swan and C. H. Stearn made possible domestic electric lighting by private and public supply and this began to be undertaken in 1882. It necessitated the manufacture of constant voltage dynamos for supplying current to a number of lamps arranged in parallel between two conductors (*see* DYNAMO), and a number of small inventions such as sockets for lamps, switches, fuses and switch-boards. The conductors in buildings are nearly always high conductivity copper stranded or single wire which is tinned and insulated with vulcanized india-rubber and protective hemp. These are run in pairs in steel conduit tubing placed under floors or behind plaster of walls. In some cases twin insulated wire is enclosed in a continuous lead sheathing and used with or without steel conduit tubing.

The lamps now used have a filament of drawn tungsten wire. They may be vacuum lamps in which the bulb is highly exhausted or gas-filled lamps containing argon or some neutral gas. The vacuum lamp when properly incandescent gives light at the rate of 1¼ watts per candle power and the gas-filled lamps about ½ watt per candle power (c.p.). Hence a 16 c.p. vacuum lamp takes about 20 watts.

Private Installations.—In arranging an electric supply by a private plant the first step is to mark down on a plan of the building the position of every lamp required and to estimate the maximum number of lamps which may be in use at one time. From the wattage of each lamp the total electrical power required can then be determined and it is a safe rule to install dynamo and engine plant for double this maximum. The position and type of motive power, whether steam, gas, or oil engine, can then be determined. For such plants it is best to use a supply voltage of 100, unless the generating plant must be placed far from the installation. It is also usual to install a storage battery to give supply during the night and to preserve continuity of supply at all times. The dynamo must then be able to give the necessary maximum voltage required to charge the cells, viz., 2·6 volts per cell, and for 100-volt installation it is usual to employ 55 or 56 cells with a regulator for controlling the number of cells put in connection with the supply line. An automatic cut-out must be provided to prevent current coming back through the dynamo in case of failure of motive power.

If perfect security from interruption of supply is required then the engine and dynamo plant must be duplicated, each part being equal to maintaining the full supply. The engine-room must be equipped with current and volt-measuring instruments and cut-outs and switches so that the engineer in charge can know at all times the state of the plant and have control over it. In the building itself the main supply cable from the storage cells terminates at a main switch-board of slate or marble fitted with double-pole switches and fuses for each branch circuit. These branch circuits run without break or joint to distributing boxes on the various floors from which again sub-circuits are run to each room. These sub-circuits terminate in double-pole fuses on the distributing boards. No such circuit should carry more than 1 to 3 amp. of current. The whole wiring installation should be put in in accordance with the wiring regulations of the Institution of Electrical Engineers or of the principal fire insurance offices to secure safety from fire. The insulation of the whole installation should be tested on completion of the wiring contract.

The Institution of Electrical Engineers' (I.E.E.) rule for direct current installations is as follows. The insulation resistance with all lamps and fuses in place and switches on shall be measured by applying between earth and the whole system of conductors, or any section thereof, a direct current pressure of not less than twice the working pressure and the insulation shall not be less than a number of megohms equal to 25 divided by the number of lighting points on the system. Thus for a 100-lamp installation it must not be less than ¼ megohm.

It is usual also to test each side of the system with all lamps removed from sockets. The actual size of wires or conductors put in is chiefly determined by the permitted drop in voltage at the most distant point on the system between full load and no load. It is generally limited by specification to not more than 2 or 3% of the standard supply pressure. Thus for 100-volt supply the voltage at the point most remote from the entrance switch-board must not rise to more than 102 or 103 volts when all lamps installed are switched off compared with its voltage 100 when all lamps are on. The installation should be tested for insulation from time to time and any defect immediately remedied.

For private country-house installations there is a very extensive use of small direct current dynamos coupled direct to an internal combustion engine worked with petrol or paraffin, and these are so arranged that they may be operated without skilled labour. This generator is commonly associated with a suitable storage battery so that the plant can be run during the day and stopped at night. With care a good battery should last 15 years but the life of the positive plates can easily be very much abbreviated by careless use, overcharging or allowing to stand unused and partly discharged.

Various Systems of Supply.—For large private installations of electric supply plant for purposes of either lighting, power or traction there is a choice of several different types of electric current according to the requirements of the case. The supply may be in the form of: (1) direct or unidirectional current and utilized by lamps or direct current motors; (2) single-phase alternating current used on lamps or alternating current motors, or rectified by mercury arc rectifiers and used to drive direct current motors, or (3) the supply may be in the form of three-phase alternating current which may be used for power with induction motors or rectified for use with direct current motors. In the case of direct current plants of any magnitude it is economical to employ the three-wire system when the supply is for lighting chiefly or only small motors.

In this system (*see* fig. 1) as used also for public supply, there are three bars on the main switch-board called positive, middle and negative, O_1, O_2, O_3. From these proceed sets of three underground or overhead conductors called feeders, F_1, F_2, F_3, which run to the area of consumption. They connect into three other sets of conductors called distributing mains, D_1, D_2, D_3. The consuming devices H_1, H_2, either lamps or small motors, are connected in about equal number in parallel between the positive (+) and middle main (M) and the negative (—) and middle wire (M). Between the positive and negative bus bars are connected the direct-current generating dynamos giving a voltage equal to double that required for the lamps or consuming devices placed on the two sides of the middle wire. If the number of such lamps or total current taken by them all is equal on the two sides of the middle wire then this last will serve merely to distribute the current differently to lamps on the two sides of the middle wire. If, however, the current demand on the two sides

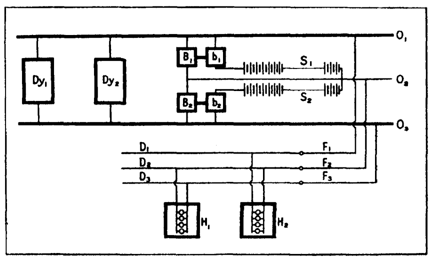

FIG. 1.—DIAGRAM OF THE THREE-WIRE SYSTEM OF ELECTRICITY SUPPLY

Dy_1, Dy_2 are separate steam dynamos connected with omnibus bars, O_1, O_2, O_3. F_1, F_2, F_3 are three parts of the switchboard; D_1, D_2, D_3, the positive, middle and negative distributing mains; B_1, B_2, balancing machines; b_1, b_2, small dynamos known as "boosters"; S_1, S_2, storage batteries, and H_1, H_2, houses supplied from the plant

is unequal, their two shunt-wound direct current generators B_1, B_2 with very low resistance armatures have to be joined across the outer mains in series and their junction point connected to the middle wire. These machines are called *balancers*. If then the outgoing current in the positive main I_1 is greater than the return current I_2 in the negative main, the difference I_1-I_2, called the out-of-balance current, returns along the middle wire. Half of it passes each way into the balancer armatures. The machine on the negative side becomes a motor and drives the other machine as a generator and the latter supplies the out-of-balance current.

The equality of voltage on the two sides is improved by connecting the fields of the balancers in series across the outer mains but so that the current enters the field of the negative side balancer first at that end nearest the negative main. If it is desirable to employ storage batteries to assist supply at heavy loads or for supply during the night then each battery on the two sides must have in series with it a direct current dynamo called a *booster* to add to the main generator voltage the extra volts of 0·6 volt per cell required to charge the batteries. These boosters have their shafts directly coupled to the balancers and are driven by them. The booster voltage is regulated by resistance inserted in their shunt-field circuits. The ideal condition desired is that the main generators should work under constant load so that when the external load of lamps or other devices is light, the battery would be charged, and at times of heavy external load the battery would discharge and supply the excess current required, the terminal voltage remaining all the time constant. This condition, however, is difficult to fulfil, but many connections of boosters, such as the Highfield, approximate to it. If a booster is used simply to supply the extra charging volts of a storage battery it is called an "irreversible" battery booster. In this case it is a shunt-wound generator and is driven by a motor fed from the main circuit. If the booster is a series-wound machine it can be made to add or subtract voltage so as to keep the circuit volts constant. In this latter case it must have its field magnets of well-laminated iron so that the voltage generated shall follow quickly the variations of current. Such a booster is called a reversible battery booster. There is an extensive use of boosters, called negative boosters, in traction supply systems to prevent the potential of the return rail from becoming too high relative to the earth and to prevent the flow of current through the earth which does damage to water and gas pipes. The advantage of the three-conductor system is that it effects a saving in copper in the mains for the same supply voltage at the lamp terminals and the same percentage energy loss in the mains. This saving may amount to as much as 62·5%.

Three-conductor direct current supply systems are in common use in which the generators supply current at 440 volts and the lamps and consuming devices on the two sides are worked at 220 volts. This is about the safe limit for domestic supply for lighting.

Alternating Current Systems.—When the generating station is at a considerable distance from the consuming district, or when the consumers are scattered over a large area, then alternating current systems of supply have to be employed, as this admits of transmission at high voltage and reduction to a low voltage for use. The current in this case is generated by machines called alternators and the current flows backwards and forwards in the circuit. The number of complete cycles of current per second is called the frequency and too commonly used frequencies are 50 and 25, but there are large systems of supply in which frequency as low as 15 is used. The alternators can be made to generate at low or high voltage as required and this voltage can be increased or diminished by sending the current through one coil of a static transformer which raises or lowers voltage at the expense of decreasing or increasing the current in a nearly corresponding ratio. A three-phase alternating current system involves a type of alternator which sends out three single-phase currents shifted relatively in phase by 120° with respect to each other. This involves a line comprising three or perhaps four conductors, between each pair of which consuming devices such as lamps or motors can be bridged. To transmit power long distances we must employ high voltage and correspondingly small currents because the section of the copper conductor used and therefore the cost of the line per mile depends upon the current, though the insulation of the line is determined by the voltage.

At this point some information may be given about supply conductors. These are either aerial (or overhead) or underground. The aerial lines are constructed with well-seasoned fir poles impregnated with creosote in the below-ground portion. They may be single poles or multiple poles of A or H shape. For heavy currents high voltage lines they are steel lattice towers 50 to 150 ft. in height tapering upwards and of square or triangular section. These poles or towers carry cross arms to which are attached single or else chains of porcelain insulators according to voltage. The conductors themselves are of hard drawn copper wire and sometimes aluminium or steel-cored aluminium wire. These lines are spaced apart from 2 to 12 ft. according to the voltage used. Single-phase alternating requires a pair of lines and three-phase four lines. At intervals disconnecting switches are placed and essential adjuncts of an aerial line especially in mountainous countries are lightning protectors which consist in some arrangement, generally two horn-shaped iron rods, by which, if lightning strikes the line, the discharge can get to earth over a small gap or through an electrolytic cell, but the line current cannot follow to maintain an electric arc discharge and so short circuit the line or put it to earth. On aerial lines voltages as high as 150,000 or even 250,000 volts are used. The transmission of power by small electric currents and very high voltages raises many practical problems of great difficulty. The high voltage on the line ionizes the air molecules near it and produces on the line a glow discharge called a *corona*. This involves a dissipation of energy which may be at the rate of several kilowatts per mile of overhead line. (For details see *The Electrician*, Oct. 10, 1913, p. 13.)

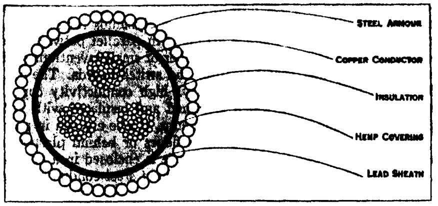

FIG. 2.—SECTION OF TRIPLE CONDUCTOR ARMOURED CABLE, SHOWING THREE COPPER CONDUCTORS SEPARATED BY INSULATING MATERIAL; THE SHEATH IS OF LEAD

Underground Lines.—Underground lines are most usually laid with steel-armoured lead-covered concentric cable (fig. 2). A central core of stranded copper wires or cable is insulated with manilla paper which is impregnated with resinous compounds. Over this is laid a cylindric conductor formed of copper wires and for three-phase cables there may be a second layer of insulation and a third concentric conductor. Then further insulation and a seamless lead covering is laid on. This is protected by impregnated jute or hemp and then an armouring of steel wires or tape is laid on in one or more layers and the whole covered again with hemp. Such a cable can be laid straight in the ground in a trench with only a protective board over it. If, however, the soil is such as to corrode steel or lead, the cable may be laid in a wooden trough and filled in with bitumen. A cable of this kind properly laid may have a life of 30 or 40 years. Concentric cables as above described can be made for voltages up to 60,000 or 70,000 volts. Suitable joint boxes must be put in at intervals to enable tests to be made and faults located. Generally speaking, an underground cable has a capacity of about one-third microfarad per mile. An aerial wire will have very much less capacity but more inductance.

The "capacity effects," as they are termed, associated with long underground cables, call for special means of connecting or disconnecting them in order to avoid the production of electric surges. Electricity flowing in conductors behaves like a very heavy incompressible fluid. It cannot be started into motion instantly and when flowing cannot be arrested suddenly without means for

nullifying its inertia. Long concentric cables must not be switched suddenly on or off the bus bars or switch-boards of alternating current supply stations but the current must be fed into the cables slowly through a variable resistance to avoid sudden pressure rises due to combined capacity and inductance which might break down the cable insulation.

The Swiss Railways.—As examples of typical electric supply for power purposes by alternating currents we may refer to the hydro-electric stations of the national railways in Switzerland. These main-line railways are now operated with single-phase alternating current at a frequency of 16·2/3. For the St. Gotthard line from Basle to Chiasso there are two generating stations, one at Amsteg and the other at Ambri-Piotta on north and south sides of the St. Gotthard pass. These stations are connected by an underground concentric cable. The power is supplied by high level stores of water derived from the river Reuss and from Lake Ritom respectively. This water is led down steel tubes to the hydraulic stations where it is used to drive Pelton turbines direct coupled to single-phase alternators of 13,600 h.p. which generate at a pressure of 15,000 volts. Theoretically, 1 cubic metre of water (or about 216 gal.) in falling down a height of 1 metre or 3¼ ft. can do work equal to 13 h.p. acting for 1 second. Modern turbines can utilize about 80% of the theoretical amount. For these railways stations the voltage of the current is first raised by large static transformers to 60,000 volts for transmission. The two stations together can supply 113,000 h.p. for railway working which is more than sufficient to operate 50 trains simultaneously. The high voltage current is led by overhead lines to various transformer stations where it is reduced to 15,000 volts. The locomotives are equipped with three compensated series alternating current electric-motors, and the current is picked up from an overhead line and returned to the rails or to a third grounded rail.

Two other similar large hydro-electric stations exist in the Rhone valley near and above Martigny to supply the Simplon railway running from Lausanne through the Simplon tunnel to Baveno and Stressa. One station, called the Barbarine station is high up on the Salvan pass and the other is at Vernayaz in the Rhone valley. There is another station at Thusis, near the entrance to the Via Mala, which supplies similarly current to operate the Rhaetic railway which runs from Coire to St. Moritz in the Engadine and to Davos. The electric locomotives on these electric lines are of 1,200 to 2,100 h.p. the latter being able to draw a train of 500 tons up an incline of 1 in 100 at a speed of 40 m. an hour. This electrification of the main lines has greatly increased the average train speed and especially the comfort of working on lines with many long tunnels such as these main Alpine lines. The electric supply lines are duplicated to secure safety and generally follow different routes. The transformers are in iron cases filled with insulating oil and these are placed in the so-called outdoor stations in which transformers and switches are arranged in the open air under a steel lattice framework which supports the insulators and these the connecting bars.

There are in France three-phase alternating current stations in which the alternating current is rectified or converted to a direct current for railway working. The direct current motor has many advantages over the single-phase or three-phase alternating current motor in that the weight per horse power is much less and the arrangements for controlling the speed much more simple. There are practical limits to the voltage which can be used for direct current motors. It is, however, quite a simple matter to build such motors for 1,200 to 2,000 volts. On the other hand the alternating current can be raised in voltage easily by static transformers for transmission and lowered again for use. The practical problem, therefore, which electric traction supply systems involve is that of converting alternating current into direct current. This can be done in one of two ways (i.) by rotary converters and (ii.) by mercury arc rectifiers. The first method uses an alternating current induction motor supplied with three-phase alternating current which is coupled direct to a direct current generator which gives current at 500 volts or 1,200 as required. The direct current is supplied to the motors of the locomotive or of the car by an overhead trolley line or by special side rails, and returned by the main rails. This arrangement is widely used on the urban electric railways in London and other large cities. It involves, however, moving machinery and therefore manual attendance.

Mercury Rectifiers.—The second method by mercury rectifiers is also much used. This depends on the fact discovered by P. Cooper Hewitt that if an exhausted tube has at one end a pool of mercury and at the other end an iron rod, connections to these being made through wires sealed through the tube walls, then such tube has a unilateral conductivity and will allow negative electricity to flow from the mercury cathode to the iron anode but not in the opposite direction. Hence it can rectify an alternating current.

In one form used for railway working the tube consists of a large steel box in which a high vacuum is created by a pump. In the bottom is a pool of mercury which acts as the cathode. In the lid of the box there are six glands through which iron rods pass air-tight and insulated electrically. These rods are connected to the two outer ends of the terminals of the three circuits on a three-phase transformer and the central junction to the mercury cathode. The mercury vapour then acts as a rectifier and converts the three-phase alternating current into a direct current. For further details special treatises must be consulted. (*See* J. A. Fleming, *Mercury Arc Rectifiers and Mercury Vapour Lamps.*)

Public Electric Supply.—The idea of supplying electric current for lighting purposes to a large number of users from a common supply station seems to have occurred about 1878 to St. G. Lane Fox in England and T. A. Edison in the United States (*see* British Patent specifications Nos. 3988 and 5306 of 1878) and was put in practice in New York in 1881, in London in 1882, and by Col. R. E. Crompton in Vienna in 1883–84. The early attempts met with many difficulties and had only a limited range of operation due to the use of a two-wire direct current system with 100–110 volts pressure between the mains. Crompton employed in Vienna a five-wire 440 volt direct current system. J. Hopkinson and T. A. Edison had devised the three-wire system, already explained, in 1883 as a means of extending the range of the direct current system. In 1884–85 S. Z. de Ferranti, who had already invented an alternating current dynamo, patented an improved form of transformer (British Patent No. 15141 of 1885) and soon after developed a system of alternating current supply

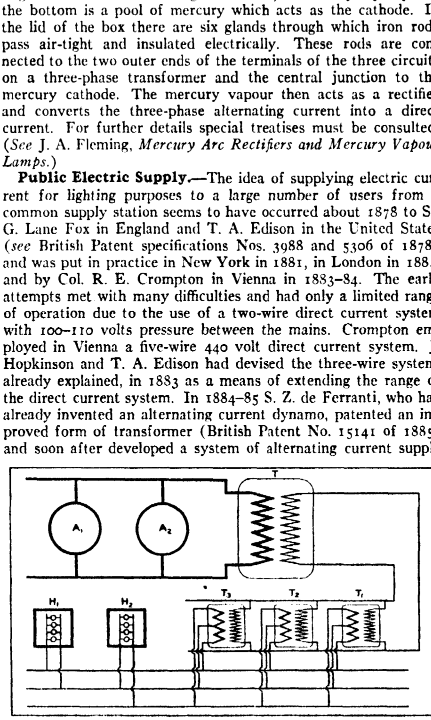

FIG. 3.—SINGLE-PHASE ALTERNATING CURRENT SYSTEM. A_1, A_2 ARE THE ALTERNATORS, PRODUCING A SINGLE-PHASE ALTERNATING CURRENT AT 1,000–10,000 VOLTS; T THE TRANSFORMER; T_1, T_2, T_3 BATTERIES OF ALTERNATING CURRENT TRANSFORMERS, AND H_1, H_2 HOUSES SUPPLIED FROM GENERATING STATION

in which electricity was generated at a high voltage, even 10,000 volts, and transmitted by underground mains to certain transformer stations where it was converted to low pressure and distributed to users at a convenient voltage. Similar systems were devised by Ganz, Westinghouse, Elihu Thomson, Parker and Mordey. S. Z. de Ferranti was unquestionably the pioneer of alternating current high voltage supply. His financial supporters erected a large station at Deptford in 1890–91 for supplying a part of London, and this London Electric Supply Corporation overcame in time many of the early difficulties of such supply

due to capacity effects in the mains and insulation. The alternating current system had great advantages in dealing with an area of scattered users in that the high voltage permitted a small current to convey a considerable amount of power and this demanded only transmission lines of small section. In the early days with the exception of the Ferranti system a very usual voltage of supply on the alternating current system was 2,000 volts on the high

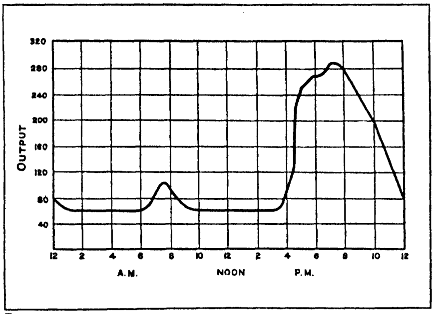

FIG. 4.—GRAPH OF LIGHTING LOAD, SHOWING GREATEST OUTPUT BETWEEN 6 AND 8 P.M., THE SUPPLY BETWEEN THESE TWO HOURS BEING ROUGHLY EQUAL TO THE SUPPLY FOR THE REMAINING 22 HOURS

tension side for generation and transmission reduced to 100 volts by transformers for use in houses.

The three-wire system can also be applied to alternating current supply as well as direct current (fig. 3). Two systems of public electric supply were therefore developed and much put in practice between the years 1882 and 1892 in all parts of the world for public electric supply. One of these was the three-wire direct current system, using dynamos generating at 220 or 440 volts connected across the outer mains, with balancers, boosters and batteries across the two side circuits. This was called the D.C. system, and was found very suitable for the central parts of large towns and thickly populated districts. The other, called the A.C. system, employed alternators and transformers and in country districts overhead high tension mains and distributed to houses at low voltage, 100–110 or 200–220 volts.

The disadvantage of this latter system was that no storage of energy was possible so that the machinery had to be kept running all night to supply the small necessary light, whereas on the D.C. system the batteries delivered the night demand. It soon became clear that in every particular district, whether business, residential, shops or places of amusement, the hourly demand for current followed a certain law which, expressed as a curve plotted in terms of hours of day and night, was called the *load diagram* (fig. 4). If the vertical ordinates of this curve represent kilowatts, the area included between the curve, the end ordinates and the time line is proportional to kilowatt-hours or B.T.U. sent out from the station. The ratio of this total output to the output which would be taken if the maximum demand continued steadily for the whole 24 hours, is called the *load factor*. In a strictly residential district this may be as low as 12 or 15%, but in a shop or theatre district much higher. If, however, there is a demand for power by motors as well as for light the load factor may rise to 45% or 50%.

Electric Meters.—It became clear at a very early stage in public electric supply that electric meters of several different kinds would be required. It is obvious that the consumer most profitable to an electric lighting supply undertaking is not the one who takes the largest supply of electric energy, very irregularly, but the one who takes his supply most uniformly. The former requires the supply station to keep plant ready for action to supply his possible extra demand taken without notice. Accordingly, electric meters were soon devised by numerous inventors of three different kinds. There are, first, meters called ampere-hour meters which measure only the total quantity of electricity passing through them irrespective of the voltage or pressure of supply. These can be designed to read Board of Trade units in kilowatt-hours on the assumption that the supply pressure remains constant. The second type of meter is the watt-hour meter which records the total electric energy which has passed through it irrespective of changes of pressure. A third type of meter is called a maximum demand meter and records the quantity of electricity taken over and above a certain average. It gives an indication of the demand made by the customer on the supply for what is called stand-by plant.

The earliest type of ampere-hour meter was the Edison zinc-sulphate electrolytic meter, but the trouble in reading it caused it to be soon replaced by mechanical meters. These are in effect small electric motors which the current drives round against a certain retarding force which is proportional to the speed. The number of revolutions made by the meter in a given time is recorded on dials like those of a gas meter. If the driving force is proportional to current passing then the dials record quantity of electricity or electric energy on the supposition that the supply voltage is constant. If the driving force is proportional to the electric power passing then the dials record true electric energy in kilowatt-hours. A large number of such motor meters have been invented, such as those by Ferranti, Elihu Thomson, S. Evershed, Chamberlain and Hookham, the Sangamo meter (Edison, Swan Electric company) and others. Some of these, such as the Elihu Thomson motor meter, are suitable both for direct and for alternating current. Others, such as the Schallenberger meter, depend on electro-magnetic repulsion and are only applicable on alternating current circuits. The most usual form of tariff is the flat rate in which the consumer is charged by meter for the units of electric energy actually taken, but owing to the fact that the chief demand for electric supply is for electric lighting and this is determined by the daylight hours and by the customary times for meals and rising and retiring to rest, the lighting supply demand runs up into a sharp peak at certain hours. The object of the various tariffs which have been introduced is therefore to encourage a demand for electric power taken either uniformly, or else at hours when the lighting demand is small for electric cooking, heating, and driving small domestic motors, etc., by giving such supply more cheaply than at the flat lighting rate.

The most common variation on the flat rate is some form of fixed charge depending on the total number of lamps installed and then a charge for electric energy supplied at a much lower than flat rate. (For the various types of tariff in use *see* J. W. Meares, *Electrical Engineering Practice*, ch. xv.)

Extra High Tension National Electric Supply.—The increasing demands for electric energy for power purposes and the numerous and very different supply pressures, voltages and systems have caused great attention to be directed to the problem of national electric supply in Great Britain. Briefly, it is proposed to construct over Great Britain a large system of overhead or aerial conductors consisting probably of steel-cored aluminium cables supported by appropriate insulators on steel lattice towers. The system of supply is to be three-phase alternating current at a frequency of 50 cycles and at a pressure of 132,000 on the main conductors. This system of mains is called the "gridiron" and will have put into it current from selected or constructed stations. From these mains electric current can be tapped off and reduced in pressure by transformers for any required purposes at any place on the route. The "gridiron" will consist of three conductors, one for each phase and doubtless a fourth conductor connecting the neutral points of the three-phase star connected circuits. Special precautions will be taken against the production of steep-fronted electric surges travelling along these lines due to lightning. The gradient of atmospheric electric potential is generally at the rate of 100 or 150 volts per metre, the earth in fine weather being negatively charged. Under thunderclouds, however, the gradient may be many hundred times as great. This means that induced electric static charges are created on an aerial line, and this is, in the old-fashioned language, a "bound" charge. When, however, the thundercloud is discharged by a lightning flash this bound charge becomes free and its potential may be

added at some instant to that of the line. The result may be a flash over at an insulator which for a moment puts the line or one phase of it "to earth," at a certain place. The result is to produce an electric wave of potential which travels away along the line. If the difference of potential between two near points on the line is very large this is called a steep-fronted surge. If such a surge passes back along the supply line into a transformer or alternator it may cause a great difference of potential between adjacent turns of wire and so cause a breakdown of insulation and do damage expensive to repair. Accordingly, many devices have been invented called surge protectors for stopping these steep-fronted surges from travelling along electric supply lines. One of these consists of a peculiar form of electrostatic condenser which is joined across the lines. When a surge comes along it darts into the condenser and expends its energy harmlessly. Another consists of a form of low resistance choking coil with a secondary circuit of non-magnetic iron in which the surge dissipates its energy as heat. (For further details *see* J. A. Fleming, *The Interaction of Scientific Research and Electrical Engineering*, ch. vi., 1927.) Electric feeders or supply lines conveying large currents are always laid in duplicate generally along different routes so that in the event of a breakdown on one line the supply is continued by the other.

Also automatic cut-outs or switches are placed at the ends, operated by relays or electro-magnets, so that in the event of a "dead earth" occurring on one section that faulty section of the line is at once removed from the live circuit. These arrangements generally operate in virtue of the fact that in a line without fault or earth or short circuit the current leaving at the far end is the same as the current entering. If, however, a fault occurs then these currents are unequal and this may be made to actuate sensitive devices called relays which in turn operate the terminal switches and cut out the faulty section of the line.

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UNITED STATES

In the United States, systems of electrical conductors within buildings where electricity is utilized are of many different types. Massive structures of fire-resisting construction, industrial and other buildings that are exposed to special fire hazards, and in some cases all buildings within "fire zones" (*i.e.*, the closely built up urban districts subject to conflagration hazards) are ordinarily provided with house-wiring systems where the conductors are drawn into metallic conduits having appropriately heavy fittings at outlets and junctions. Although this system of wiring has the merit of ruggedness, it is expensive, cumbersome, and poorly adapted for future modification or extension, and for this reason the majority of other buildings such as residences, small shops and small or detached structures generally, are equipped with lighter forms of wiring. The principal types of these are the flexible conduit system, where suitably insulated conductors are enclosed in a flexible steel armour composed of a light interlocked spirally-wound steel tape, and a system where suitably insulated conductors are run in concealed spaces upon porcelain insulator supports. The latter is known as the "knob-and-tube" system and is most extensively used. It has been in successful use for a long time, and in many ways it is the most desirable system of wiring from considerations of safety. It has also the advantages of low cost, ease of installation, and great flexibility for future changes and extensions.

The technical aspects of public electricity supply have, in the main, been especially concerned with the production and distribution of electric energy upon a very large scale. The extraordinary growth of the use of electricity, which has resulted, in part, from the steadily declining costs of service and, in part, from the increase in the size and scope of general industrial activity during the past decade, has been reflected in the advance of technical practice. Conversely, the increased efficiency in the use of fuel and the development of high-voltage power transmission over comparatively wide areas have been, to a large extent, the principal factors in lowering the cost of electric service to the public and thus, in turn, in stimulating a demand which has made possible still greater efficiencies of production and distribution. Until a few years ago, the attention of the technicians of the electricity supply enterprises was primarily concerned with the perfection of power-production equipment and with the reduction of the cost of generating energy. The advances in transmission line practice and the wide-spread adoption of the concept of "interconnection" have, however, produced a tendency to build large power-plants at some distances from the centres of consumption and have thus necessitated not only much specialized apparatus for successful delivery of this energy, but also of specialized operating practices.

Concentration of Power.—The larger of the regional schemes for the service of electricity supply represent truly enormous concentrations of power, produced in great volumes at diverse and often remote sources, which must be regulated and controlled so as to meet, at every instant, the constantly varying demands of the consumers. Here there have arisen a host of problems, some of which have successfully been solved by advances in technology, others (up to the present) have only partly been overcome, while still others remain as objectives to reward the skilled research of the future.

The insulation of electric-carrying devices is, in fact, the foundation of the electric power system. While it has been successfully accomplished in the lower range of voltages, very little is still known of its true character or the phenomena involved in its breakdown. The failure of insulation results in the escape of some of the electricity from its intended path and its travel either to ground or to another portion of the energy-carrying circuit. Where the amount of energy involved is large (as is usually the case where many power-plants are tied together in interconnected regional schemes) such a breakdown usually results in the most serious of consequences. A "short circuit" of great magnitude is often produced and this causes an electrical arc which may result in the complete destruction of all the equipment in the immediate vicinity and in the demolition of the buildings which house it. Much attention has, therefore, been devoted to the control and interruption of "short circuits" and to the design and construction of numerous types of protective devices, upon a scale undreamed of a decade ago. Such protective devices consist primarily of the following:—

(*a*) Fuses, of very large size, especially designed to extinguish any electric arc which may arise during their functioning. The usual type is the "expulsion fuse," which consists of a long, thin strip of metal inside a tube made of insulating material and, in some cases, filled with a non-conducting and fire-extinguishing liquid. When the current exceeds a pre-determined point, the metal strip melts and thus breaks the circuit and the resulting gases in the container suddenly expand and are discharged in such a way as to put out the arc formed by the melted fuse.

(*b*) Circuit-breakers, which are practically switches of great size, opening automatically whenever the current exceeds a given amount. They consist, in essence, of contacts between fixed and movable current-carrying parts, which contacts are broken when the mechanism is actuated. The contacts are submerged in oil, which smothers the arc formed when the circuit-breaker is opened. The apparatus is controlled and released by a very delicate device known as a "relay" which trips the opening mechanism as soon as the current through the line exceeds what is considered a safe value. Modern circuit-breakers to interrupt the current of large systems are enormous affairs and their functioning is usually of the order of an explosion. In such cases, their interrupting capac-

ity falls off rapidly with each successive operation unless they are overhauled and put in proper shape after each one. Because of the intensive carbonization of the oil when a heavy arc is formed in it, good practice usually dictates a complete change of oil after each functioning of a circuit breaker on high-voltage systems.

Equipment Problems.—With the growing extent and intricacy of large, interconnected schemes, a very serious problem has arisen in the successful operation of circuit-breakers in such a manner that the failure of one line, or piece of apparatus, will not interrupt service throughout the entire region. While great progress has been made in the design of duplicate equipment and of relays which will automatically isolate the affected portions from the rest of the system, no ideal method has yet been found and much work still remains to be done before this is satisfactorily accomplished. In addition to these details, the very high voltages and the large volumes of energy which are usually encountered have necessitated the design and construction of all usual switches, transformers and various auxiliary devices along lines of great size, strength and ruggedness. As a result, these appliances have attained weights and dimensions which have made their enclosure within buildings a matter of great expense and difficulty. In addition, the increased factor of safety in case of short-circuits (because of the fact that electric arcs or flames resulting from burning oil will travel upward and quickly dissipate themselves into the surrounding atmosphere) has made it much less hazardous to place such apparatus out in the open. An important development of the past decade has thus been the outdoor substation for all high-voltage lines. Such stations usually cover large areas and are laid out with mathematical precision over many acres of ground. The maze of poles, wires and insulators which accompanies an important junction point on a major transmission system is usually termed a "switch-garden."

The extent of the areas covered by most of the regional schemes and the necessity for their direction from one central point have led to the development of operating practices of remarkable scope and authority. Many systems have simultaneously in operation dozens of power-plants, containing literally hundreds of separate machines and connected in numerous places with the lines of other and similar enterprises. The Pacific Gas and Electric Company, for instance, has commonly 32 hydro-electric plants of all types and sizes and three large steam-plants all running at once and all delivering current into a common network of transmission lines. Feeding from these lines are many large sub-stations, where the voltage is lowered to that of the distribution circuits and some of which, in turn, contain further machinery for the regulation, rectification and transformation of the power for railway and special industrial purposes. In addition, current is procured from the great hydro-electric plant of the city of San Francisco and from various mines, mills and irrigation enterprises in the distant mountains, while electricity is exchanged with other systems to the north, east and south. The co-ordinated operation of this gigantic enterprise, with the proper allocation of loads so that the most efficient plants will produce their maximum of output, with the reduction of purchased current to a minimum and with provision for future surpluses or deficiencies of water-power in accordance with the precipitation and run-off of the year, is all accomplished from one central office. One man, sitting at a little desk in front of a huge map, whereon there is displayed every transmission line, every electric generator and, in coloured lights, the position of every principal switch and an indication of whether it is open or closed, directs the operation of the service of electricity supply over an area of more than 30,000 sq.m., or almost that of all England. Contact with nearby plants and stations is accomplished by telephone over the company's own system and the opening and closing of important switches and the starting and stopping of machinery is undertaken upon orders from the chief despatcher in the central office. Communication with the more distant plants, many of which are located some 200 m. away, is effected by what is commonly called the "carrier current" system of telephony, where the actual power-carrying lines of the transmission system serve, in addition, to carry certain modulations of high-frequency electric waves which can be used to convey speech.

Several special devices have been employed with success in the control of smaller hydro-electric plants and substations located in regions which are remote and sometimes difficult of access. One such development is the automatic station, which is supervised by mechanism actuated from the central point of authority. Water-power plants, up to a capacity of 10,000 h.p., are operated in this manner in numerous sections of the country and eliminate, to a large extent, a personnel of considerable size.

Meteorological Factors.—In various parts of the United States, special conditions are encountered which further complicate the functioning of large regional schemes. A characteristic of urban operation in the older cities (such as Boston, New York and Philadelphia) is the heavy demand for service in the late afternoon. The coincidence of the use for light throughout the commercial districts with that of the transportation systems, at a time when the exodus from business areas to the residential sections and suburbs is at its height, produces a "peak" (or period of maximum electrical demand) of great magnitude. Similar "peaks" of equal size are produced at other times of day whenever the temporary darkness of an approaching storm brings forth an immediate and unexpected demand for light. During such periods, the capacity of the enterprise is taxed to its utmost and generating machinery, held in reserve, must suddenly be called upon to go into action at practically a moment's notice. The forecasting of such periods of darkness has been made the subject of much study and large urban systems are usually equipped with storm detectors. Some of these are essentially barometric, while others are devices which are sensitive to unusual electro-static conditions of the atmosphere. By their use, the director of operations (or "load despatcher") receives some forewarning of the oncoming obscurity and has, in this way, a short time in which to marshal his forces to meet the impending lighting demand upon his enterprise. Other meteorological conditions have caused many difficulties and have influenced, to no slight degree, the technology of the wide-spread transmission and distribution of electricity. Two of these of major importance are lightning and sleet. The northern section of the United States, lying east of the Rocky mountains, is subject to frequent and violent atmospheric disturbances and, during the summer months, to thunder-storms of remarkable severity. Transmission lines are very susceptible to lightning, because not only a direct hit damages them, but also a flash in their immediate neighbourhood is sometimes sufficient to set up serious electrical disturbances within the system. Lightning arresters, by means of which the discharge is permitted to reach the ground through a path which the regular electrical current cannot follow, are therefore placed at all stations between the transmission wires and the sub-station apparatus. On some lines an additional wire is placed above all the others at the very top of the transmission line towers, and this wire (connected to "ground") serves, to a considerable extent, to act as a continuous lightning rod. Many parts of the country, especially the North-eastern section and the Central-middle West, are visited, during the winter months, by severe sleet storms. These are the result of peculiar atmospheric conditions, where moisture is precipitated as rain into a region where the temperature is below freezing. A heavy coating of ice soon forms upon all objects and, in the case of electric supply systems, this produces an additional weight which may be very destructive. The strength of insulators and attendant structures must, therefore, be designed with a view towards the successful support, not only of the usual dead weight of the wires, but also of the additional burden of the maximum expected coating of ice, plus the added strain of a heavy gale of wind which may blow against wires whose size is increased by this ice-coating. Based upon observations and past experience, the United States is roughly divided into three zones, where sleet storms of various degrees of severity may be expected to occur and the standards of construction for electrical lines have been determined accordingly. These districts are:—

(a) The "heavy loading" district, lying east of the Rocky mountains and north of the Southern States. Here provision is made

for a coating of ½ in. of ice (in radial thickness) upon all wires, together with a wind pressure of 8 lb. per square foot of surface (which corresponds to an indicated velocity of some 73 m. per hour).

(*b*) The "medium loading" district, comprising the North Pacific coast, the Rocky mountains and a belt approximating the Piedmont region of the Southern States. Provision is made for ¼ in. of ice and the same wind pressures.

(*c*) The "light loading" district, being the balance of the country and embracing the California coast, and the territory along the Mexican border and the Gulf and South Atlantic coasts. Here no sleet may be expected, but provision for 12 lb. wind pressure (an indicated velocity of 92 m. per hour) is made.

Actual conditions throughout the country, together with proper design to withstand weights of ice even greater than the above, are still the subjects of much study and experimentation. An interesting method for the prevention of sleet has been successfully adopted by several Eastern regional schemes. This consists of the discontinuance of the transmission line as a carrier of the usual high-voltage energy and the transfer, through it, of considerable current at very low voltages at recurring periods ranging from 30 min. to an hour. This heats the wires to an extent which inhibits the formation of ice upon them. This scheme is, however, practicable only where a large number of circuits are available, so that the several wires may be kept hot, in rotation, without making it necessary to discontinue service on the entire system.

High-tension Underground Cable.—An important development of high-voltage transmission has been the successful design of the high-tension underground cable, which avoids not only all troubles arising from lightning and sleet but also makes possible the transmission of energy through districts where the density of population or the expense of the land necessary for a right-of-way would render the installation of overhead wires impossible. Cables of this kind usually consist of one single conductor made up of a core of several strands of copper wire and wrapped around with many layers of paper impregnated with a mineral insulating material. This, in turn, is covered with a heavy lead sheath. Such a cable, carrying 132,000 volts, was put in operation in the city of Chicago by the Commonwealth Edison Company late in 1927. The insulation consists of paper $\frac{11}{16}$ in. thick and the outside diameter of the complete cable is 3·1 inches. A peculiarity of this cable is its hollow centre, through which oil is forced under pressure and which assists not only in preventing excessive heating, but also in maintaining the insulating qualities of the paper wrapping. At high voltages in the usual three-wire alternating current practice, three such cables must, of course, be used for each electrical circuit and commonly occupy three separate ducts throughout the underground system. At regular intervals manholes of large dimensions are provided for the splicing of the various lengths of cables and for their ventilation, inspection and repair.

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ELECTRICITY TRANSMISSION: *see* Electrical Power Transmission.

ELECTRIC LAMPS AND VALVES, MANUFACTURE OF. The history of the incandescent lamp has centred mainly round improvements in the filament. In the first practical lamps (produced independently by T. A. Edison and J. W. Swan between 1878 and 1880), carbon filaments were used, and carbon had no real rival until the appearance first of the Osmium lamp (1898) and then of the Tantalum lamp (1903). By 1904 Tungsten had begun to establish itself as the most suitable filament material, and although there was one fundamental improvement in its manufacture (the change from the squirted filament to the drawn wire which began in 1906), its supremacy has not so far been challenged.

Side by side with this improvement in the filament, there has gone improvement in the manufacture of the whole lamp. The earlier lamps were hand made; gradually automatic methods have been developed, and the cost has fallen progressively while the performance of the lamp has improved.

By 1927 the total world consumption of electric lamps had reached a figure of 950 millions per annum, and manufacture on this scale is inevitably conducted on lines of specialized mass production. Now it is not within the scope of this article to discuss the methods of mass-production—they are mainly matters of organisation,—but it is relevant to explain that the success of mass-production depends largely on a knowledge of the scientific principles underlying its processes and products. In what follows, therefore, these principles are explained in detail in their relation to the actual methods and materials used in the manufacture of lamps.

The Principles of Lamp Design.—Let us first consider what happens when a filament is heated in a vacuum. The whole of the energy supplied to the filament is radiated in the form either of heat or light (except for that negligible amount conducted away by the filament leads). The proportion of the energy which is radiated as light increases with the temperature, and it is therefore the aim of the lamp maker to arrange that the filament temperature shall be as high as possible consistent with a reasonable life (in practice 1,000 hours is accepted).

The first essential, then, is to find the filament material which can best stand these conditions, and tungsten, with its exceptionally high melting point (3,380° C) is the outstanding material for the purpose.

The limiting temperature in practice is far below the melting point of the filament; long before that temperature is reached other factors come into play which tend to shorten the life of the filament; these are evaporation of the metal (which both thins the filament and obscures the glass bulb), and loss of mechanical strength. Of these, evaporation is the more important, and for a life of 1,000 hours, it sets a practical limit of about 2,100° C to the temperature at which a tungsten filament may be maintained in a vacuum. (Carbon has an even higher melting point than tungsten, but it fails at a much lower temperature through disintegration.)

The use of a vacuum has this advantage, that the only loss of energy from the filament is by radiation. On the other hand, if the filament is surrounded by an inert gas (*i.e.*, one which will not attack it chemically), its temperature can be raised considerably higher than is possible in a vacuum before the loss of tungsten by evaporation becomes serious. It is true that the vapour pressure of the tungsten has gone up with the temperature, but in spite of this, evaporation is suppressed by the surrounding gas, the molecules of which prevent the tungsten molecules from leaving the filament permanently as freely as they otherwise would. But this is not the whole story. The use of a gaseous atmosphere instead of a vacuum allows the temperature of the filament to be raised, but at the same time in addition to the heat wasted by radiation, a certain amount is now carried away by conduction and convection.

These terms require some explanation. Heat carried by conduction is passed on from molecule to molecule of the gas, just as happens in a solid. Convection on the other hand is the transfer of heat by moving streams of gas. The gas near the filament becomes heated by conduction; its density decreases and it rises, cool gas taking its place. The hot gas goes on rising till it reaches the walls of the bulb, where it is cooled, and sinks again till it reaches the filament; thus a continuous cycle is set up, which is termed convection.

Now in general the amount of heat carried away from a hot body by a gaseous atmosphere is proportional to its surface area; but in the case of a thin filament the statement requires qualification. Langmuir showed that any hot body in a gas is surrounded by a stagnant layer of gas; heat passes through this layer by conduction and is then carried away from its surface mainly by convection. It is therefore the surface area of this gas layer, and not of the solid body itself which determines the amount of heat lost.

Applying this knowledge to the case of a filament, it is found

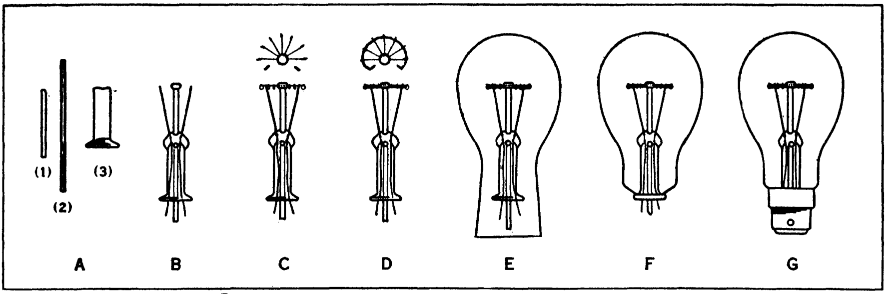

FIG. 1.—DIAGRAMS ILLUSTRATING THE ASSEMBLY OF AN ELECTRIC LAMP
A. (1) Glass rod; (2) glass exhaust tube; (3) glass tube flanged on an automatic machine. B. The parts shown in (A) have been assembled and sealed together, with the lead-in wires in place. A small hole will be seen in the "pinch" through which the exhaust tube ultimately connects with the inside of the bulb. C. Molybdenum support wires have been inserted and bent to shape. D. The filament has been placed in position. E. The bulb is ready for "sealing-in." F. After sealing-in, the bulb has been exhausted (or filled with gas, as the case may be) and the exhaust tube sealed off. G. The finished and capped lamp

that the thickness of the stagnant gas layer, which is independent of the diameter of the filament, is very large compared with the diameter for ordinary sizes of lamp, so that for thin filaments the advantage of the extra temperature attainable in a gaseous atmosphere is more than offset by the greater convection losses. The use of thick filaments is in most cases not practicable, as they are suitable only for very large currents, but it was found that a thin filament coiled into a close spiral behaves, so far as convection losses are concerned, almost exactly like a solid filament of the same diameter as the spiral, while the spiral form allows the wire to be long enough to have the necessary electrical resistance. It thus becomes possible to use a gas to cut down the evaporation of the filament and at the same time to obtain the increased efficiency due to the higher temperature.

This then is the principle on which the so-called "gasfilled" lamp depends. In order to make fullest use of it, the right gas must be chosen. For all but the largest sizes of lamp, argon (mixed with a little nitrogen) is used. Argon is chosen because it is chemically inactive, and being a heavy gas it carries away less heat from the filament than would a lighter gas. The nitrogen is added to lessen the tendency for discharges to take place in the gas at the higher voltages. In the very largest lamps argon shows no advantage in efficiency over nitrogen, but as the latter re-acts slightly with tungsten, the argon-nitrogen mixture is frequently preferred even for large lamps in spite of its increased cost.

The Rating of Lamps.—Lamps are classified according to the voltage on which they are intended to run, and are rated in watts (the watt is the electrical unit of power and equals $\frac{1}{746}$ horse power). The ratings of lamps for use on supply mains range from about 15 watts to 1,500 watts. Smaller lamps (*e.g.*, motor car lamps, flash lamps and so on), and larger lamps (*e.g.*, lighthouse lamps and cinema studio lamps) are also made.

The light given by electric lamps is measured in lumens (a lumen is equal approximately to eight-hundredths of the intensity of the light emitted by a uniform source of one candle power. *See* article on "Photometry"), and the "efficiency" of a lamp is measured in lumens per watt. This efficiency is, as previously explained, dependent on the filament temperature, and it can always be increased (up to the melting point of tungsten) at the sacrifice of life.

It is therefore necessary to decide on a suitable life, and arrange for the filament to run at the temperature (and therefore efficiency) which will give that life. It has been found in practice that the most economical life is about one thousand hours, and this figure has therefore been taken as the standard.

The size of the lamp introduces another factor. Lamps of large wattage can, owing to their thicker filaments and for other reasons, run at higher efficiencies than smaller lamps, and in practice the efficiency of lamps for a thousand-hour life range from 8 lumens per watt for the smallest lamps to 20 lumens per watt for the largest.

One of the biggest difficulties encountered in fixing the suitable ratings of lamps is the fluctuating voltage which occurs in most electric supplies. Every lamp made is marked with its rating in watts and the voltage for which it is designed. Unfortunately, the rate at which life (and efficiency) changes with changes in voltage is very high, as the following table shows.

TABLE I.

The figures below are typical, and refer to a 220 volt 100 watt gas-filled lamp, *i.e.*, a lamp designed to consume 100 watts on a 220 volt circuit, and to live 1,000 hours. Corresponding to the voltage changes in column (a) are given the corresponding changes in watts consumed, light emitted, efficiency and life. All of these are expressed as *percentages* of the nominal or rated figures.

(a) Percentage of nominal volts	(b) Percentage of nominal watts	(c) Percentage of nominal lumens	(d) Percentage of nominal efficiency	(e) Percentage of nominal life
90	85	69	81	437
95	93	83	89	226
100	100	100	100	100
105	108	118	109	55
110	116	138	119	30

Thus if a lamp is correctly designed to have a life of 1,000 hours at the declared voltage of the electricity supply, its actual life will be 600 or 2,000 hours according as the supply voltage is 4% high or 4% low.

Another difficulty is the existence of electricity supplies of many different voltages in different districts; its effect is, of course, to multiply unnecessarily the number of types of lamp which need to be manufactured. There is, however, a strong movement towards standardisation, which, fairly complete in U.S.A., is making great progress in Great Britain, but less in the rest of Europe.

The Materials and Processes of Manufacture. *Glass Work and Assembly of the Lamp.*—The first components to be considered are the glass parts—the bulb, the tubing and the rod. It is not proposed to describe in very great detail the manufacture of these, as the technique involved is for the most part that usually followed in the large scale manufacture of blown glass articles. It is however necessary to explain the reasons which determine the choice of the particular types of glass used, as they are of interest not only in themselves but as illustrations of important principles in mass production.

The bulbs are made of a "crown" or lime-soda glass, largely because this type of glass has a shorter working range than a lead glass, that is to say it remains soft over a shorter range of temperature. This property suits the automatic type of machines used for blowing bulbs and for sealing the bulb on to the internal glass

work. On the other hand, the same glass cannot be used for the internal part of the lamp, for electrical reasons. Glass is a good insulator at ordinary temperatures, but when heated it gradually becomes a conductor, and moreover conducts electrolytically so that in the case of a soda glass metallic sodium would be liberated in quantities sufficient to upset the working of the lamp. Lead glass does not cause this trouble—if it does electrolyse, the product is lead, which is inoffensive—and therefore lead glass has to be used for the "pinch" (*see* figure 1 [b]) and for the studs which carry the support wires.

At the same time, there must be constancy of composition from day to day. A skilled glass blower blowing bulbs or assembling lamps by hand can vary conditions to suit the glass as he gets it; automatic machines cannot do this without resetting; and if this is required too frequently the machines cease to be automatic. A further factor necessitating constancy of composition is that the lead-in wires which carry the current to the filament have to be sealed through the glass, and therefore the coefficient of expansion of the glass must be kept closely within the limits which suit the wires used.

The lime-soda glass used for the bulbs is melted in tank furnaces having a capacity of about 80 tons. The blowing of the bulbs is entirely automatic; the "gathering" of the necessary amount of glass for one bulb is done by suction applied through a long arm which dips momentarily into the tank and then transfers the glass to a mould in which it is blown by compressed air into the correct shape. Even the cutting off of the surplus glass at the neck is done automatically.

The glass tubing and rod used in the internal structure of the lamp is also made by machine; in this case the molten glass is fed continuously on to a rotating mandrel (hollow in the case of tube, solid for rod) from which it is as continuously drawn off in the state of finished tube.

The sequence of operations in the assembly of a lamp ready for pumping is shown in figure 1, which is mainly self explanatory. Two points only need further mention. The lead-in wires are made of a nickel-iron alloy, copper plated and then covered with potassium borate. The composition of the alloy and the thickness of the copper coating are so adjusted that the composite wire has approximately the same coefficient of expansion as the glass. The borate coating is added to allow the glass when melted to "wet" the wire and make a gas-tight seal.

The support wires are made of molybdenum, a metal of very high melting point (2,600° C). The molybdenum wire is made by a process similar to that described later for the tungsten filament; it is used in preference to tungsten for the supports because its mechanical properties make it more suitable.

Evacuation.—The next stage after assembling the electric lamp is to evacuate it; this applies equally to vacuum and gas-filled lamps, but the technique and the reasons behind it, although over-lapping somewhat, are not quite the same in the two cases. In each case the chief difficulty to be overcome is the removal of the gas which is occluded on the bulb walls and other internal surfaces of the lamp, rather than the air which is "free" in the bulb. ("Occlusion" is a term used rather loosely to describe the state in which gases are held either in the body of a solid or on its surface. The theoretical aspects of the subject are too complex to discuss here; for all practical purposes it is enough to picture glass or metals holding gases in solution as water dissolves air.) Dealing with vacuum lamps first, the occluded gas is freed from the walls by heating the bulb to about 400° C during the pumping process.

This process is carried out on automatic machines consisting roughly of a turntable rotating step by step, the hollow stems of the lamps being inserted in suitable holders. As the machine rotates, these are connected successively with suitable vacuum pumps. It is not, however, practicable on a mass production scale to pump each lamp by mechanical means to the required vacuum, which is of the order of 0·0001 mm. mercury. On the other hand, if the residual pressure is much greater (*i.e.*, anywhere between ·005 and 1 mm.) destructive discharges are liable to take place in the bulb.

The necessary high vacuum is therefore produced by physico-chemical means after the lamp has been sealed off from the pump. The usual method is to apply to the filament, before mounting, a thin coat of red phosphorus mixed with a binder and an additional material such as cryolite or another fluoride. (The action of the cryolite is to keep as transparent as possible the film formed on the inside surface of the bulb.) The whole mixture is known as a "getter."

When the lamp has been sealed off from the pump the operation termed the "clean-up" is carried out, during which the getter fulfils its function of completing the evacuation to the necessary high degree. In this operation the lamp is connected in series with a suitable resistance (to protect the lamp from the passage of destructive space-currents) and the filament is then heated, first to a fairly low temperature to volatilize the phosphorus (actually about 90% of its rated voltage is used) and then to a higher temperature than it normally attains in its life (about 110% of its normal voltage). During these stages the clean-up takes place. Finally the lamp is burnt for a short time at 110% of its rated voltage without the protection of a series resistance; this serving to test finally that the lamp has cleaned up, and also to bring the filament to a stable condition which it will maintain during its life. The above described series of operations is carried out on an automatic machine analogous in principle to the pumping machine: The turntable in this case carries lamp holders which are connected at each successive step to the appropriate electric circuits.

The exact mechanism of the clean-up is not fully known, but the following may be taken as a fairly exact picture of what happens. When the filament is first lighted up, the phosphorus vaporises, and then condenses as red phosphorus on the inside walls of the bulb. At the same time a great proportion of the gas molecules go down on the bulb surface and are held there, mixed up with the phosphorus layer. But while this is going on, violent ionization of the gas is occurring, as a result of which the phosphorus already on the glass is subjected to electronic bombardment.

This bombardment re-converts some of the phosphorus to the white variety which vaporises and recondenses again as red phosphorus, burying more gas molecules and presenting a fresh surface to which still more gas can attach itself. The process is mainly completed in a few seconds, but it can continue so long as there is any electronic bombardment of the surface. If, therefore, any gas tends to be freed during the life of the lamp, the clean-up will recommence on a smaller scale. Thus a vacuum lamp carries throughout life its own automatic device for dealing with any traces of gas liberated, before they can become harmful.

There is only one limitation to the use of "getters" in vacuum lamps, and that is that the voltage must be higher than the ionisation potential of the gases and vapours present; in practice it must be well above this figure, and "getters" cannot satisfactorily be used in lamps working at less than 50 volts.

Capping.—After pumping the lamp is capped. The cap shells are stamped out of sheet brass, placed in position in a mould together with the contacts; liquid black glass is run into the shell and pressed into shape by a plunger to form the base of the cap.

After capping, the lamp is tested, and it remains only to stamp the bulb and wrap the finished lamp.

Gasfilled Lamps.—The process just described for the removal of traces of residual gas by means of "getters" does not apply to gasfilled lamps. In this case it is equally if not more important to remove all traces of residual gas and vapours before filling the bulb with inert gas. This is usually accomplished by evacuating to as low a pressure as possible with all the glass work hot, and then washing out the bulb several times with pure dry nitrogen before the final filling takes place. The purification of this nitrogen, and also of the gas (argon or nitrogen) actually used for the filling requires to be very carefully carried out; elaborate chemical methods of purification being used to remove all traces of oxygen, carbon dioxide, and water vapour. Of these, water vapour is the actively dangerous impurity, the others are harmful because they readily form water vapour with any traces of hydrogen

present (and the metal work can always supply these).

Very small amounts of water vapour can seriously shorten the life of a gasfilled lamp; this is due to a cyclic action in which the water vapour acts as a catalyst. The mechanism of the action is worth describing in some detail, because water vapour attack was, and to some extent still is, one of the most difficult problems to overcome in the manufacture of gasfilled lamps Briefly, the water vapour attacks the hot filament forming hydrogen and tungsten oxide; the latter volatilises and leaves the spot where it was formed. Its rate of travel through the stagnant layer of gas round the filament is however very slow, and by the time it has travelled a short distance away it has cooled enough for the reverse action to take place; *i.e.*, metallic tungsten is again formed, together with water vapour, the latter being free to start a new cycle. The tungsten usually finds its way to an adjoining part of the filament, where it builds up a thick patch. The action is cumulative since the hot spot first attacked tends to become thinner and therefore hotter, so stimulating the attack. The only preventive is very careful pumping—great care in drying and purification of the wash-out and filling gases and extreme cleanliness of metal parts. The clean-up method is useless because of the presence of a gaseous atmosphere, nevertheless phosphorus is frequently used as it can combine chemically with traces of free oxygen.

The Manufacture of the Tungsten Filament.—Although metallic tungsten can be liberated fairly easily from its ores, the high melting point of the metal has necessitated the development of quite special methods for its conversion into wires and other usable forms. The earliest tungsten filaments were made from tungsten powder by mixing it with a binder into a paste which was squirted through dies; the binder was afterwards burnt off leaving a coherent but fragile filament. The squirted filament was superseded by drawn tungsten wire.

The first step is to produce a pure tungstic oxide, which is reduced in hydrogen leaving tungsten in the form of a fine powder. The powder is pressed hydraulically into rectangular "slugs" which may be anything from 8 in. to 12 in. long and from ¼ in. to ½ in. square; these on removal from the mould are just strong enough to be handled. The slugs are hardened by heating in a hydrogen atmosphere to about 1,200° C, and then "sintered" by the passage of a current great enough to bring them to nearly 3,000° C (400° below the melting point). During the sintering process the grains of metal powder grow together, and the sintered slug or ingot has a coarse crystalline structure.

The size of the grain can be controlled by many factors such as the fineness of the original oxide, and of the tungsten powder, also the temperature and time of sintering, and can vary between a microscopically fine structure and one so coarse that the whole ingot may consist of a few large crystals. At this stage, however, the individual crystals are not the homogeneous close-packed molecular lattices usually associated with crystal structure; under the microscope voids are visible, and the density of the ingot is only 17–18 as compared with 19·32 for a perfect tungsten crystal.

The ingot is next "swaged"—an operation consisting in hammering the heated ingot by means of a pair of rapid-acting mechanical hammers. The swaging operation is repeated many times, the hammer clearance being gradually reduced as the ingot becomes a thin rod; the swaging temperature is also reduced progressively from 1,500° C heat to a dull red (about 900° C). The final product of swaging is a rod about 0·75 mm. (3½ in.) in diameter; the metal has been consolidated and at the same time the crystal axes have been elongated in the direction of the axis of the rod giving a fibrous structure.

The thin rod is now strong enough to be drawn through dies. The drawing process is similar to that normally employed for other metals; the main difference is that the wire is heated to a temperature which gradually falls from about 1,000° C to 600° C as the diameter decreases; the dies are made of diamond or similarly hard material and are kept heated. As the drawing progresses the metal becomes increasingly ductile, in which respect it appears to differ from other metals, which if drawn without annealing become harder. The structure of the finished wire is in effect a bundle of fine elongated crystalline threads.

The spirals used in gasfilled lamps and in some vacuum lamps are made by coiling the wire on a mandrel from 3 to 7 times the diameter of the filament, the spaces between the turns being about ⅓ to ½ of the diameter of the wire itself. The coils are made on automatic machines in continuous lengths, the mandrels being removed by solution in acid. As a matter of interest, the following figures of wire size are given. The filament of a 240 volt 15 watt vacuum lamp has a diameter of 0·015 mm., that of a 240 volt 60 watt gasfilled lamp has a diameter of ·030 mm. for the actual wire, the diameter of the spiral being 0·21 mm. approximately. Its length is 56 mm. while the total length of filament wire used is approximately 900 mm.

The Behaviour of the Filament in the Lamp.—In the case of the straight filament vacuum lamp, when the filament is heated the fine crystals begin to grow in size and diminish in number by mutual absorption, and after a short time the filament consists of a relatively small number of large crystals many of which extend right across its width. This process of growth by absorption continues during the life of the lamp, and after some time the boundaries between pairs of crystals may stretch across the filament. Failure of the filament may take place by lateral slip of the crystals at such boundaries, or by thinning of individual crystals, either by viscous flow or by evaporation.

All of these types of failure have been studied experimentally, and the efficiencies of lamps have been fixed at such figures that such failures shall not normally occur during the standard life of the lamp. Incidentally, failure by slip at the boundaries can be controlled to some extent by the addition of traces of other materials to the tungsten before it is made into wire; this question is more fully discussed below in connection with coiled filaments for gasfilled lamps.

In the case of the gasfilled lamp, the problem is a different one. The spiral filament is arranged as a flat wreath (in small lamps) or in a series of V's (in large lamps). The spiral is not under tension, but hangs freely under its own weight. Now when crystal growth takes place in such a filament, there is a tendency for the spiral to open out and sag. This opening of the spiral allows of excessive cooling of the wire by the gas stream, and if continued, results in a serious loss in efficiency. (The reasons for this have been explained above under "Principles of Lamp Design.")

Much experimental work has been done with a view to developing a filament which shall not sag appreciably. The earliest method used was to add about 0·5% of thoria to the tungstic oxide from which the metal powder was made: in the finished wire the thoria segregates in the grain boundaries and hinders grain growth and therefore sagging of the spiral. This slowing of the grain growth was only partly successful, and the problem was attacked from another angle; instead of slowing the growth it was accelerated so as to be finished within the first second of heating the filament, thus giving the filament no time to sag appreciably.

Curiously enough, this end can be achieved in two entirely different ways. One is to add thoria as before, but with an alkali salt such as sodium or potassium chloride in addition. The other is to add to the tungsten a small amount of silica and an alkali salt (such as sodium chloride). In this case the additives do not remain in the finished wire; apparently they boil out during the sintering process carrying away other impurities, and leaving the tungsten purer than it can be obtained without their use.

When spiral filaments made of such metals as these are burnt, very rapid grain growth ensues, and within a second or so, whole turns of the spiral, and in some cases many consecutive turns are found to consist of single crystals. Moreover, the orientation of these crystals is such that their axes do not follow the convolutions of the spiral, but are parallel to its axis; that is, the structure is such as would be obtained by carving the coils out of a solid crystal. This condition is conducive to the maximum stability, and no further molecular rearrangement takes place during life so that sag is practically eliminated.

No comprehensive theory has yet been established to explain this phenomenon of rapid crystal growth in coiled filaments.

Special Types of Lamps.—The processes of manufacture just described are those characteristic of what might be termed the

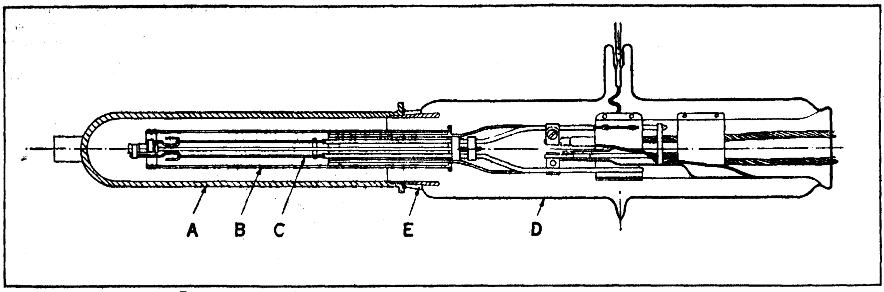

FIG. 2.—DIAGRAMMATIC SKETCH OF A SECTION OF A TYPICAL COOLED-ANODE VALVE
A. the copper anode. B. a grid of molybdenum wire woven on a braiding machine. C. the tungsten filament. D. the glass envelope. E. a thin nickel iron sleeve joining the glass to the copper anode

common type of lamp, that is to say, those which run off ordinary supply mains, with ratings between 15 and 1,500 watts. Besides these there are of course the various kinds of low voltage lamps, of which those used in motor-cars and pocket torches are typical, and very large lamps such as are used in lighthouses and aerodromes. Figure 2 shows these two extremes compared with an ordinary lamp.

The principles involved in the manufacture in the case of the small low voltage lamps are essentially the same as have been already described; certain difficulties arise in matters of detail. Gettering, for instance, is not applicable for the reasons already mentioned. Again a very short filament suffers unduly from the disproportionate cooling of its ends by the supports, so making it necessary that the rest of the filament shall run at a correspondingly higher temperature to give a reasonable efficiency.

The very large lamp differs in another respect; the number required being comparatively small, mass production methods are not applicable, and the construction becomes a matter of skilled craftsmanship rather than of machine design.

The Testing of Lamps.—To complete the account of lamp manufacture it is necessary to mention very briefly the checks imposed on the quality of the product. The two important tests are those for uniformity of manufacture and for quality of the lamp.

In the *Rating Test* for uniformity of manufacture, the lamps are burnt at the rated volts marked on them, and their consumption in watts and efficiency in lumens per watt are observed. These must fall within definite limits laid down in standard specifications.

Life Tests are naturally carried out on only a small proportion of the lamps made. The lamps so tested are always burnt at the efficiency (lumens per watt) for which they were designed; this is arranged either by selecting lamps found to be very exactly rated or by adjusting the voltage slightly to give the correct efficiency. The lamps are run to extinction, the candle power being measured at regular intervals. The average performance called for is a life of 1,000 hours with an average candle and efficiency maintenance of not less than 90%.

THERMIONIC VALVES

The term "thermionic valve" is a very wide one, covering a field which ranges from the smallest amplifiers and detectors used in radio reception to mercury vapour rectifiers handling hundreds of kilowatts. It is proposed only to discuss those valves which depend for their operation on the use of a heated filament.

In general, the technique of large-scale manufacture of such valves has been based almost entirely on that of lamps, which had reached the mass production scale while the valve was in its infancy.

Owing to the extreme rapidity with which the use and development of valves has grown (mainly due to broadcasting), there has not yet been time for the manufacture to settle down on the standardised lines reached in the case of lamps, but the general principles are sufficiently clear to enable a fairly accurate picture to be drawn.

The Filament.—As in the case of the lamp, the filament is the crux of the problem, but the problem is different. In each case the filament is heated by a current, but while the lamp filament has to emit radiant energy, the valve filament has to emit electrons. Electron emission, like energy emission, increases with the temperature, and the same difficulty arises—that as the temperature is pushed up to increase the emission, the life of the filament is shortened by evaporation.

It should be explained at once that three types of filament are in common use. Plain tungsten is used in large transmitting valves, and in the nearly obsolete "bright-emitting" receiving valves. Most receiving valves have filaments of the kind known as "dull-emitters," the active emitting material being not the metal of the filament itself, but a surface layer of some other material which emits electrons more readily.

Two distinct types of dull-emitting filament are in use, one using thorium as the active material, and the other barium or similar alkaline earths. The thorium dull-emitting filament is made from a tungsten wire containing about 1% of thoria (the manufacturing processes are similar to those described for lamp filaments).

The dull-emitting property is developed, after the valve has been evacuated, by heating the filament to 2,600° C for 1 minute, then to 1,900° C for 5 minutes. In the first heating, some of the thoria is reduced by the tungsten to metallic thorium; during the second stage, thorium diffuses through the tungsten and forms a layer on the surface. This thorium surface has a lower resistance to the passage of electrons than a surface of tungsten; so that at a temperature of 1,600° C the emission is equivalent to that of a plain tungsten filament at 2,200° C. The layer of thorium atoms is continuously renewed by diffusion through the tungsten.

The other type of dull-emitting filament is a modern development of the Wehnelt cathode. This filament has a core of pure tungsten or nickel or one of the platinum metals, and the emitting surface is a coating of an alkaline earth oxide, usually barium or strontium (or a mixture of the two). In the manufacture of filaments, the coating is applied either mechanically before mounting the filament or by chemical action inside the valve. This third type of filament emits at even lower temperatures than thoriated tungsten, with consequent improvement in current consumption. A comparison of relative emissions of the three kinds of filament at their normal operating temperatures is interesting. The emissions in milliamperes per watt of heating current are respectively 5, 30 and 100 for plain tungsten, thoriated tungsten and coated filaments.

Valves with Indirectly Heated Cathodes.—In these valves a tungsten filament is employed, not as an emitter of electrons, but as a heater for a nickel tube covered with alkaline earth oxides which acts as a cathode. Their purpose is to eliminate the hum caused by the use of an alternating supply for the heating current.

The methods of manufacture are in general similar to those already described.

Evacuation.—This is an even more complex manufacturing problem with valves than with lamps. In the first place, the valve contains much more metal work than the lamp, and this has to be freed from occluded gas. Most of the gas can be removed by preheating all metal parts *in vacuo* before assembly; the surface gas can then be dealt with either by bombarding to make the anode hot during the pumping operation (in large valves) or by getters (in receiving valves). The getter generally used in receiving valves is metallic magnesium, a small piece of which is fixed on to some metal part of the valve before assembly, and after pumping is volatilized. This is done by enveloping the valve for a short time in a coil carrying a high frequency current, which by induction causes eddy-currents in the metal parts, so heating them to the necessary temperature.

The reasons which make an extra high vacuum necessary are twofold. In the case of large transmitting valves with plain tungsten filaments, traces of gas cause wastage of the filament by bombardment and also affect the operation of the valve, while in the case of receiving valves the dull-emitting properties of the filament are rapidly destroyed by the minutest traces of oxygen or other electro-negative gases.

GENERAL CONSTRUCTION OF VALVES

Receiving valves such as are used for broadcast reception are made by methods recalling those described for lamps. The glass problem is a similar one. The inside construction is more complicated, owing to the multiplicity of parts, and very exact work is necessary to ensure that correct clearances are maintained between the filament, grid and anode. This is, in fact, a special problem of valve manufacture, and has no analogue in the case of lamps. Grids for these valves are made in continuous lengths by machines which wind molybdenum wire spirally on to nickel supports and automatically spot-weld each turn on to the support. The anodes are of sheet nickel.

Transmitting Valves.—Up to about 2 kilowatts, the construction of these is similar in principle to that of receiving valves, but being much larger and required only in small numbers they are mainly hand-made. Evacuation is carried out without getters, pumping being continued for a matter of hours, while the anode is freed from gas by vigorous high tension bombardment which raises it to a high temperature (1,200°–1,600° C). The anodes are made of nickel, molybdenum or tantalum.

Cooled Anode Valves.—In the transmitting valves just mentioned, the anodes become heated during operation, and this heat has to be dissipated by radiation. The difficulties so caused in the design of valves for handling very large powers led to the development of a radically different type, in which the anode itself becomes part of the envelope of the valve, and can be cooled by the circulation of water or oil through a "jacket" fixed round it. Figure 3 shows diagrammatically a section through such a valve. Figure 4 is an actual X-ray photograph showing the grid and filament system inside a copper anode. Perhaps the most interesting part of the construction is the joint between the anode and the glass envelope. This takes various forms; in the original one a thin copper sleeve was sealed on to the glass and brazed at the other end to a copper anode; the sleeve was made so thin that it could "give" enough to allow for the difference of expansion between itself and the glass. Another method using copper anodes is to make the sleeve of a nickel-iron alloy having the same coefficient of expansion as the lead glass used; to ensure proper welding of the nickel-iron on the melted glass it is copper plated and covered with borax. In a third kind of seal soda glass is used, and the anode is made of a chromium-iron alloy of the same coefficient of expansion as the glass. In this case no plating is required, the alloy itself welding easily with the glass.

A few figures may be quoted to give some idea of the size these valves have reached. Transmitting valves are made having an input of 15 kw.; the waste energy taken away in the cooling water reaches about 5 kw.; the filament has a diameter of 1 mm., and requires a current of 50 amp. at 20 volts to heat it.

And with evolution in size there has gone an even more striking evolution in appearance. That characteristic feature, the bulb, has dwindled to a mere appendage, and the transmitting valve, ceasing to be an example of the glass-blowers art, has become an elaborate engineering structure incorporating a small glass insulator.

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(C. C. Pa.)

ELECTRIC LIGHTING: *see* Lighting and Illuminating Engineering; Electric Lamp, Manufacture of.

ELECTRIC LOCOMOTIVE: *see* Locomotive.

ELECTRIC MOTORS: *see* Motors, Electric.

ELECTRIC TRACTION. Although experimental electric motors were built nearly a century ago electric traction is a modern development. Briefly described, an electric railway is a combination of a source of electric energy, means for transmitting it to vehicles along a right of way, including the raising and lowering of electrical pressures and conversion of type of current, and motors on the several vehicles provided with means for collecting and controllably converting the energy received into mechanical power.

Early History.—The electric industry, so far as dependent upon dynamo-electric machinery, rests largely upon the researches of the American scientist, Joseph Henry. In 1834–35, only three years after his invention of the electric motor, and a decade following Faraday's discovery that electricity could produce continuous motion, Thomas Davenport, a blacksmith of Brandon, Vt., mounted a toy motor and primary battery on a small vehicle and operated it on a short circular track. This experiment marked the inception of the electric railway, but for two score years many inventors laboured with small result. Among them were Jacobi on the River Neva, and Robert Davidson of Aberdeen, who about 1838 built a five ton locomotive which made several trips on the Edinburgh-Glasgow railway. The use of the rails to conduct current was first shown in an English patent granted to Henry Pinkus in 1844, while French and Austrian patents were granted to Major Bassolo the following year which indicated the use also of a third rail. In 1847, Prof. Moses G. Farmer, one of the earliest experimenters with incandescent lights, operated a small car at Dover, N.H., while three years later one Thomas Hall exhibited in Boston an automatically reversing car mounted on rails. These are the first recorded instances in which the rails were actually used as carriers of the current, as well as the first use of gear reduction from motor and axle. Soon afterwards Prof. Page of the Smithsonian Institution constructed a locomotive which, driven by a battery of 100 Grove elements, was operated on April 29, 1851 on a road near Washington. These early experiments were doomed to commercial failure, because the source of power was a primary battery, but they indicated what was possible with the evolution of the dynamo-electric machine.

Development of the Dynamo.—Beginning with improvements by Wheatstone and Cook in 1845 and by Hjork in 1854, in 1858 an unknown inventor disclosed the vital principle of self-excitation of the field magnets, and three years later came Pacinotti's invention of the continuous-current dynamo, followed shortly by announcement of self-excitation, developed also independently in 1866–67 by Wheatstone, Varley and Ladd in England, Siemens in Germany, and Farmer in the United States. Three years later Gramme combined the two vital features in a single machine, and to him is due the credit of producing the first commercial machine for continuous current operation.

Some time elapsed before the remarkable characteristic of reversibility of function was known, with the natural corollary of the electric transmission of energy by the use of two similar machines connected in the same circuit, one generating and the other reconverting electricity. It is the fundamental of all modern power development of whatever character. It has been claimed that this principle was enunciated by Pacinotti in 1867, but certainly no use of it was made until about 1873, when Gramme and Fontaine demonstrated it at the Vienna Exposition.

The first public demonstration using the dynamo-electric machine was made at the Berlin Exhibition in 1879 by the Siemens firm. The transmission of electric energy for transportation was a

natural sequence, and at this exhibition was installed and operated an equipment comprising a third of a mile of track, a small locomotive and three cars having a capacity of about 20 people. The current was supplied through a central rail, with running rails for a return. The motor was carried longitudinally, motion being transmitted through spur and bevel gears to a central shaft from which connection was made to the wheels. This exhibit was followed by others at Brussels, Düsseldorf and Frankfort, but the first regular line, a short one with one motor car, was installed at Lichterfelde, and opened for traffic in May 1881. At first both rails were used for conducting the current at low potential. The motor was carried on a frame underneath the car between the wheels, the power being transmitted to the axles by steel cables, and a maximum speed of about 30 m. was attained. Some years later the rail distribution was replaced by overhead conductors. The Siemens firm also installed at the 1881 Paris Exposition a tramway about a third of a mile long. The overhead conductors consisted of two slotted tubes, in which slid shoes held in contact by an underrunning wheel on a framework supported by the conductors and connected to the car by flexible cables. The motor was placed between the wheels and the power transmitted by a chain.

EARLY AMERICAN EXPERIMENTS

About this same period various American inventors undertook experimental work. With the possible exception of one George Greene of Kalamazoo, Mich., who repeated some of the early primary battery experiments, apparently the first of these were Stephen D. Field and T. A. Edison. These inventors became involved in a patent interference with each other and with Siemens, all having filed applications within a few months in 1880. Siemens' early testimony was rejected under the existing rules and priority for limited features was awarded to Field, who filed a caveat in 1879, in February of which year he made plans for an electric railway to use current from a stationary generator through a conductor carried in a conduit, with rail return.

In 1880 at Menlo Park, Edison operated a small electric locomotive pulling a trail car. Two of his early lighting dynamos were used, one for generating the current and the other as a motor. The two rails, insulated from each other, were used for current supply through wheel contact, one wheel being insulated from the axle. The power was transmitted to the axle and at first the speed was varied by a friction drum or a belt with a tightener. Two years later, at the instance of Henry Villard, similar experiments were repeated on a larger scale but without material change. The system was impracticable because the use of the two rails as conductors was prohibitive on account of the impossibility of preventing short circuits under commercial conditions. The method of transmitting and controlling power was likewise impracticable. Siemens meanwhile continued work, constructing experimental roads near Meran in the Tyrol and elsewhere.

At a somewhat earlier period F. J. Sprague, a midshipman in the U.S. navy, had constructed in 1881 a series-parallel controlled dynamo and motor of novel design, this method of control having also been independently invented in England by Dr. John Hopkinson the year before. While acting as a juror at the 1882 Crystal Palace Electrical Exhibition Sprague considered the possibility of operating the District Railway electrically, first planning the use of main and working conductors, the latter to be carried between the tracks with automatic means for maintaining tension; but to meet the complication of switches he later conceived the idea of a car moving freely between two contact planes, the terminals of a constant potential generating system, for which in practice would be substituted the rails and switches, with wheel contact, and roof-supported conductors following the centre lines of tracks and switches, with under contact from a compensating device carried on the car over the centre of the trucks. This was the genesis of the present trolley in tramway and main line practice, but was not put into effect until four years later.

In the fall of 1882 Dr. Finney of Pittsburgh proposed operating omnibuses electrically with current from overhead wires carrying a small trolley connected to the vehicle with a flexible cable, while in England Profs. Ayrton and Perry read a paper on automatic railways before the Royal Institution, and Dr. Fleeming Jenkin, the distinguished Scotch scientist, proposed a telepherage system, or automatic overhead railway for carrying merchandise. The development by Faure and Brush of the storage battery was followed by experiments in London and Berlin in 1883 by Reckenzaun. Here the car body was carried by two trucks, each equipped with a motor and worm gear drive. Two sets of brushes were used and speed varied by using the batteries in series or parallel, with resistances to reduce sparking in changing.

The Development Period.—In the United States a Belgian, Charles J. Van Depoele, originally a sculptor and an indefatigable worker, attacked the railway problem, on which he left a permanent impress. His first experiment, using an arc light dynamo as a motor and taking current from a wire laid in a trough, was made at his shop in Chicago in the winter of 1882–83, and in the following autumn the car was exhibited at the Chicago Industrial Exhibition. About this period he tried out an underrunning contact, and in a patent interference with Sprague three years later was successful, because the latter's testimony as to conception prior to reentry in the United States in May 1883 was not available. The English-born Leo Daft in 1883 began work at Greenville, N.J., continuing at Saratoga, where his locomotive, "The Ampere," pulled a full sized car. The motor was mounted on a platform and connected by belts to an intermediate shaft carried between the wheels, from which another set of belts led to pulleys on the driving axles. Current supply was by centre and running rails at low potential. Speed variation was obtained by variation of field resistances, both iron and copper being used. In Great Britain, the first installation was for the Portrush Electric railway in Ireland, in 1883 by Siemens Brothers of London and Hopkinson. The power was generated by a water turbine and current at 250 volts transmitted by a third rail carried on posts along the track, with track return.

Following their experiments in the United States the Field and Edison interests were combined in a corporation, which first operated a small locomotive equipped with a Weston machine at the Chicago Railway Exposition in 1883. The motor was connected by bevel gears to a shaft from which power was transmitted by belts to one axle, and the current was taken from a centre rail with track return. A lever operated clutches on the driving shaft and the speed was varied by resistances. Reversal of movement was effected by two movable brushes, only one of which could be thrown into the circuit at a time. A short experiment was made by Field at Stockbridge and another on the 34th street branch of the New York Elevated, but no commercial installations were made by the company. Field later joined with Eickemeyer in the development of a side-rod driven equipment but this was short-lived.

The use of the conduit for carrying the conductors was undertaken by Bentley and Knight, who in 1884 installed a 2 m. section and two cars on the tracks of the East Cleveland Railway Company, the wooden conduits being laid between the tracks. The motors were carried under the car bodies and power transmitted by cables. This installation was operated during the following winter and abandoned later. At this period J. C. Henry entered the field and installed a small line in Kansas City, using two overhead conductors on each of which travelled a trolley connected to the car by a flexible cable. The motor was mounted on a frame supported on the car axle, with power transmitted through a clutch and a nest of gears. Experiments conducted on another section of the road included use of the rails as a return circuit. The collectors were of different types but the preferred one was a trolley carried by and gripping the sides of the wires.

In the next two years Prof. Short of Denver began experiments on a short track, and the construction with Nesmyth of a section for conduit operation. The series system was used, a constant current being sent through all the motors on the line by automatic sectionalizing of the conductors, the total potential varying according to the number of motors. Speed and direction were varied by shifting the commutator brushes or diverting a part of the current around the motor. The experiments were continued into the following year and repeated at Columbus but failed because of the principle involved.

Daft and Van Depoele meanwhile were continuing work, the former making an installation on the Union Passenger railway of Baltimore, the first in the United States to regularly operate for fares. Here were installed four dummies which pulled regular street cars. Centre and running rails were used for the normal current supply, and at crossings an overhead conductor with under-running contact. Daft's most ambitious project was the equipping of a 2 m. section of track on the Elevated road, on which tests were conducted late in 1885 with the "Benjamin Franklin," operated by a motor mounted on a platform and pivoted at one end, the drive being through grooved friction drums held in close contact. Then followed installations in Los Angeles and elsewhere, using double overhead wires carrying a trolley carriage with flexible connection to the cars.

Van Depoele's work in this period was the equipping of a locomotive, current being taken from an underground conduit, to pull a train at the Toronto Exhibition. In the following year he used an overhead wire and a weighted under-contact arm at the end of the car. His next installations were on the South Bend railway with several cars, and in Minneapolis, where an electric car took the place of a steam locomotive. The next year he equipped a road at Montgomery, Ala., first using a travelling trolley connected to the car by a flexible conductor, but later a non-reversible under-running contact mounted at one end of the car. Other small installations were made in Windsor, Ont., Detroit, Mich., Appleton, Wis., and Scranton, Pa. In these equipments the motor was carried on the platform and connected to the wheels by belts or chains. The cars operated from one end only.

Following motor exhibits at the Philadelphia Electrical Exhibition in 1884, Sprague in the following year essayed a major project, the equipment of the New York elevated system with motors carried on the regular car trucks, beginning actual construction of a test equipment that was transferred to the 34th street branch of the "L" where regular tests began in May 1886. These motors were the parent models of modern equipment. They were centred on the driving axles, connected to them by adjustable single-reduction gears, and the free ends were carried by springs from the transom, now known as the "wheelbarrow suspension." One set of brushes was used for both directions of movement, and the motors were used not only for propulsion but for braking. A shunt field coil was supplemented by a coil in series with the armature at right angles to the normal field, to prevent shifting of the neutral brush point, this being the first "interpole" winding used on railway motors. They were operated at 600 volts, at each end of the car by similar switches, and variation of speed was effected by inverse changes of resistances and field strength. This control provided the means for regeneration, energy being first returned to the line when slowing down from high speed and the motor circuit then closed on itself. Then construction began of a locomotive car of 300 h.p. capacity, all axles to be equipped. Later followed motors for experiments with storage batteries in Philadelphia, New York and Boston in 1886.

In Europe a short road was installed at Bessbrook-Newry under the direction of the Messrs. Hopkinson in 1885, and one at Ryde in 1886, in which year Holroyd Smith equipped the Blackpool road, using a conduit with a complete metallic circuit, the first of this type abroad. The motor was carried under the car between the axles and connected by chain gearing. Fixed brushes with end contact were used for both directions in running.

The Trolley Age.—Reviewing the conditions in 1887, eight years after the Berlin Exhibition by Siemens, there were only nine installations in Europe and ten in the United States, with an aggregate of about 60 m. of track and less than 100 motors and motor cars, characterized by the utmost diversity of practice. The art was in a chaotic state and commercial success on a large scale, with radical improvements in practice, was essential to focus the advantages claimed for electric traction. In the spring of this year three important contracts were made—two, those for the Union Passenger railway of Richmond, Va., and St. Joseph, Mo., by Sprague; and one for the Observatory Hill railway of Allegheny City, Pa., by Bentley-Knight. The latter road was about 4 m. long, one-quarter being of conduit construction and the remainder having a double trolley line on side poles supporting a travelling trolley. There were 34 curves and many heavy grades, the maximum being over 12% and one averaging 6% for nearly a mile. The cars were equipped with two 15 h.p. over-hung motors geared to the axles, and the control was by resistance variation. This line was opened in 1888 and continued in service for some time, but the conduit was abandoned and new equipment installed with an under-running trolley.

The Richmond contract called for completion in 90 days of an installation for a road with 12 m. of track, at that time unlaid and with route undetermined, of equipment for a complete steam and electric central-station plant and 80 motors on 40 cars, with all the appurtenances necessary for operation. This was nearly as many motors as were in use on all existing installations. Thirty cars were to be operated at one time and many heavy grades and curves negotiated. Finally, the payment was to be $120,000 "if satisfactory." Experimental operation began in the fall of 1887 and regular service in Feb. 1888. The difficulties met were numerous, but after many vicissitudes which taxed the technical and financial resources of the company, success was achieved, and the Richmond road is now recognized as the first of the modern systems in which a large railway was equipped and operated under service conditions by electricity, and as the pioneer of commercial electric traction.

Its features included distribution by an overhead line over the centre of the track, reinforced by a main conductor in turn supplied at central points from a constant potential plant operated at 450 volts, and with reinforced track return. Current was taken from the overhead line, at first by fixed upward pressure contacts and later by a wheel carried on a pole supported over the centre of the car and having free up and down and reversible movement. Series-wound motors, one to each axle, were centred on and geared to them on the wheelbarrow suspension method, at first by single adjustable and then by double reduction gears. All the weight was available for traction and the car could be operated in either direction from either end of the platform. Control was at first by variation of the field coils from series to multiple relation and series-parallel grouping of armatures by a separate switch. Motors were run in both directions with fixed brushes, at first laminated ones placed at an angle, then solid metallic ones with radial bearing and finally carbon ones as proposed by Van Depoele.

Prior to this time the cable system had been adopted on several roads and was under consideration for the West End road of Boston, but was abandoned by its president, Henry M. Whitney, in favour of Sprague equipment. Soon afterwards the cable road in Minneapolis was abandoned. Meanwhile the Van Depoele interests had been absorbed by the Thomson-Houston Electric Company and there followed a period of extraordinary activity in the United States, in which this company and the Sprague Electric Railway and Motor Company were the principal competitors. It resulted in contracts for over 200 railways within two years. There followed continuous improvement and increase in the size of apparatus. Form-wound armatures, proposed by Eickemeyer, replaced irregular windings, and metallic brushes gave way to carbon, this single change initiated by Van Depoele being of prime importance. Cast and wrought iron yielded to steel, two-pole motors to four-pole, double reduction gears to single, and open motors to closed, protected by their own castings. In 1892 the Reckenzaun-Condict single movement series-parallel and resistance control was adopted and the Thomson magnet blow-out successfully applied to controllers by Potter.

The rapid spread of electric railway in the United States resulted in installations in Europe at Florence-Fiesole, Halle and elsewhere, but it was not until some time later that there was any general adoption of the electric railway. Meanwhile the Sprague Company was absorbed in 1890 by the Edison General Electric Company, which later combined with the Thomson-Houston Company and others in the General Electric Company, and the Westinghouse Company also entered the field.

Effect on Telephone Systems.—No sooner had the Richmond road started than there was emphasized a series of disturbances on the telephone lines, it being the general practice to install tele-

phones with earth return circuits. The service had become unsatisfactory because of the multiplicity of electric installations of various kinds, with consequent ground leakages and troubles from induction. The first attempt to meet this trouble was to replace the ground connection by a metallic return, which obviated most leakage troubles but did not get rid of induction. Numerous lawsuits followed, the telephone companies attempting to force the railways to use double overhead circuits, but the trolley contentions were in the main successful and individual balanced metallic circuits, vital to successful operation and without which the long distance telephone is impracticable, were finally adopted.

Heavy Electric Traction.—Despite the success of the trolley there was little immediate effort to extend electric operation to other types of railroad service, and for the next six years the record is that of an industrial development, the replacement of horse and cable power on existing lines and the creation of new ones. However, in Nov. 1890, the South London line, originally designed for cable, was opened, using Siemens' electric gearless locomotives, and in Feb. 1892 Sprague offered to install on the New York elevated road two test trains, one to be operated by a locomotive car and the other with motors distributed under the cars, and to make a speed of 40 m. per hour. A year later the Liverpool overhead railway was put in operation, with two-car trains, each with one motor but both operated by direct control. In the spring of the same year the Intramural railway was constructed at the Chicago World's Fair with equipment supplied by the General Electric Company, and two years later the Metropolitan West Side elevated road in the same city was equipped on the same general plan, both installations using a motor car to pull trail cars. In May 1896, the Nantasket Beach road, a branch of the New York and New Haven railway, was put in operation; in September the Lake street elevated of Chicago, and shortly afterwards electric service began on the Brooklyn bridge. There were few attempts, however, to replace steam on main line roads, and only occasionally were electric locomotives used for special reasons. Among the earlier ones built were one of 1,000 h.p. in 1892–93, designed by Sprague, Duncan and Hutchinson for Henry Villard for experimental operation on lines out of Chicago, and the still larger locomotive built by the General Electric Company, which began hauling trains in the Baltimore and Ohio tunnel in 1895.

For a long time the conduit system, after its abandonment in Allegheny City and Boston, remained undeveloped and installations were with the overhead trolley, using 500 volt direct current series motors. The first important installation in the United States using a metal conduit in which the two conductors are supported and current collected by a plough carried by the car and projecting through the slot was made in Washington under the direction of Connett. The success of this installation and of tests carried out on the Lenox avenue line in New York led to the adoption of this type in many cities in the United States and Europe where the capital expenditure seemed to warrant it.

The development of interurban railways was aided by the inventions in polyphase alternating current transmission by Tesla, Farraris and Stanley, and in rotary transformers by Bradley and others. The first proposal to use these in electric railways seems to have been made in 1896 by B. J. Arnold, in plans for a road near Chicago. This road was not built but the plans were utilized for a line two years later, which was the forerunner of the standard practice of to-day.

The Multiple-Unit System.—Although the limitation of distance had been thus practically eliminated by the adoption of alternating current for the initial transmission of electric energy to sub-stations from which it could be delivered to the working conductor, whether overhead with running or sliding contact or to protected third rails with top or bottom contacts, there remained the limitations of operating motor potential and unit capacity of equipment. The former led to the gradual raising of direct-current operating potential from 500 to 3,000 volts, with interpole motors, in the face of much criticism, and the use of alternating currents on overhead lines up to 11,000 volts, and the latter to a new system of control known as the "Multiple-Unit," invented by Sprague in 1895 and first installed on 120 cars of the South Side elevated road in Chicago in 1897. This is a system of electrical control of controllers, by means of which any number of individually equipped cars or locomotives, with or without unequipped units, may be assembled in any desired manner, end-relation or sequence, and operated from any one of a number of master controllers through a secondary train line extending throughout the train, with provision for automatic equalization of duty on the different equipments. This development has made possible great aggregations of power under remote control, and the system has been universally adopted on all electrical elevated and subway rapid transit lines, with great resulting increase of capacity and speed of operation, and on all suburban trains and locomotives operated on electrified main lines where two or more units are under a single control.

Future of Electric Traction.—The advantages of electric operation as compared with horse or cable operation are so manifest that the latter has been practically displaced, and this form of electric utility has grown until in the United States alone it represents a capitalization of $6,000,000,000 and an employment of 350,000 people. But the advent of the gasolene engine for private and public vehicles has militated against trolley as well as main line railroad operation, so that in many cases electric roads, with their restricted route, high capital investment and reduced patronage have been abandoned, while the remainder have been obliged to improve equipment and service. Despite these handicaps the trolley, as a system, will continue. Where traffic is concentrated, as on rapid transit lines with exclusive rights of way, no other form of present known motive power can approach electric operation in capacity, efficiency and economy.

The electrification of the standard main line railroads, although slow in beginning, is now making definite progress and will proceed at an accelerated pace. At first, on account of the high capital costs installations were confined to special conditions, as the operation of city terminals and tunnels. For a general solution the use of high electrical pressure is vital, and before the increased possibilities of the direct current motor were demonstrated this need led to attempts to use both polyphase and single phase alternating currents without intermediate moving wayside apparatus. One of the earliest undertakings of this kind was the high speed test on the Zossen Military line in 1903, where a car was operated at 126 m. per hour, current being supplied on the polyphase system from three overhead wires through sliding contacts at 14,000 volts pressure. The Valentina line, equipped by Ganz, also used the polyphase system, but with the rails as one conductor and at a lower pressure of 6,000 volts. In the United States a like equipment was installed on the Great Northern railway, but this has been abandoned. The multiplicity of conductors militates against this system, and where used directly alternating current will be supplied through a single overhead trolley line supported by a catenary.

On the other hand, certain advantages inherent to the direct current motor, the raising of its operating potential to 3,000 volts, the development of the mercury rectifier and the automatic substation, the growing density of traffic and the expanding general uses of electricity from central generating stations, inter-connected but maintaining the advantages of primary transmission by polyphase alternating currents at high pressures, have strongly entrenched the direct current motor as a favoured form of locomotive equipment. One difficulty experienced has been decision as to type of locomotive. The early ones either carried the armatures on the axles or geared the motor to them, as in trolley car practice. Then appeared the Bachelder direct bi-polar type, in which the armatures are carried on the axles, while the field magnets, with flattened pole pieces and tandem magnetic flux, form part of the spring-supported super-structure. The raising of the centre of gravity to reduce lateral pressures on the rails has been obtained by gearing motors to jack shafts from which drive rods extend to the side rods, while in other forms direct connection of motor to side rods is made through automatic adjusting couplings, so as to allow support of the motor above the springs. Experience will determine which forms are best adapted for special and general service, and the electric locomotive will

inevitably achieve supremacy because of the possible concentration of power, ability to maintain speeds on heavy grades, capacity of continuous duty, and the advantages of regenerative braking, low cost of upkeep and simplicity of operation.

Among conspicuous installations in the United States are the New York Central terminal, operated with Wilgus and Sprague under-contact protected third rail at 600 volts, the New York, New Haven and Hartford railroad with 11,000 single phase trolley and motors, the Butte and Montana and the 437 m. section of the Chicago, Milwaukee and St. Paul railroad, operated with direct current motors at 2,400 and 3,000 volts respectively, the Virginian, with single phase trolley and split-phase polyphase motors, and the extensive installations projected for the Pennsylvania, Lackawanna and New York Central railroads, and many important railroads in France, Italy, Switzerland and elsewhere. In Switzerland, electrification, aided by abundant water-power, had by the end of 1928, according to the report made by technical director Dr. E. Huber to the Zurich Natural History Society, reached 58% of route, 67% of track and 85% of trailing-ton miles —an augury of the passing of the steam locomotive. (F. J. Sp.)

ELECTRIC WAVES. The enormous development in the use of electrical waves for wireless telegraphy and other purposes has led to such a multitude of investigations on their properties and the methods of producing and detecting them that the subject has become far too large to be dealt with in one article. A detailed account of the present position of various branches of the subject will be found in the articles WIRELESS, THEORY OF; WIRELESS, PRACTICE OF; THERMIONIC VALVES; ELECTROMAGNETIC SPECTRUM. This article will deal with the history of the initiation of the subject and the first stages of its development.

Clark-Maxwell.—It is to Clark-Maxwell that we owe not only the origination of the idea that electrical and magnetic effects are propagated by waves, but also the establishment of equations giving a mathematical theory by which these effects can be calculated. The equations known as Maxwell's equations are, if we accept the view that the constitution of matter is fundamentally electrical, the key to the solution of many of the most fundamental problems in physics. Maxwell's discovery was inspired by Faraday's view that the forces between electrified bodies was not due to direct action at a distance between the electric charges on these bodies, but to the presence in the region occupied by these bodies of lines of force, these lines started from bodies charged with electricity of one sign and ended on bodies charged with electricity of the opposite sign; these lines of force were supposed to be in a state of tension, and thus were striving to shorten while at the same time they repelled laterally the adjacent lines of force. These tensions and repulsions produced in Faraday's view the forces which electrified bodies exert on each other. Maxwell's first paper was "On Faraday's Lines of Electric Force" (*Proc. Cambridge Philosophical Society*, x. part i., 1855). In this he puts Faraday's conception into a form suitable for mathematical treatment by the introduction of the idea of tubes of force, a tube of force being the tubular service formed by the lines of force which pass through a small closed curve drawn in the electric field. He shows that the electric force at any point along this tube is inversely proportional to the cross section of the tube at the point, so that the tubes are thinner when the force is large than when it is small, and the variations in the sizes of the tube will indicate the variation in the electric force. These tubes start from positively electrified bodies and end on negatively electrified ones. The charge enclosed by the tube on the surface from which it starts is equal to the charge it encloses on the surface where it ends, if the size of the tube is chosen so that this charge is unity. Thus a charge of electricity e will be the origin or terminus of e tubes of force. In the *Philosophical Magazine*, March, April, May 1861, he works out a theory of magnetic lines of force, supposing that a tube of magnetic force is a vortex whose axis of rotation coincides with the direction of the force, he shows that these vortexes would give rise to forces analogous to those observed in the magnetic field. Inasmuch as contiguous positions of neighbouring vortexes must be moving in opposite directions he supposes that the vortexes are separated by particles which act like the idle wheels in a train of mechanism, so that each vortex has a tendency to make a neighbouring vortex rotate in the same direction as itself. The motion of these particles constituted in Maxwell's view the electric current. Though Maxwell in his later papers did not make much reference to this theory, it seems to have been the consideration of this hypothetical mechanism which suggested the conception which is the very keystone of his theory in the final form given in the paper "A Dynamical Theory of the Electromagnetic Field" (*Phil. Trans.*, clv. 1864). This conception was that magnetic forces could be produced not only by the ordinary convective currents flowing through wires and electrolytes which had previously been supposed to be the sole source of magnetic force, but by another type of current to which he gave the name of displacement currents, and which can occur in insulators as well as conductors. The displacement current exists when the electric force is changing and the components of the intensity of this current, *i.e.*, the current per unit area parallel to the axes x, y, z are

$$\frac{K}{4\pi}\frac{dX}{dt},\quad \frac{K}{4\pi}\frac{dY}{dt},\quad \frac{K}{4\pi}\frac{dZ}{dt}$$

where X, Y, Z, are the components of the electric force and K the specific induction capacity of the medium.

Different Theories.—The difference between Maxwell's theory and the earlier ones is well illustrated by the consideration of the charging up of a condenser. Suppose the condenser consists of two parallel metal plates A and B and that it is charged by connecting A and B by wires with the terminals of a battery, if Q, −Q are the charges at a time t on the plates, then there is a convective current i along the wires equal to dQ/dt, this on the old view would be the only current that would have to be taken into account when calculating the magnetic forces; there would be no currents in the dielectric between the plates and the magnetic forces in that region would be derivable from a potential. On Maxwell's view there is a displacement current between the plates equal to $\frac{K}{4\pi}\frac{dX}{dt}$ per unit area, where X is the electric force between the plates and K the specific inductive capacity of the dielectric separating them. The density of the electricity on a plate is equal to Q/A where A is the area of a plate, hence by Coulomb's law

$$KX = 4\pi Q/A$$

so that

$$\frac{K}{4\pi}\frac{dX}{dt} = \frac{1}{A}\cdot\frac{dQ}{dt} = \frac{i}{A}$$

where i is the current through the wires, this is the expression for the displacement current per unit area, the total current across the area A is equal to Ai/A or i. Thus the displacement current through the dielectric is the same as the current through the wire, so that the Maxwellian currents form a closed circuit; this can easily be seen to be true generally, so that on Maxwell's theory all current circuits are closed. The displacement as well as the convective currents admit of simple representation in terms of the motion of tubes of electric force (J. J. Thomson, *Elements of Electricity and Magnetism*, chap. xiii.). The wave propagation of electric and magnetic force is an immediate consequence of Maxwell's generalization of the idea of an electric current. For let u, v, w be the components of the effective current, (X, Y, Z) (α, β, γ) the components of the electric and magnetic force respectively, K the specific inductive capacity of the medium, μ its magnetic permeability. The equations which express Ampères law that the work done in taking a magnet pole round a closed circuit is equal to 4 times the current passing through the circuit arc.

$$\left.\begin{aligned} 4\pi u &= \frac{d\gamma}{dy} - \frac{d\beta}{dz}, \\ 4\pi v &= \frac{d\alpha}{dz} - \frac{d\gamma}{dx}, \\ 4\pi w &= \frac{d\beta}{dx} - \frac{d\alpha}{dy} \end{aligned}\right\} \qquad A$$

while those which express Faraday's law that the electromotive force round a closed circuit is equal to the rate of diminution of the magnetic induction through the circuit are

$$\left.\begin{aligned}-\mu\frac{d\alpha}{dt}&=\frac{dZ}{dy}-\frac{dY}{dz}\\ -\mu\frac{d\beta}{dt}&=\frac{dX}{dz}-\frac{dZ}{dx}\\ -\mu\frac{d\gamma}{dt}&=\frac{dY}{dx}-\frac{dX}{dy}.\end{aligned}\right\}\quad B$$

Take now the case of a dielectric in which there are no convective currents, then $u=\frac{K}{4\pi}\frac{dX}{dt}$, hence differentiating (1) of A with respect to t we have

$$K\frac{d^2X}{dt^2}=\frac{d}{dy}\frac{d\gamma}{dt}-\frac{d}{dz}\frac{d\beta}{dt}$$

substituting the values of $\frac{dy}{db}$ and $\frac{d\beta}{dt}$ from β, we get, since in the dielectric

$$\frac{dX}{dx}+\frac{dY}{dy}+\frac{dZ}{dz}=0$$

$$\mu K\frac{d^2X}{dt^2}=\frac{d^2X}{dx^2}+\frac{d^2X}{dy^2}+\frac{d^2X}{dz^2}$$

with similar equations for Y, Z, α, β, γ. These equations are of the type of the wave equation

$$\frac{1}{V^2}\frac{d^2\phi}{dt^2}=\frac{d^2\phi}{dx^2}+\frac{d^2\phi}{dy^2}+\frac{d^2\phi}{dz^2}$$

and represent a disturbance propagated as a wave with the velocity V, in the electrical case is given by $V=1/\sqrt{\mu\kappa}$.

Thus we see that on Maxwell's theory the components of the electric and magnetic force in a dielectric satisfy the wave equation, so that electric and magnetic forces travel as waves through the dielectric, the velocity of propagation being $1/\sqrt{\mu\kappa}$. Now μ and κ can be measured by purely electrical methods, the value of $1/\sqrt{\mu\kappa}$ for air being the ratio of the electrostatic to the electromagnetic unit of electricity which has been found by experiment to be very nearly 3×10^{10} ampere, and thus equal to the velocity of light. Thus it follows from Maxwell's theory that electric and magnetic disturbances travel through dielectrics with the velocity of light.

Let us consider the distribution of electric force in a plane electromagnetic wave. If X, Y, Z are the components of the electric force, l, m, n the direction cosines of the normal to the wave front and λ the wave length we may put

$$X,\ Y,\ Z,\ =(X_0,\ Y_0,\ Z_0)\cos\frac{2\pi}{\lambda}(lx+my+nz-VE)$$

since $\qquad \frac{dX}{dx}+\frac{dY}{dy}+\frac{dZ}{dz}=0$

we have $\qquad lX_0+mY_0+nZ_0=0$

so that $\qquad lX+mY+nZ=0$

which expresses the fact that the electric force is perpendicular to the direction of propagation of the waves. From equations B we find.

$$\alpha=KV(nY-mZ)$$
$$\beta=KV(lZ-nX)$$
$$\gamma=KV(mX-lY)$$

Thus $l\alpha+m\beta+n\gamma=0$ and $X\alpha+Y\beta+Z\gamma=0$, thus the magnetic force is at right angles to the direction of propagators of the wave and also to the electric force. We see too that

$$\sqrt{(\alpha^2+\beta^2+\gamma^2)}=KV\sqrt{(X^2+Y^2+Z^2)}$$

so that the magnetic force bears a constant ratio to the electric. Hence in a plane electromagnetic wave the electric and magnetic forces are in the wave front, and at right angles and in constant proportion to each other.

If the medium through which the waves are travelling is a conductor of electricity there will be convective as well as displacement currents, hence if p, q, v are the convective currents

$$u=\frac{K}{4\pi}\frac{dX}{dt}+p;\quad v=\frac{K}{4\pi}\frac{dY}{dt}+q,\quad w=\frac{K}{4\pi}\frac{dZ}{dt}+\nu$$

if the convective currents obey Ohms law, $p=X/\sigma$, if σ is the specific electrical resistance of the material hence

$$u=\frac{K}{4\pi}\frac{dX}{dt}+\frac{X}{\sigma}$$

with corresponding expressions for v, and w, using these expressions in equation A, we find

$$\mu K\frac{d^2X}{dt^2}+\frac{4\pi\mu}{\sigma}\frac{dX}{dt}=\frac{d^2X}{dx^2}+\frac{d^2X}{dy^2}+\frac{d^2X}{dz^2}.$$

This equation represents waves spreading through an absorbing medium the amplitude of the disturbance diminishes exponentially with the distance from the source and the phase velocity of the waves diminishes with their frequency.

If the frequency of the vibrations is p, $\mu K\frac{d^2X}{dt^2}=-\mu Kp^2X$ and $\frac{4\pi\mu}{\sigma}\frac{dX}{dt}=-\frac{4\pi\mu\iota}{\sigma}pX$, hence if p is large compared with $4\pi/K\sigma$, the second term on the left hand side of above equation is small compared with the first and may be neglected and the equation approximates to the wave equation, if on the other hand p is small compared with $4\pi/K\sigma$ the first term is small compared with the second and the equation approximates to that which expresses the conduction of heat.

Passage of Electrical Waves Through an Ionized Gas.—A case of great importance in the theory of the propagation of electrical waves through the atmosphere is when the conductivity of the medium is due to the presence of gaseous ions and the pressure of the gas is so low that the motion of the ions is not interfered with by collisions with the molecules of the gas. In this case p, q, r the components of the convective current are given by the equations

$$p=\Sigma e\dot{\xi},\quad q=\Sigma e\dot{\eta},\quad r=\Sigma e\dot{\zeta}$$

where $\dot{\xi}$, $\dot{\eta}$, $\dot{\zeta}$ are the components of the velocity of an ion, e discharge and the summation is to be extended to all the ions in unit volume. Thus $\frac{dp}{dt}=\Sigma e\ddot{\xi}$

and since the motion of the ions is free

$$m\ddot{\xi}=Xe,$$

where m is the mass of an ion.

Thus if u is the total current

$$\frac{du}{dt}=\frac{K}{4\pi}\frac{d^2X}{dt^2}+\Sigma re\ddot{\xi}$$
$$=\frac{K}{4\pi}\cdot\frac{d^2X}{dt^2}+\frac{\Sigma e^2}{m}\cdot X$$

if there are n negative and n positive ions per unit volume

$$\Sigma\frac{e^2}{m}=Ne^2\left(\frac{1}{m_1}+\frac{r}{m_2}\right)X=p_0^2,$$

where m_1, m_2 are the masses of the negative and positive ions respectively, using this value of du/dt in equations (A) we get

$$\mu K\frac{d^2X}{dt^2}+4\pi\mu\cdot p_0^2X=\frac{d^2X}{dx^2}+\frac{d^2X}{dy^2}+\frac{d^2X}{dz^2}-\frac{d}{dx}\left(\frac{dX}{dx}+\frac{dY}{dy}+\frac{dZ}{dz}\right)$$

for the electric forces and

$$\mu K\frac{d^2K}{dt^2}+4\pi\mu p_0^2\alpha=\frac{d^2\alpha}{dx^2}+\frac{d^2\alpha}{dy^2}+\frac{d^2\alpha}{dz^2}$$

for the magnetic. This equation differs from that for a non-conducting dielectric by the presence of the term $4\pi\mu p_0^2\alpha$ on the left hand side, and this produces effects which differentiate sharply the behaviour of waves in a non-conducting and in an ionized medium.

These differences are (1) waves of any frequency can travel through the insulating medium while through the ionized one it is only waves whose frequency is greater than $p_0\sqrt{\frac{4\pi}{K}}$ which are able to do so; (2) the phase velocity of the waves in the insulating medium is independent of the wave length and equal to c the velocity of light; in the ionized medium, if V is the phase velocity and λ the wave length $V^2=c^2+\frac{p_0^2\lambda^2}{K}$ thus the phase velocity is always greater than the velocity of light and is infinite for infinitely long waves. (3) In the insulating medium the energy travels out with the velocity c, in the ionized medium it travels with the velocity $V-\lambda\frac{dV}{d\lambda}=c^2/V$, since V is always greater than c, the velocity of the energy in the ionized medium is less than in the insulating one.

The velocity of the waves in the ionized medium depends upon the value of p_0^2 a quantity which is proportional to the number of ions per cubic centimetre in the medium. Thus if the number of ions in the upper regions of the atmosphere varies with the height above the surface of the earth the waves in these regions will be passing through a medium in which the refractive index varies from place to place, this, as in the analogous optical case of the mirage, will lead to a bending of the waves so that instead of continually travelling away from the earth they may be bent round so as to return to it. There are good reasons for believing that in the upper regions of the atmosphere there is a layer of ionized gas, known as the Heaviside side, and that this plays a most important part in long distance wireless. (*See* WIRELESS, THEORY OF.)

Hertz's Experiments.—Though Maxwell's theory was published in 1864, it was not until 1887, seven years after the death of Maxwell that any direct experimental proof of its validity was obtained. On Maxwell's theory electrical waves ought to radiate from any system in which electrical oscillation is produced. Lord Kelvin, in 1853, proved from electromagnetic theory that the discharge of a condenser is oscillatory, a result which Feddersen (*Pogg. Ann.*, 103 p. 69) verified by a series of beautiful experiments. The oscillatory character of the discharge of a condenser had been inferred by Henry as long ago as 1842 from his experiments on the magnetization produced in needles by the discharge of a condenser. Thus, if Maxwell's theory is true, electric waves must pass through the dielectric surrounding a condenser in the act of discharging, but it was not until 1887 that the existence of such waves was proved by direct experiment. This great step was made by Hertz (*Wied. Ann.* 34, pp. 155, 551, 609; *Ausbreitung der elektrischen Kraft*, Leipzig, 1892), whose experiments on this subject form one of the greatest contributions ever made to experimental physics. The difficulty which had stood in the way of the observations of these waves was the absence of any method of detecting electrical and magnetic forces, reversed some millions of times per second, and only lasting for an exceedingly short time. This was removed by Hertz, who showed that such forces would produce small sparks between pieces of metal very nearly in contact, and that these sparks were sufficiently regular to be used to detect electric waves and to investigate their properties. Other and more delicate methods have subsequently been discovered, but the results obtained by Hertz with his detector were of such signal importance, that we shall begin our account of experiments on these waves by a description of some of Hertz's more fundamental experiments.

To produce the waves Hertz used two forms of vibrator. The first is represented in fig. 1. A and B are two zinc plates about 40 cm. square; to these brass rods, C, D, each about 30 cm. long, are soldered, terminating in brass balls E and F. To get good results it is necessary that these balls should be very brightly polished, and as they get roughened by the sparks which pass between them it is necessary to re-polish them at short intervals; they should be shaded from light and from sparks, or other source of ultra-violet light. In order to excite the waves, C and D are connected to the two poles of an induction coil; sparks cross the air-gap which becomes a conductor, and the charges on the plates oscillate backwards and forwards like the charges on the coatings of a Leyden jar when it is short-circuited. The object of polishing the balls and screening off light is to get a sudden and sharp discharge; if the balls are rough there will be sharp points from which the charge will gradually leak, and the discharge will not be abrupt enough to start electrical vibrations, as these have an exceedingly short period. From the open form of this vibrator we should expect the radiation to be very large and the rate of decay of the amplitude very rapid. Bjerknes (*Wied. Ann.* 44, p. 74) found that the amplitude fell to $1/e$ of the original value, after a time 4T where T was the period of the electrical vibrations. Thus after a few vibrations the amplitude becomes inappreciable. To detect the waves produced by this vibrator Hertz used a piece of copper wire bent into a circle, the ends being furnished with two balls, or a ball and a point connected by a screw, so that the distance between them admitted of very fine adjustment. The radius of the circle for use with the vibrator just described was 35 cm., and was so chosen that the free period of the detector might be the same as that of the vibrator, and the effects in it increased by resonance. It is evident, however, that with a primary system as greatly damped as the vibrator used by Hertz, we could not expect very marked resonance effects, and as a matter of fact the accurate timing of vibrator and detector in this case is not very important. With electrical vibrators which can maintain a large number of vibrations, resonance effects are very striking, as is beautifully shown by the following experiment due to Lodge (*Nature*, 41, p. 368), whose researches have greatly advanced our knowledge of electric waves. A and C (fig. 2) are two Leyden jars, whose inner and outer coatings are connected by wires, B and D, bent so as to include a considerable area. There is an air-break in the circuit connecting the inside and outside of one of the jars, A, and electrical oscillations are started in A by joining the inside and outside with the terminals of a coil or electrical machine. The circuit in the jar C is provided with a sliding piece, F, by means of which the self-induction of the discharging circuit, and, therefore, the time of an electrical oscillation of the jar, can be adjusted. The inside and outside of this jar are put almost, but not quite, into electrical contact by means of a piece of tin-foil, E, bent over the lip of the jar. The jars are placed face to face so that the circuits B and D are parallel to each other, and approximately at right angles to the line joining their centres. When the electrical machine is in action sparks pass across the air-break in the circuit in A, and by moving the slider F it is possible to find one position for it in which sparks pass from the inside to the outside of C across the tin-foil, while when the slider is moved a short distance on either side of this position the sparks cease.

Hertz found that when he held his detector in the neighbourhood of the vibrator minute sparks passed between the balls. These sparks were not stopped when a large plate of non-conducting substance, such as the wall of a room, was interposed between the vibrator and detector, but a large plate of very thin metal stopped them completely.

To illustrate the analogy between electric waves and waves of light Hertz found another form of apparatus more convenient. The vibrator consisted of two equal brass cylinders, 12 cm. long and 3 cm. in diameter, placed with their axes coincident, and in the focal line of a large zinc parabolic mirror about 2 metres high, with a focal length of 12·5 cm. The ends of the cylinders nearest each other, between which the sparks passed, were carefully polished. The detector, which was placed in the focal line of an equal parabolic mirror, consisted of two lengths of wire, each having a straight piece about 50 cm. long and a curved piece about 15 cm. long bent round at right angles so as to pass through the back of the mirror. The ends which came through the mirror were connected with a spark micrometer, the sparks being observed from behind the mirror. The mirrors are shown in fig. 3.

Reflection and Refraction.—To show the reflection of the waves Hertz placed the mirrors side by side, so that their openings looked in the same direction, and their axes converged at a

point about 3 metres from the mirrors. No sparks were then observed in the detector when the vibrator was in action. When, however, a large zinc plate about 2 metres square was placed at right angles to the line bisecting the angle between the axes of the mirrors sparks became visible, but disappeared again when the metal plate was twisted through an angle of about 15° to either side. This experiment showed that electric waves are reflected, and that, approximately at any rate, the angle of incidence is equal to the angle of reflection. To show refraction Hertz used a large prism made of hard pitch, about 1·5 metres high, with a slant side of 1·2 metres and an angle of 30°. When the waves from the vibrator passed through this the sparks in the detector were not excited when the axes of the two mirrors were parallel, but appeared when the axis of the mirror containing the detector made a certain angle with the axis of that containing the vibrator. When the system was adjusted for minimum deviation the sparks were most vigorous when the angle between the axes of the mirrors was 22°. This corresponds to an index of refraction of 1·69.

Analogy to a Plate of Tourmaline.—If a screen be made by winding wire round a large rectangular framework, so that the turns of the wire are parallel to one pair of sides of the frame, and if this screen be interposed between the parabolic mirrors when placed so as to face each other, there will be no sparks in the detector when the turns of the wire are parallel to the focal lines of the mirror; but if the frame is turned through a right angle so that the wires are perpendicular to the focal lines of the mirror the sparks will recommence. If the framework is substituted for the metal plate in the experiment on the reflection of electric waves, sparks will appear in the detector when the wires are parallel to the focal lines of the mirrors, and will disappear when the wires are at right angles to these lines. Thus the framework reflects but does not transmit the waves when the electric force in them is parallel to the wires, while it transmits but does not reflect waves in which the electric force is at right angles to the wires. The wire framework behaves towards the electric waves exactly as a plate of tourmaline does to waves of light. Du Bois and Rubens (*Wied, Ann.* 49, p. 593), by using a framework wound with very fine wire placed very close together, have succeeded in polarizing waves of radiant heat, whose wave length, although longer than that of ordinary light, is very small compared with that of electric waves.

Angle of Polarization.—When light polarized at right angles to the plane of incidence falls on a refracting substance at an angle $\tan^{-1}\mu$ where μ is the refractive index of the substance, all the light is refracted and none reflected; whereas when light is polarized in the plane of incidence, some of the light is always reflected whatever the angle of incidence. Trouton (*Nature*, 39, p. 391) showed that similar effects take place with electric waves. From a paraffin wall 3ft. thick, reflection always took place when the electric force in the incident wave was at right angles to the plane of incidence, whereas at a certain angle of incidence there was no reflection when the vibrator was turned, so that the electric force was in the plane of incidence. This shows that on the electromagnetic theory of light the electric force is at right angles to the plane of polarization.

Stationary Electrical Vibrations.—Hertz (*Wied. Ann.* 34, p. 609) made his experiments on these in a large room about 15 metres long. The vibrator, which was of the type first described, was placed at one end of the room, its plates being parallel to the wall, at the other end a piece of sheet zinc about 4 metres by 2 metres was placed vertically against the wall. The detector—the circular ring previously described—was held so that its plane was parallel to the metal plates of the vibrator, its centre on the line at right angles to the metal plate bisecting at right angles the spark gap of the vibrator, and with the spark gap of the detector parallel to that of the vibrator. The following effects were observed when the detector was moved about. When it was close up to the zinc plate there were no sparks, but they began to pass feebly as soon as it was moved forward a little way from the plate, and increased rapidly in brightness until it was about 1·8 metres from the plate, when they attained their maximum. When its distance was still further increased they diminished in brightness, and vanished again at a distance of about 4 metres from the plate. When the distance was still further increased they reappeared, attained another maximum, and so on. They thus exhibited a remarkable periodicity similar to that which occurs when stationary vibrations are produced by the interference of direct waves with those reflected from a surface placed at right angles to the direction of propagation. Similar periodic alterations in the spark were observed by Hertz when the waves, instead of passing freely through the air and being reflected by a metal plate at the end of the room, were led along wires, as in the arrangement shown in fig. 4. L and K are metal plates placed parallel to the plates of the vibrator, long parallel wires being attached to act as guides to the waves which were reflected from the isolated end. (Hertz used only one plate and one wire, but the double set of plates and wires introduced by Sarasin and De la Rive make the results more definite.) In this case the detector is best placed so that its plane is at right angles to the wires, while the air space is parallel to the plane containing the wires. The sparks instead of vanishing when the detector is at the far end of the wire are a maximum in this position, but wax and wane periodically as the detector is moved along the wires. The most obvious interpretation of these experiments was the one given by Hertz—that there was interference between the direct waves given out by the vibrator and those reflected either from the plate or from the ends of the wire, this interference giving rise to stationary waves. The places where the electric force was a maximum were the places where the sparks were brightest, and the places where the electric force was zero were the places where the sparks vanished. On this explanation the distance between two consecutive places where the sparks vanished would be half the wave length of the waves given out by the vibrator.

Some very interesting experiments made by Sarasin and De la Rive (*Comptes rendus*, 115, p. 489) showed that this explanation could not be the true one, since by using detectors of different sizes they found that the distance between two consecutive places where the sparks vanished depended mainly upon the size of the detector, and very little upon that of the vibrator. With small detectors they found the distance small, with large detectors, large; in fact it is directly proportional to the diameter of the detector. We can see that this result is a consequence of the large damping of the oscillations of the vibrator and the very small damping of those of the detector. Bjerknes showed that the time taken for the amplitude of the vibrations of the vibrator to sink to $1/e$ of their original value was only 4T, while for the detector it was 500T′, when T and T′ are respectively the times of vibration of the vibrator and the detector. The rapid decay of the oscillations of the vibrator will stifle the interference between the direct and the reflected wave, as the amplitude of the direct wave will, since it is emitted later, be much smaller than that of the reflected one, and not able to annul its effects completely; while the well-maintained vibrations of the detector will interfere and produce the effects observed by Sarasin and De la Rive. To see this let us consider the extreme case in which the oscillations of the vibrator are absolutely dead-beat. Here an impulse, starting from the vibrator on its way to the reflector, strikes against the detector and sets it in vibration; it then travels up to the plate and is reflected, the electric force in the impulse being reversed by reflection. After reflection the impulse again strikes the detector, which is still vibrating from the effects of the first impact; if the phase of this vibration is such that the reflected impulse tends to produce a current round the detector in the same direction as that which is circulating from the effects of the first impact, the sparks will be increased, but if the reflected impulse tends to produce a current in the opposite direction the sparks will be diminished. Since the electric force is reversed by reflection, the greatest increase in the sparks will take place when the impulse finds, on its return, the detector in the opposite phase to that in which it left it; that is, if the time which has elapsed between the departure and return of the impulse is equal to an odd multiple of half the time of vibration of the detector. If d is the distance of the detector from the reflector when the sparks

are brightest, and V the velocity of propagation of electromagnetic disturbance, then $2d/V=(2n+1)(T'/2)$; where n is an integer and T′ the time of vibration of the detector, the distance between two spark maxima will be VT′/2, and the places where the sparks are a minimum will be midway between the maxima. Sarasin and De la Rive found that when the same detector was used the distance between two spark maxima was the same with the waves through air reflected from a metal plate and with those guided by wires and reflected from the free ends of the wire, the inference being that the velocity of waves along wires is the same as that through the air. This result, which follows from Maxwell's theory, when the wires are not too fine, had been questioned by Hertz on account of some of his experiments on wires.

Detectors.—The use of a detector with a period of vibration of its own thus tends to make the experiments more complicated, and many other forms of detector have been employed by subsequent experimenters. For example, in place of the sparks in air the luminous discharge through a rarefied gas has been used by Dragoumis, Lecher (who used tubes without electrodes laid across the wires in an arrangement resembling that shown in fig. 7) and Arons. A tube containing neon at a low pressure is especially suitable for this purpose. Zehnder (*Wied. Ann.* 47, p. 777) used an exhausted tube to which an external electromotive force almost but not quite sufficient of itself to produce a discharge was applied; here the additional electromotive force due to the waves was sufficient to start the discharge. Detectors depending on the heat produced by the rapidly alternating currents have been used by Paalzow and Rubens, Rubens and Ritter, and I. Klemenčič. Rubens measured the heat produced by a bolometer arrangement, and Klemenčič used a thermo-electric method for the same purpose; in consequence of the great increase in the sensitiveness of galvanometers these methods are now very frequently resorted to. Boltzmann used an electroscope as a detector. The spark gap consisted of a ball and a point, the ball being connected with the electroscope and the point with a battery of 200 dry cells. When the spark passed the cells charged up the electroscope. Ritter utilized the contraction of a frog's leg as a detector, Lucas and Garrett the explosion produced by the sparks in an explosive mixture of hydrogen and oxygen; while Bjerknes and Franke used the mechanical attraction between oppositely charged conductors. If the two sides of the spark gap are connected with the two pairs of quadrants of a very delicate electrometer, the needle of which is connected with one pair of quadrants, there will be a deflection of the electrometer when the detector is struck by electric waves. A very efficient detector is that invented by E. Rutherford (*Trans. Roy. Soc.* A. 1897, 189, p. 1); it consists of a bundle of fine iron wires magnetized to saturation and placed inside a small magnetizing coil, through which the electric waves cause rapidly alternating currents to pass which demagnetize the soft iron. If the instrument is used to detect waves in air, long straight wires are attached to the ends of the demagnetizing coil to collect the energy from the field; to investigate waves in wires it is sufficient to make a loop or two in the wire and place the magnetized piece of iron inside it. The amount of demagnetization which can be observed by the change in the deflection of a magnetometer placed near the iron, measures the intensity of the electric waves, and very accurate determinations can be made with ease with this apparatus. It is also very delicate, though in this respect it does not equal the detector to be next described, the coherer; Rutherford got indications in 1895 when the vibrator was ¾ of a mile away from the detector, and where the waves had to traverse a thickly populated part of Cambridge. It can also be used to measure the coefficient of damping of the electric waves, for since the wire is initially magnetized to saturation, if the direction of the current when it first begins to flow in the magnetizing coil is such as to tend to increase the magnetization of the wire, it will produce no effect, and it will not be until the current is reversed that the wire will lose some of its magnetization. The effect then gives the measure of the intensity half a period after the commencement of the waves. If the wire is put in the coil the opposite way, *i.e.*, so that the magnetic force due to the current begins at once to demagnetize the wire, the demagnetization gives a measure of the initial intensity of the waves. Comparing this result with that obtained when the wires were reversed, we get the coefficient of damping. A very convenient detector of electric waves is the one discovered almost simultaneously by Fessenden (*Electrotech. Zeits.*, 1903, 24, p. 586) and Schlömilch (*ibid.* p. 959). This consists of an electrolytic cell in which one of the electrodes is an exceedingly fine point. The electromotive force in the circuit is small, and there is large polarization in the circuit with only a small current.

When the circuit is struck by electric waves there is an increase in the currents due to the depolarization of the circuit. If a galvanometer is in the circuit, the increased deflection of the instrument will indicate the presence of the waves.

Coherers.—The most sensitive detector of electric waves is the "coherer," although for metrical work it is not so suitable as that just described. It depends upon the fact discovered by Branly (*Comptes rendus*, 111, p. 785; 112, p. 90) that the resistance between loose metallic contacts, such as a pile of iron turnings, diminishes when they are struck by an electric wave. One of the forms made by Lodge (*The Work of Hertz and some of his Successors*, 1894) on this principle consists simply of a glass tube containing iron turnings, in contact with which are wires led into opposite ends of the tube. The arrangement is placed in series with a galvanometer (one of the simplest kind will do) and a battery; when the iron turnings are struck by electric waves their resistance is diminished and the deflection of the galvanometer is increased. Thus the deflection of the galvanometer can be used to indicate the arrival of electric waves. The tube must be tapped between each experiment, and the deflection of the galvanometer brought back to about its original value. This detector is marvellously delicate, but not metrical, the change produced in the resistance depending upon so many things besides the intensity of the waves that the magnitude of the galvanometer deflection is to some extent a matter of chance. Instead of the iron turnings we may use two iron wires, one resting on the other; the resistance of this contact will be altered by the incidence of the waves. To get greater regularity Bose uses, instead of the iron turnings, spiral springs, which are pushed against each other by means of a screw until the most sensitive state is attained. The sensitiveness of the coherer depends on the electromotive force put in the galvanometer circuit. Very sensitive ones can be made by using springs of very fine silver wire coated electrolytically with nickel. Though the impact of electric waves generally produces a diminution of resistance with these loose contacts, yet there are exceptions to the rule. Thus Branly showed that with lead peroxide, PbO_2, there is an increase in resistance. Aschkinass proved the same to be true with copper sulphide, CuS; and Bose showed that with potassium there is an increase of resistance and great power of self-recovery of the original resistance after the waves have ceased. Several theories of this action have been proposed. Branly (*Lumière électrique*, 40, p. 511) thought that the small sparks which certainly pass between adjacent portions of metal clear away layers of oxide or some other kind of non-conducting film, and in this way improve the contact. It would seem that if this theory is true the films must be of a much more refined kind than layers of oxide or dirt, for the coherer effect has been observed with clean non-oxidizable metals. Lodge explains the effect by supposing that the heat produced by the sparks fuses adjacent portions of metal into contact and hence diminishes the resistance; it is from this view of the action that the name coherer is applied to the detector. Auerbeck thought that the effect was a mechanical one due to the electrostatic attractions between the various small pieces of metal. It is probable that some or all of these causes are at work in some cases, but the effects of potassium make us hesitate to accept any of them as the complete explanation. Blanc (*Ann. chim. phys.*, 1905, [8] 6, p. 5), as the result of a long series of experiments, came to the conclusion that coherence is due to pressure. He regarded the outer layers as different from the mass of the metal and having a much greater specific resistance. He supposed that

when two pieces of metal are pressed together the molecules diffuse across the surface, modifying the surface layers and increasing their conductivity.

Generators of Electric Waves.—Bose (*Phil. Mag.* 43, p. 55) designed an instrument which generates electric waves with a length of not more than a centimetre or so, and therefore allows their properties to be demonstrated with apparatus of moderate dimensions. The waves are excited by sparking between two platinum beads carried by jointed electrodes, a platinum sphere is placed between the beads, and the distance between the beads and the sphere can be adjusted by bending the electrodes. The diameter of the sphere is 8 mm., and the wave length of the shortest electrical waves generated is said to be about 6 mm. The beads are connected with the terminals of a small induction coil, which, with the battery to work it and the sparking arrangement, are enclosed in a metal box, the radiation passing out through a metal tube opposite to the spark gap. The ordinary vibrating break of the coil is not used, a single spark made by making and breaking the circuit by means of a button outside the box being employed instead. The detector is one of the spiral spring coherers previously described; it is shielded from external disturbance by being enclosed in a metal box provided with a funnel-shaped opening to admit the radiation. The wires leading from the coherers to the galvanometer are also surrounded by metal tubes to protect them from stray radiation. The radiating apparatus and the receiver are mounted on stands sliding in an optical bench. If a parallel beam of radiation is required, a cylindrical lens of ebonite or sulphur is mounted in a tube fitting on to the radiator tube and stopped by a guide when the spark is at the principal focal line of the lens. For experiments requiring angular measurements a spectrometer circle is mounted on one of the sliding stands, the receiver being carried on a radial arm and pointing to the centre of the circle. The arrangement is represented in fig. 5.

With this apparatus the laws of reflection, refraction and polarization can readily be verified, and also the double refraction of crystals, and of bodies possessing a fibrous or laminated structure such as jute or books. (The double refraction of electric waves seems first to have been observed by Righi, and other researches on this subject have been made by Garbasso and Mack.) Bose showed the rotation of the plane of polarization by means of pieces of twisted jute rope; if the pieces were arranged so that their twists were all in one direction and placed in the path of the radiation, they rotated the plane of polarization in a direction depending upon the direction of twist· if they were mixed so that there were as many twisted in one direction as the other, there was no rotation.

A series of experiments showing the complete analogy between electric and light waves is described by Righi in his book *L'Ottica delle oscillazioni elettriche*. Righi's exciter, which is especially convenient when large statical electric machines are used instead of induction coils, is shown in fig. 6. E and F are balls connected with the terminals of the machine, and AB and CD are conductors insulated from each other, the ends B, C, between which the sparks pass, being immersed in vaseline oil. The period of the vibrations given out by the system is adjusted by means of metal plates M and N attached to AB and CD. When the waves are produced by induction coils or by electrical machines the intervals between the emission of different sets of waves occupy by far the largest part of the time. Simon (*Wied. Ann.*, 1898, 64, p. 293; *Phys. Zeit.*, 1901, 2, p. 253), Duddell (*Electrician*, 1900, 46, p. 269) and Poulsen (*Electrotech. Zeits.*, 1906, 27, p. 1070) reduced these intervals very considerably by using the electric arc to excite the waves, and in this way produced electrical waves possessing great energy. In these methods the terminals between which the arc is passing are connected through coils with self-induction L to the plates of a condenser of capacity C. The arc is not steady, but is continually varying. This is especially the case when it passes through hydrogen. These variations excite vibrations with a period $2\pi\sqrt{LC}$ in the circuit containing the capacity of the self-induction. By this method Duddell produced waves with a frequency of 40,000. Poulsen, who cooled the terminals of the arc, produced waves with a frequency of 1,000,000, while Stechodro (*Ann. der Phys.* 27, p. 225) claims to have produced waves with 300 times this frequency, *i.e.*, having a wave length of about a metre. When the self-induction and capacity are large so that the frequency comes within the limits of the frequency of audible notes, the system gives out a musical note, and the arrangement is often referred to as the singing arc.

Waves in Wires.—Many problems on electric waves along wires can readily be investigated by a method due to Lecher (*Wied. Ann.* 41, p. 850), and known as Lecher's bridge, which furnishes us with a means of dealing with waves of a definite and determinable wave-length. In this arrangement (fig. 7) two large plates A and B are, as in Hertz's exciter, connected with the terminals of an induction coil; opposite these and insulated from them are two smaller plates D, E, to which long parallel wires DFH, EGJ are attached. These wires are bridged across by a wire LM, and their farther ends H, J, may be insulated, or connected together, or with the plates of a condenser. To detect the waves in the circuit beyond the bridge, Lecher used an exhausted tube placed across the wires, and Rubens a bolometer, but Rutherford's detector is the most convenient and accurate. If this detector is placed in a fixed position at the end of the circuit, it is found that the deflections of this detector depend greatly upon the position of the bridge LM, rising rapidly to a maximum for some positions, and falling rapidly away when the bridge is displaced. As the bridge is moved from the coil end towards the detector the deflections show periodic variations, such as are represented in fig. 8 when the abscissae represent the deflections of the detector and the ordinates the distance of the bridge from the ends D, E. The maximum deflections of the detector correspond to the positions in which the two circuits DFLMGE, HLMJ (in which the vibrations are but slightly damped) are in resonance. For since the self-induction and resistance of the bridge LM is very small compared with that of the circuit beyond, it follows from the theory of circuits in parallel that only a small part of the current will in general flow round the longer circuit; it is only when the two circuits DFLMGE, HLMJ are in resonance that a considerable current will flow round the latter. Hence when we get a maximum effect in the detector we know that the waves we are dealing with are those corresponding to the free periods of the system HLMJ, so that if we know the free periods of this circuit we know the wave length of the electric waves under consideration. Thus if the ends of the wires H, J are free and have no capacity, the current along them must vanish at H and J, which must be in opposite electric condition. Hence half the wave length must be an odd submultiple of the length of the circuit HLMJ. If H and J are connected together the wave length must be a submultiple of the length of this circuit. When the capacity at the ends is appreciable the wave length of the circuit is determined by a somewhat complex expression. To facilitate the determination of the wave length in such cases, Lecher introduced a second bridge L'M', and moved this about until the deflection of the detector was a maximum; when this occurs the wave length is one of those corresponding to the closed circuit LMM'L', and must therefore be a submultiple of the length of the circuit. Lecher showed that if instead of using a single wire LM to form the bridge, he used two parallel wires PQ, LM, placed close together, the currents in the further circuit were hardly appreciably diminished when the main wires were cut between PL and QM. Blondlot used a modification of this apparatus better suited for the production of short waves. In his form (fig. 9) the exciter consists of two semicircular arms connected with the terminals of an induction coil, and the long wires, instead of being connected with the small plates, form a circuit round the exciter.

As an example of the use of Lecher's arrangement, we may quote Drude's application of the method to find the specific induction capacity of dielectrics under electric oscillations of varying frequency. In this application the ends of the wire are connected to the plates of a condenser, the space between whose plates can be filled with the liquid whose specific inductive capacity is required, and the bridge is moved until the detector

at the end of the circuit gives the maximum deflection. Then if λ is the wave length of the waves, λ is the wave length of one of the free vibrations of the system HLMJ; hence if C is the capacity of the condenser at the end in electrostatic measure we have

$$\frac{\cot(2\pi l/\lambda)}{(2\pi l/\lambda)} = \frac{C}{C'l}$$

where l is the distance of the condenser from the bridge and C' is the capacity of unit length of the wire. In the condenser part of the lines of force will pass through air and part through the dielectric; hence C will be of the form $C_0 + KC_1$ where K is the specific inductive capacity of the dielectric. Hence if l is the distance of maximum deflection when the dielectric is replaced by air, l' when filled with a dielectric whose specific inductive capacity is known to be K', and l'' the distance when filled with the dielectric whose specific inductive capacity is required, we easily see that—

$$\frac{\cot(2\pi l/\lambda) - \cot(2\pi l'/\lambda)}{\cot(2\pi l/\lambda) - \cot(2\pi l''/\lambda)} = \frac{1-K'}{1-K}$$

an equation by means of which K can be determined. It was in this way that Drude investigated the specific inductive capacity with varying frequency, and found a falling off in the specific inductive capacity with increase of frequency when the dielectrics contained the radicle OH. In another method used by him the wires were led through long tanks filled with the liquid whose specific inductive capacity was required; the velocity of propagation of the electric waves along the wires in the tank being the same as the velocity of propagation of an electromagnetic disturbance through the liquid filling the tank, if we find the wave length of the waves along the wires in the tank, due to a vibration of a given frequency, and compare this with the wave lengths corresponding to the same frequency when the wires are surrounded by air, we obtain the velocity of propagation of electromagnetic disturbance through the fluid, and hence the specific inductive capacity of the fluid.

Velocity of Propagation of Electromagnetic Effects through Air.—The experiments of Sarasin and De la Rive already described have shown that, as theory requires, the velocity of propagation of electric effects through air is the same as along wires. The same result had been arrived at by J. J. Thomson, although from the method he used greater differences between the velocities might have escaped detection than was possible by Sarasin and De la Rive's method. The velocity of waves along wires has been directly determined by Blondlot by two different methods. In the first the detector consisted of two parallel plates about 6 cm. in diameter placed a fraction of a millimetre apart, and forming a condenser whose capacity C was determined in electromagnetic measure by Maxwell's method. The plates were connected by a rectangular circuit whose self-induction L was calculated from the dimensions of the rectangle and the size of the wire. The time of vibration T is equal to $2\pi\sqrt{(LC)}$. (The wave length corresponding to this time is long compared with the length of the circuit, so that the use of this formula is legitimate.) This detector is placed between two parallel wires, and the waves produced by the exciter are reflected from a movable bridge. When this bridge is placed just beyond the detector vigorous sparks are observed, but as the bridge is pushed away a place is reached where the sparks disappear; this place is distance $2/\lambda$ from the detector, when λ is the wave length of the vibration given out by the detector. The sparks again disappear when the distance of the bridge from the detector is $3\lambda/4$. Thus by measuring the distance between two consecutive positions of the bridge at which the sparks disappear λ can be determined, and v, the velocity of propagation, is equal to λ/T. As the means of a number of experiments Blondlot found v to be $3{\cdot}02\times10^{10}$ cm./sec., which, within the errors of experiment, is equal to 3×10^{10} cm./sec., the velocity of light. A second method used by Blondlot, and one which does not involve the calculation of the period, is as follows:—A and A' (fig. 10) are two equal Leyden jars coated inside and outside with tin-foil. The outer coatings form two separate rings a, a_1; a', a'_1, and the inner coatings are connected with the poles of the induction coil by means of the metal pieces b, b'. The sharply pointed conductors p and p', the points of which are about ½ mm. apart, are connected with the rings of the tin-foil a and a', and two long copper wires pca, $p'c'a'_1$, 1029 cm. long, connect these points with the other rings a_1, a_1'. The rings aa', a_1a_1', are connected by wet strings so as to charge up the jars. When a spark passes between b and b', a spark at once passes between pp', and this is followed by another spark when the waves travelling by the paths $a_1\,cp$, $a'_1c'p'$ reach p and p'. The time between the passage of these sparks, which is the time taken by the waves to travel 1029 cm., was observed by means of a rotating mirror, and the velocity measured in 15 experiments varied between $2{\cdot}92\times10^{10}$ and $3{\cdot}03\times10^{10}$ cm./sec., thus agreeing well with that deduced by the preceding method. Other determinations of the velocity of electromagnetic propagation have been made by Lodge and Glazebrook, and by Saunders.

On Maxwell's electromagnetic theory the velocity of propagation of electromagnetic disturbances should equal the velocity of light, and also the ratio of the electromagnetic unit of electricity to the electrostatic unit. A large number of determinations of this ratio have been made:—

Observer.	Date.	Ratio $10^{10}\times$.
Klemenčič	1884	3·019 cm./sec.
Himstedt	1888	3·009 cm./sec.
Rowland	1889	2·9815 cm./sec.
Rosa	1889	2·9993 cm./sec.
J. J. Thomson and Searle	1890	2·9955 cm./sec.
Webster	1891	2·987 cm./sec.
Pellat	1891	3·009 cm./sec.
Abraham	1892	2·992 cm./sec.
Hurmuzescu	1895	3·002 cm./sec.
Rosa	1908	2·9963 cm./sec.

The mean of these determinations is $3{\cdot}001\times10^{10}$ cm./sec., while the mean of the last five determinations of the velocity of light in air is given by Himstedt as $3{\cdot}002\times10^{10}$ cm./sec. From these experiments we conclude that the velocity of propagation of an electromagnetic disturbance is equal to the velocity of light, and to the velocity required by Maxwell's theory.

In experimenting with electromagnetic waves it is in general more difficult to measure the period of the oscillations than their wave length. Rutherford used a methad by which the period of the vibration can easily be determined; it is based upon the theory of the distribution of alternating currents in two circuits ACB, ADB in parallel. If A and B are respectively the maximum currents in the circuits ACB, ADB, then

$$\frac{A}{B} = \sqrt{\frac{S^2+(N-M)^2p^2}{R^2+(L-M)^2p^2}}$$

when R and S are the resistances, L and N the coefficients of self-induction of the circuits ACB, ADB respectively, M the coefficient of mutual induction between the circuits, and p the frequency of the currents. Rutherford detectors were placed in the two circuits, and the circuits adjusted until they showed that A = B; when this is the case

$$p^2 = \frac{R^2-S^2}{N^2-L^2-2M(N-L)}.$$

If we make one of the circuits, ADB, consist of a short length of a high liquid resistance, so that S is large and N small, and the other circuit ACB of a low metallic resistance bent to have considerable self-induction, the preceding equation becomes approximately $p = S/L$, so that when S and L are known p is readily determined. (J. J. Th.)

ELECTRIFICATION OF INDUSTRY. There are three considerations involved in the application of the electric drive in industry, all of which need careful attention if the work is to be fully successful. These are (1) the motor; (2) the control gear; (3) the close co-ordination of these two components with the apparatus to be driven. Progress has been made during recent years particularly as a result of the great developments in auto-

matic and heavy duty control gear, and in the co-ordination of all the components into a harmonious unit. The author, therefore, proposes to begin by considering briefly the chief types of motor employed for industrial drive, and the most recent forms of control gear by which their utility has been extended. The electrification of specific industries and equipment will then be considered.

ELECTRICAL EQUIPMENT

Electric Motors.—The principal industrial motors are as follows: (*a*) Direct current—series, shunt, compound. (*b*) Alternating current—squirrel-cage induction, squirrel-cage induction "across-the-line" type, slip-ring induction, synchronous. For a description of the principles and capabilities of these, the reader is referred to the article on ELECTRIC MOTORS.

ELECTRIC CONTROL GEAR

The principal control operations required by an industrial motor are starting, stopping, speed adjustment; and protection of the machine under all circumstances. The control gear may be hand-operated or automatic, there being varying of automatic devices, according to the amount of responsibility that may still be reposed in the operator. For example, the apparatus may be controlled by automatic switches, or "contactors," every one of which may, however, act only at the will of an attendant, who is provided with small "pilot" switches or a "master controller" for governing the movements of the units that actually make and break the main circuit. Again, the rate of acceleration only may be decided automatically, in accordance with the loading conditions; and thus the motor safeguarded while at the same time all unnecessary delay is avoided. Finally, the whole of an elaborate series of operations may be effected solely at the instance of a set of relays without any human guidance whatever.

The two principal control methods that combine to bring about the complete government of an electric motor are, first, the making and breaking of circuits, and secondly the variation of the voltage applied to a winding, such as that of an armature, rotor or stator. The latter function may be achieved by varying the amount of resistance in series or parallel with the winding, and this again usually requires the making and breaking of auxiliary circuits by exactly the same means as were needed for the former function. This function may also be performed through the use of an auto-transformer for starting induction motors on voltages lower than line voltage. Voltage variation may however be performed directly and with greater efficiency, for example by regulating the field of a generator, and thus the use of resistors may be largely avoided in heavy equipments.

The chief types of control apparatus may thus be tabulated as follows: (*a*) Manual apparatus—(1) switch type, (2) face-plate type, (3) drum type, (4) liquid type. (*b*) Automatic apparatus—(1) contactor type, (2) variable voltage type.

Manual Apparatus.—The simplest piece of manually operated control gear is of course the switch, in which one or more pairs of contacts can be brought together by hand. Of the various patterns, the knife switch is the most common, enabling an efficient contact to be made by means of a simple and compact device. In its usual form, however, it does not lend itself to frequent use (such as once every 10 sec.), and it is generally employed as a main isolating device for putting the whole equipment into commission at the beginning of the working period.

A single switch may be employed for starting any induction motor, or a D.C. shunt motor up to ½ or 1 h.p., a compound motor up to about 2 h.p., and a series motor up to 8 horse-power. Above these sizes, the rush of current due to the low armature resistance and the absence of counter E.M.F. when at rest necessitates the use of a preliminary stage of resistance. "Push" switches are very useful for starting the smallest motors and for controlling small currents generally. Large oil-immersed switches may be used for making and breaking the stator circuits of high-voltage (*e.g.*, 3,000 volt) induction motors or of lower voltage motors of large rating where the currents are of considerable magnitude.

The face-plate starter or controller is really a radial distributing switch for cutting out successive steps of resistance. It is a cheap and compact device, and enables a comparatively heavy contact pressure to be maintained without demanding a corresponding force to move it. Nearly all manual starters for D.C. motors up to 100 h.p., and most A.C. resistance starters for small motors are of this type; but it is adapted to the simplest changes in the circuit, and hence starters for squirrel-cage motors

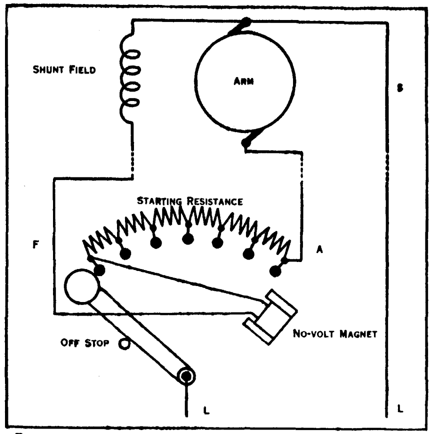

FIG. 1.—DIAGRAM SHOWING CONNECTION FOR FACE-PLATE STARTER

which aim at reducing the voltage to the stator by other than resistance means almost invariably employ another pattern. It is also not adopted for robust service, *i.e.*, for the frequent breaking of large currents, and it is usually designed to *make* the currents only, all breaking being done by a knife switch before the starter arm is automatically released by a "no-volt" or "under-voltage" retaining magnet.

The method of connection of a typical face-plate starter is indicated in fig. 1, in which it is shown connected to a D.C. shunt motor. A compound motor would have a series field located at *S*, while a series motor would only have the latter, the lead that includes the shunt winding in the figure being omitted and the no-volt coil connected across the line in series with an appropriate resistance.

When used for almost any of the various industrial purposes, the face-plate should be protected by enclosing it with a metal cover.

For frequent service, heavier duty, and more elaborate changes of circuit, a drum starter or controller is used, in which the moving contacts are sector-shaped and are clamped on to a square spindle covered with insulation; and the fixed contacts are "fingers" with heavy copper renewable tips forced against the sectors by spring pressure. A powerful magnetic blow-out is always fitted for all but the smallest sizes; and a locating "star-wheel" device, which enables the operator to halt the contacts exactly in engagement.

A typical D.C. drum controller diagram corresponding in most respects to the face-plate scheme in the last figure is shown in fig. 3; but the drum sectors are duplicated to give both forward and reverse running from the same handle, the line connections being made and reversed by the section enclosed in the lower chain-dotted outline. As before the motor parts are shown in place on a reduced scale, and either field winding may be omitted. The sectors are represented by horizontal strips and the fingers by large dots. As is necessary with reversing installations, the shunt field is shunted by a non-inductive resistance. Other and somewhat more elaborate drum diagrams are shown in figs. 4 and 7.

Drum starters (also called compensators or auto-starters) are also used for squirrel-cage motors when (as is usually the case for motors over 5 h.p.) local regulations require starting at reduced voltage, obtained by the use of a step-down transformer, or by connecting the stator windings first in star and then in mesh.

Liquid rheostats are suitable for use with any type of motor, but especially with those over about 100 h.p. and which start under load for which the previously described manual equipment is not

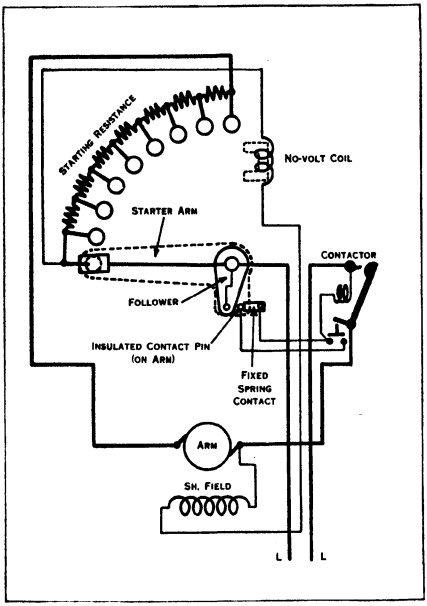

FIG. 2.—DIAGRAM SHOWING INCHING STARTER AND PARTS

well adapted. They are especially adapted to the absorption of large amounts of power.

In all but the largest, the "dippers," or moving contacts, are moved in and out of the liquid; but in the largest models (viz., up to and exceeding 2,000 h.p.), the plates are fixed and the liquid is caused to rise by means of an electrically driven pump. When the apparatus is used for controller duty, cooling pipes are immersed in the liquid. The weir-type controller, in which the height of the liquid is regulated by the moving of a weir mechanically connected to the driver's lever, is a variant of the rising liquid starter. The principal advantages of the liquid type are the indestructibility of the resistor, smoothness of acceleration, cheapness and suitability for the largest sizes. Chemical action is absent with alternating currents.

Automatic Apparatus.—The contactor, or magnet switch, is a marked advance in control equipment used in industrial electrification during recent years, especially for horse-powers up to 500. It is a magnetically operated switch, and its most usual forms cover voltages up to 600 and currents up to 1,000 amperes, although ratings up to 11,000 volts and 5,000 amperes are in existence. For D.C. circuits, single-pole models are the rule, but for A.C., as many as four, or even more, moving contacts are mounted upon the one rocker shaft. The contacts are usually of a flat horn shape, engaging with a rolling motion and making a line contact, and breaking circuit between the poles of a powerful magnetic blow-out.

Contactors may be normally-open or normally-closed, the contacts in the latter case being pulled open by the energizing of the coil. D.C. models are sometimes designed to hold themselves open until the current in the main circuit falls to a given value, when they close: this characteristic being required for automatic acceleration by the cutting out of resistance. Series and shunt lock-out contactors belong to the latter category.

Fully automatic characteristics are given to contactor installations by means of relays, the chief varieties of which are included in the following list: Current-limit, time limit, float, pressure, overload, low-voltage, inching, torque, step-back, change-over, field-accelerating, field-braking and field-protection relays. Of these, the first two are the most important, since they provide for automatic acceleration without requiring lock-out contactors, the use of which has its limitations. Current-limit relays permit their contacts to close when the peak current, due to the switching-in of the motor or the cutting out of a previous step of resistance, falls to a predetermined value, whereupon the next accelerating contactor is caused to close. Time-limit relays bring about closing of the accelerating units at definite time intervals. The former method is appropriate for heavy and fluctuating duty, such as rolling-mill auxiliaries and general industrial control; and the latter for such loads as air-compressors, pumping, ventilating, etc. Float and pressure relays are employed for starting and stopping the operations for the latter type of load.

Examples of the various types and arrangements of contactors and relays will be given in succeeding sections. It will be sufficient here to indicate that most contactor diagrams consist of a line group and an accelerating group, which are connected in series in the case of D.C. motors, but form the stator and rotor circuits in the A.C. cases.

Auxiliary switches, such as push-switches, master-switches and master-controllers, are employed in the handling and general control of contactor installations; and interlocks, both mechanical and electrical, are added to prevent the consequences of improper

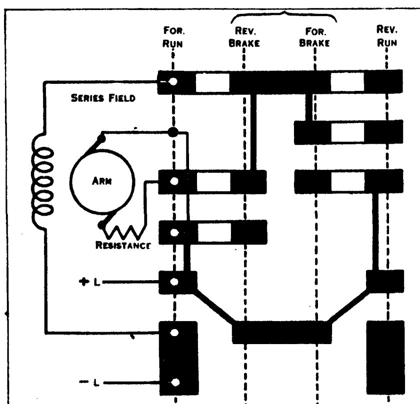

FIG. 3.—REVERSING DRUM CONTROLLER

operation, *e.g.*, two contactors of opposite polarity making contact with the one lead.

Variable voltage control is nearly always effected by use of a motor-generator, set apart for the supply of the D.C. motor to be controlled, and caused to develop the voltage required at any stage by virtue of the field regulation of the generator. The arrangement is shown in its fundamental form in fig. 5 and is usually termed the "Ward-Leonard system."

An A.C. supply is presupposed, driving the induction motor of

the motor-generator, which also often includes an exciter for the two D.C. fields, though in large sets this may be a separate unit. The main driving motor is shown on the right, and this is started, stopped, reversed and regulated at any speed by the corresponding variation of the generator voltage by means of the reversing potentiometer-type field rheostat. The scheme will be seen to dispense with resistors in the main circuit, all switching and adjustment being carried out upon the exciting current. Since the field flux of even a moderate-sized dynamo changes gradually, the control is remarkably smooth and sensitive. Ward-Leonard control is especially appropriate for securing very wide speed regulation, and for use where preliminary creeping speeds are required.

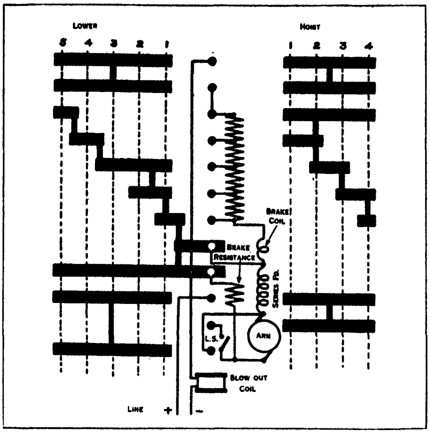

FIG. 4.—DIAGRAM OF DRUM CONTROLLER FOR CRANE

If the induction motor is equipped with a fly-wheel and given a variable speed characteristic, by connecting a fixed resistance in its rotor circuit, or preferably by employing a variable slip-regulator which introduces resistance in proportion to the overland peaks, the motor-generator is now able to store energy during light-load periods and to give it back during overloads. This is called the "Ilgner system," and possesses the great advantage of much reducing the maximum demand on the line. It also renders a much smaller induction motor suitable. Large rolling-mill drives are usually of this type.

Other methods of producing partial voltages without the use of resistance, which are suitable for small powers, are the series-parallel system employing two motors, and the multi-wire system, in which more than one voltage is given by the factory distribution. These methods however have only a limited application for industrial work.

THE ELECTRIFICATION OF FACTORIES

Advantages of Electrification.—In no situation have the benefits accruing from industrial electrification been more important than in the factories, where the amelioration of the working conditions has been able to affect the lives of so great a portion of the population. Yet through lack of a sufficiently disseminated understanding as to the advantages thus held out, the improvement is far from being as complete as is possible, either as regards economy of working or convenience. There is much to gain, therefore, from a consideration of the available benefits, and the means whereby these may be fully secured.

If the old method of single-unit drive for an entire factory by means of a steam or internal-combustion engine and lineshafting are contrasted with employing electrical drive, two changes in principle are found to take place. First, it is not now compulsory to lay down an engine-room at all, and the capital so locked up may be devoted to an extension of the factory proper. Secondly, the transmission of power about the works is effected electrically, and thus invisibly, safely and economically, instead of by a mass of shafts and belting which is so conspicuous a feature in the older order of things. At once, without going into details, several important advantages are evident.

First, the saving in running cost is great. The average expense of supplying a works with motive power by means of a steam engine and the usual belts and shafting, assumed to be in good condition, may be taken as 2% of the value of the output. This figure may be greatly reduced if the machines be driven in groups by motors of, say, 10 to 20 h.p.; while if all the belts and shafts are dispensed with, and a motor installed for every machine, the cost is still further reduced.

Secondly, the full consequences of a breakdown in the motive power or in an important link in the transmission are greatly reduced. Thirdly, the power supply is now much more direct, and is therefore subject to less fluctuation. Fourthly, the interior of the factory is transformed and improved in every detail by the absence of the mechanical transmission; while all the additional advantages of electrical working are provided. The individual gains comprehended in the last category are worth enumerating in some detail:—

(1) The factory is made more fit to work in; it has gained greatly in cleanliness, wholesomeness, safety, illumination and consequently in the standard of work that can be turned out in it. (2) Belt troubles are done away with. (3) The factory structure may be more lightly and cheaply constructed, as it does not have to withstand the stresses of belt drive. (4) Factory transport is very much facilitated by the possibility of installing overhead cranes wherever required. (5) The whole of a shop need not be run during overtime; while with individual drive only those machines actually required are actuated. (6) Fly-wheel operation at variable speed may be employed, without special arrangements, for fluctuating loads. (7) A greater amount of power is available at individual machines, giving a greater overload capacity. (8) With individual drive the closest and the most constant speed regulation is possible for every machine, while variable speed may be obtained in any number of steps by field adjustment, with greater ease and exactness than is possible by mechanical means. (9) The difficulties of installing line shafting in concrete buildings are avoided.

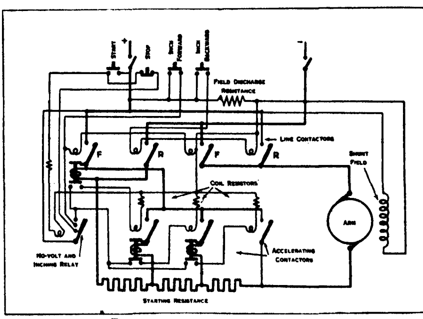

FIG. 5.—AUTOMATIC CONTROL GEAR

Motors may be installed on machines at the factory of the machine builder, thus insuring the correct motor for the application. The initial investment in power-driving equipment is higher in the case of a factory using individual drive than in one using the older method of line-shaft drive. The advantages of the former, however, so unquestionably overbalance the latter that there is today practically no justification for the older method.

In designing the electrified factory, the best results will be achieved by bearing these possibilities in mind, and taking pains

to secure them to the full, and at the same time avoiding the introduction of any fresh drawbacks not possessed by the old scheme. The latter category might include, if the installation were carelessly effected, electrical dangers to the building or workpeople, and risk of breakdown through damp, dirt, mechanical weakness or inexpert handling. Details of design are considered below.

Size of Groups.—As the advantages that have been enumerated are the more fully experienced the more nearly the ideal of individual drive is reached, it is obvious that the size of the groups should be made as small as practicable. All authorities are agreed that the larger equipment, such as punching and shearing machines, large planers, borers, lathes, etc., should be individually driven; but many still consider that the high cost of numerous small motors as compared with a single large one is not justified. On the other hand, many others, who are more willing to break away from the old traditions, maintain that individual drive is preferable in every case, even with the smallest machines; and the author inclines to the latter view. However, the present section will deal with those cases of group and individual drive in which special control gear is not required, and the more advanced cases of automatic individual control will be considered under MACHINE TOOLS.

Motors.—From what has already been said it is evident that line shafting, requiring as it does a constant speed, should be operated either by shunt or squirrel-cage induction motors, depending on whether D.C. or A.C. is available. If there is a choice of system, the A.C. is preferable, on account of its smaller cost and greater robustness. Care should be taken to locate the motors in positions where they are out of harm's way and do not use up valuable space, such as on the driven machines themselves, or upon the ceiling, walls or columns of the building. Many machine-tool makers provide a seating for a motor as a matter of course, *e.g.*, above the headstock in the case of a lathe; and it is to be hoped that it will not be long before the practice becomes general.

Control Gear.—The control gear simply consists of a starter, sometimes alone (as with A.C.) and sometimes accompanied by a knife switch and fuses. For individual drive, such as in textile factories, all that is often needed is a simple on-and-off switch, such as a push switch, or one of a small drum ("loom") type, mounted at a place convenient to the operator's hand. The larger and more complicated apparatus may be mounted on the wall or column, or may be of the "pillar" or "pedestal" type. All should be ironclad and as fool-proof as possible, and should be easily accessible to the operator. For starting comparatively large motors driving line shafting, an "inching" starter mounted in a control pillar has the great advantage of reliability under inexpert handling. As illustrated in the diagram forming fig. 2, the contact arm may with impunity be "backed" in a way that would ruin the studs of an ordinary starter; for here the loose "follower" arm will lag behind and cause the circuit to be broken effectively at the contactor. Such pillars are usually provided also with overload relays, which at once open the contactor if the arm is moved over too rapidly, or if similar misuse occurs.

MACHINE TOOLS

Electrical Design.—The great importance of designing an electrically-driven apparatus as a harmonious unit, and not as an aggregate of a machine, a motor and a more or less unsuitable starter connected by wiring but otherwise not co-ordinated in any way, applies with special force to machine tools.

The policy should be rigorously observed of making both motor and control gear as much part of the machine tool as any of its mechanical components. Moreover, the handle controlling the movements of the motor should be located among the other handles and in a position as convenient to the operator as possible, and the whole scheme should be so designed that this handle needs no greater care in its operation than any of the purely mechanical levers. The operation of machine tools will be considered under the following headings:—

(1) *Small-power Tools.*—Many tools, such as portable drillers, grinders, etc., as well as small bench drillers and similar machines, are driven by small motors that require only a simple switch for setting them in motion. Portable tools in particular are usually equipped with a series-wound "universal" motor suitable for D.C. or A.C. of any periodicity, and having a capacity seldom exceeding 1 horse-power. Tools having induction motors not exceeding 2 h.p. also come under this category, as do larger induction motors when the supply authority does not insist on star-delta or auto transformer starting. A robust push switch or simple drum switch is quite appropriate here. A no-volt release is a desirable addition, but is seldom fitted for the smaller examples.

(2) *Auxiliary Drives.*—A slightly more elaborate installation is required for performing the auxiliary functions of a large machine tool, such as raising and lowering the tool-head, radial arm or cross-bar of large boring mills, planers and radial drillers. Series D.C. or squirrel-cage A.C. motors are usually employed for these purposes, of about 5 to 10 horse-power.

The D.C. motor is somewhat the more convenient on account of its self-braking capabilities; a compact drum controller may be employed which completely governs such a motor without requiring a magnetic blow-out, or more than the single small resistor. There are four positions of the drum in all, but these in reality constitute three for each direction of rotation. When the cylinder is moved to the position at one end or to that at the opposite extremity of its movement, the armature is connected across the line in series with the resistance for forward or reverse running. When it is moved one step back, the line is disconnected and the motor "drifts"; but upon a further movement being made, the armature and resistance are connected to the field in the correct direction to drive a powerful current through the circuit, bringing about a quick stop by "dynamic" braking.

(3) *Small Lathes, etc.*—Many machines of moderate horse-power such as small lathes, shapers, drillers, etc., that require infrequent starting and no reversing or braking, and usually no speed control, are driven by shunt or squirrel-cage motors and simple ironclad starters. The latter are usually hand-operated, but automatic starting is preferable, especially in the D.C. case. A simple scheme would consist of start and stop push buttons, or other form of pilot switch, operating a 25 ampere line contactor followed by one or two accelerating contactors of similar capacity.

The most convenient method of operating a manual drum-starter, or a master switch for contactor gear, when employed for lathe control, is to mount it horizontally at the end of a spline shaft which is rotated by a lever situated upon the tool saddle.

(4) *Radial Drillers and Screwing Machines.*—Machines of moderate horse-power (*e.g.*, 5 to 10 h.p.) that need repeated starting and reversing and must be lever-controlled, but do not call for special braking or speed regulation, mostly require automatic control gear and are represented by a radial driller having a built-in compound motor. The controller may be built into a pocket in the radial arm, or may be mounted out of the way at the back of the arm, and operated from the handle at the tool-head by means of bevel gearing. Great simplicity may be given to the control scheme by the use of a reversing drum switch for making, breaking and reversing the line connections, the first current-limit relay being mechanically interlocked with the shaft of the drum in such a way that its armature is released as soon as the drum contacts have met; and the acceleration then proceeds as usual. Upon the drum switch being completely reversed, the motor is brought to rest by "plugging" and immediately accelerated in the opposite direction.

(5) *Boring Mills.*—Machines of fairly large horse-power, such as boring mills, that require to be started infrequently in one direction only, but must be capable of being inched both forward and back for setting up, require automatic push-button operation. Shunt-wound D.C. or slip-ring induction motors of about 25 h.p. are used for this purpose, a suitable control scheme, designed for a D.C. motor, being shown in fig. 2. This gear is housed in a control pillar located near the motor and is interesting in that

it illustrates the application of inching buttons and no-volt protection to a scheme. The push buttons are all of the "spring-off" type, making only momentary contact.

Direct current equipments sometimes have speed control by field regulation, and dynamic braking to render inching more effective.

(6) *Wheel Lathes.*—Large lathes for wheel and tyre turning must have provision for slowing down at "hard spots," or for turning cranks. A push button is usually located on the head-stock for effecting the slow-down, and this is accomplished by the cutting out of field resistance with a variable speed motor or else by the cutting in of the armature or rotor-starting resistance. D.C. compound or slip-ring induction motors of about 15 to 40 h.p. are employed, the compounding in the former case being required for steadying the running when operating with a weak field.

(7) *Large Planers, Slotters and Shapers.*—Reciprocating machine tools of fairly large power, such as planers, slotters, shapers, etc., that require reversal of the motor at the beginning and end of each stroke, demand a special form of motor and the most advanced form of contactor gear. There are three grades of planer, which may be taken as typical, viz., plate-edge planers, ordinary planers with a speed range not exceeding 3:1, and those with a range of about 10:1. The first cuts in both directions at an even speed, and problems as to reversal and braking are less severe than with the other forms. The latter have a shorter stroke, must reverse very quickly and accurately and therefore need dynamic braking, and nearly always need an accelerating arrangement for saving time when the tool is "cutting air" and for permitting the tool to enter the metal slowly when planing sheets. In general, a special "planer" motor is used, having a low diameter armature to decrease the stored energy and thus secure quick reversal. Owing to ease of dynamic braking and speed control, D.C. compound motors are at an advantage.

Both A.C. and D.C. motors are used for plate edge planers. The control gear is usually operated by a stationary switch opened and closed by an endless cord. For ordinary planers with a 3:1 speed range, a D.C. compound motor of about 20 h.p. is used, controlled by contactor gear having a single accelerating contactor, push buttons for starting and stopping and inching both ways, double-throw dynamic-braking reversing contactors, two-field rheostats for cutting and return strokes respectively, and an auxiliary switch turned "on" and "off" by the platen for bringing about quick speed during a portion of the cutting stroke by temporarily changing over to the return-stroke rheostat.

For all A.C. equipments, and for D.C. circuits when a greater speed range than about 3:1 is required, the Ward-Leonard type of control is used. Instead of the potentiometer regulator being employed, two ordinary rheostats are provided, for cutting and return strokes respectively, and a switch actuated by the platen changes over from one to the other.

In a 10:1 range planer, it is usual to obtain a 2:1 adjustment of the return speed by field regulation of the reversing motor, and a 5:1 adjustment of the cutting speed by means of the generator field rheostat.

ELECTRIFICATION OF STEELWORKS

The application of the electric drive to steelworks forms a good example of the more recent advances into the field of heavy industries, where conditions were for many years most unfavourable to the use of the electric motor. The high acceleration required, the violent fluctuation of the load, and the huge power demand, all taxed the mechanical and electrical robustness of the motor to the limit, in a situation where continuity of service was all-important; while the prevalent high temperatures and the all-pervading grit strongly militated against the durability of insulation and wearing parts. In spite of all these difficulties, electricity has won the day, and steam drive has been forced into obsolescence, by virtue of the developments in control methods that have been described in the first section, aided by the production of the "mill" type of motor.

The chief pieces of steelworks equipment that call for comment are the following: (*a*) Furnace hoists; (*b*) main rolling-mill drives—large main rolls, requiring up to about 20,000 h.p.; smaller mills, requiring up to about 500 h.p.; (*c*) mill auxiliaries—live rolls, lifting and tilting tables, screw-downs, manipulators, side-guards; (*d*) transport equipment—various highly developed

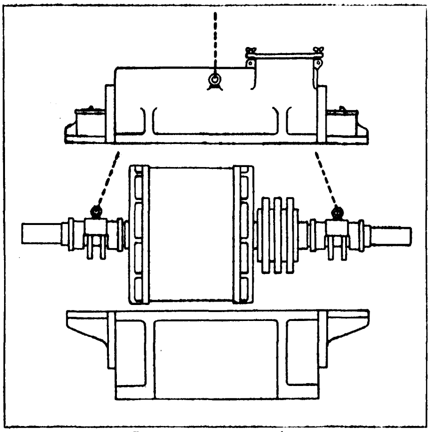

FIG. 6.—MILL TYPE MOTOR

cranes; (*e*) other equipment; *e.g.*, hot saws, air compressors, etc.

Motors.—The special motors may be divided into two classes. First, there are the very large units, up to about 20,000 h.p. instantaneous rating, operated by Ilgner sets. These are mostly double-armature machines, being really designed as twinned units with the object of keeping the diameter and therefore the inertia low, to facilitate quick reversal. As regards shaft diameter and mechanical design generally, they are made robust; but the treatment accorded to them is not so severe as in the case of the smaller auxiliaries. Secondly, there are the motors used for the latter purpose, which are designed to withstand the roughest mechanical and electrical conditions experienced in any situation. The "mill type," illustrated in fig. 6, was developed for this purpose, and is made for both D.C. and A.C. It is totally enclosed, and the frame is split in halves horizontally to facilitate rapid opening up. The shaft is made to project from each bearing, so that the rotor or the whole machine may be reversed endwise if the driving end should be twisted off. Full use has been made of eye-bolts on bearing bushes and frame to render the most rapid refitting possible.

Control Gear.—Ward-Leonard (including Ilgner) and contactor control divide the field between them, and are designed for operation by unskilled attendants whose faculties are concentrated on the actual work that is in progress. The various types of installation are most conveniently dealt with in connection with the equipment to be driven.

Furnace Hoists.—Simple push-buttons or pull-lever operation and accurate decking are the essentials for furnace hoist control, the conditions for which are not so strenuous as they are in the actual mill. The power required is in the vicinity of 100 h.p., and is provided by compound motors with "straight" contactor control gear for D.C. circuits, and by Ward-Leonard gear when the supply is A.C. A typical A.C. equipment is illustrated in fig. 7. It will suffice to explain that the regulator is operated by one of two cams, for up and down motions respectively, and the travel is started by changing the drum over from one cam to the other by means of a lever.

Rolling Mills.—Large reversing main rolls are driven by

Ilgner gear, the scheme being broadly as in fig. 7, with the addition of a slip regulator and fly-wheel to the induction motor. Particulars of a typical large set are as follows: Mill (reversing) motor—6,000 to 18,000 h.p. at 1,600 volts, twin-armature type. Generators—three in series, 4,500 kw. total continuous rating. Induction motor—3,000 h.p., 2,750 volts, three-phase.

The comparatively small size of the induction motor will afford an indication as to the equalizing of the load due to the fly-wheel

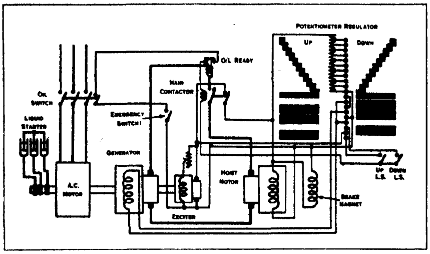

FIG. 7.—DIAGRAM OF MOTOR-GENERATOR CONTROL SCHEME FOR FURNACE HOIST

and slip regulator. Something like a quarter of the whole input is stored and returned by this wheel in the form of regenerative braking.

Small main rolls and many large non-reversing (including three-high) mills are driven direct by induction motors, with or without gearing. For non-reversing (continuous) mills, a fly-wheel is usually mounted on the mill shaft or that of the motor. The control gear is of the contactor type, with slip-regulator if a fly-wheel is employed.

Auxiliaries.—It is for the drive of the auxiliaries, requiring from 50 to 100 h.p., that the mill type of motor was developed. The policy as to control gear is to keep it as simple as possible, and series or induction motors are in most general use, with plain reversing contactor equipment, braking being typically by plugging. For screw-downs and similar equipment, a solenoid brake may be added.

The operation of a lifting table is an exacting procedure, and requires a special control system.

Cranes and Machine Tools.—Except for the general need for robustness and for protection against grit, etc., the drive of steel-works cranes and machine tools does not differ in principle from standard machine-shop practice.

ELECTRIC CRANES AND GANTRIES

Cranes are lifting machines that move an object in three directions at right angles to one another; and in the electric crane each of these movements is carried out by a separate motor and operated by a separate controller, in such a way that all three may be in action at the same time. The problems involved in its design include not only the carrying out of the positive motion, but also the effective stopping of the movement and the lowering of the load at a desired safe speed. Braking thus becomes an important item.

The most common types are jib cranes and girder cranes. For small versions of the latter, the motors are controlled from the floor by means of pendant cords; but for ordinary sizes, the operator travels with the girder in a cab usually suspended from one end. For large varieties, the cab is supported by the carriage itself, which is then termed a "man-trolley." Instead of running along a pair of girders, such a trolley may be arranged to travel on the horizontal members of a gantry, which is supported on two legs having wheels and driving motors, the whole then constituting an "unloading bridge"; or it may travel over a special overhead runway about a yard or warehouse. Other variants, such as the hammer-head crane, as well as the portal crane, semi-portal crane, etc., are in every-day use.

Motors.—The chief features required of crane motors are the ability to overcome heavy starting torques and to accelerate as quickly as possible; and also preferably to lower the load at a convenient speed, the services of an external friction brake being dispensed with whenever possible. The first group of requirements point to the series D.C. or the slip-ring induction motor as being appropriate, but the second indicate the definite superiority of D.C. working; and where a number of cranes are located close together in a district only served by an A.C. supply, it is a frequent practice to employ a converting plant for providing them with direct current. A.C. motors with solenoid brakes are, however, quite a practicable alternative. For such infrequent duty, "crane-rated" windings are the rule, which are generally designed to carry full load for only half to one hour continuously without over-heating.

***Control Gear.**—The control gear may be either of the hand-operated drum or of the automatic contactor type. The former is the standard for the smaller capacities, but the advantages of automatic working often secure the use of contactor gear for small as well as large models. Whichever type is used, the rule is to render the operator's duties as simple and subconscious as possible, in order that he may be able to concentrate almost the whole of his attention upon the movements of the load. What is known as the "sympathetic" arrangement of control levers will be found to very greatly assist towards this end. In this system two of the controllers are so geared together as to be operated by different movements of the same lever; and both levers are so designed that the driver's motions are always in the same direction as those in which he desires the load to travel.

No special comment is needed regarding the control of the two horizontal travels, for which ordinary armature or rotor resistance control is employed. Braking is usually effected by "plugging" or reversing the motor through the whole of the control resistance; and foot brakes may also be used. But the hoisting motor requires quite specialized control when advantage is to be taken of the braking facilities of direct current. Very convenient lowering characteristics are given by what is called "potentiometer" braking, the principle of which is shown in fig. 5. Here the armature of the series motor is reconnected in shunt with a portion of the control resistance, so that it behaves similarly to a shunt motor, acting as a generator (and thus developing a negative torque) when rotating in the same direction as it did as a motor. The full series of connections is indicated in fig. 6, in which an auxiliary solenoid for releasing a friction brake is also shown. The hoisting is carried out in the usual manner, by cutting

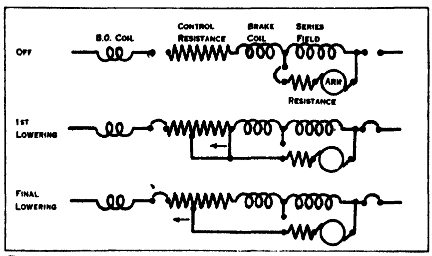

FIG. 8.—DIAGRAM SHOWING CONNECTIONS FOR DYNAMIC AND POTENTIOMETER BRAKING

out the series resistance. In the "off" position, the armature is reconnected in a closed ring with the field and a resistance, giving ordinary "dynamic" braking for bringing about a stop. For the slowest lowering speed, the potentiometer connection is carried out as in the middle diagram, and the speed is increased by progressively cutting the main resistance into the ring circuit and out of circuit with the armature as indicated by the arrows.

For some cranes, such as those used in foundries, very slow speeds and gradual acceleration are needed, and these are ob-

tained by means of diverter control. Series resistance is used, which is cut out in the usual manner; but for extra low speeds, not only is the whole of this left in circuit, but the armature current is further reduced by diverting current from it through a variable resistance shunt. In one controller type the diverting resistance is varied by a drum, which is mechanically interlocked with the larger so that it cannot be moved unless the main drum is in the "off" position, after which the latter can only be advanced to the first or second steps, while the auxiliary drum cannot be moved to the "off" position until the circuit has been ruptured by the main unit.

Contactor controllers carry out the same routine as the manual type, and their circuits do not call for special comment. What are known as "crane protective panels" are employed with any type of gear, and employ a master contactor controlling the current for all the crane motors. An overload relay is provided for each independent circuit, and one also for the common return lead. An excessive current in any can open the contactor, which is reclosed by a special auxiliary switch or contact convenient to the operator. The chief advantage of this type of overload protection is economy of time.

PRINTING MACHINERY AND CALENDERS

A number of industrial operations, of which rotary printing presses form a typical example, involve an accurate regulation of the working speed over a very wide range. Methods of control employing field regulation, resistance in series with the armature, and diverting resistance have already been described; but for the group of functions to be dealt with in this section, additional means are frequently essential.

The inadequacy of series and diverter resistances is chiefly due to their destroying the constant speed characteristic of the shunt motor, and causing serious variability with loading conditions. Field regulation is however available as far as it goes; while the Ward-Leonard system of control is an ideal, though frequently a too expensive, method. Multiple-voltage control is also of assistance. But for many purposes, especially in connection with printing, rubber calendering and paper making, special methods are directed to the great importance of securing a definite and steady slow speed for threading-in; for a sudden spurt immediately the initial static friction is overcome must be rigorously avoided.

For the least exacting requirements, the "inching" starter shown in fig. 2 may be serviceable, since it permits the motor to be inched or "jogged" at slow speed as a preparation to the main run.

More delicate operation is given by a combination of field, series and diverting resistances with two-voltage control; and a scheme for effecting the change-over of voltage together with the other methods is shown in fig. 9. The supply is here assumed to be derived from an ordinary three-wire system at, say, 115/0/–115 volts. There are eight contactors in all, and the scheme of operation would be as follows: Close 1, 2 and 7—thread-in speed; open 2—slow speed; close 3, 4 and 5 in succession—acceleration to half-speed; close 8, then open 3, 4, 5 and 7—transition to full voltage; close 6, 3, 4 and 5 in succession—acceleration to full speed; open 1 and 8, and close 2—stop. This scheme would preferably be combined with field regulation; while all the methods of control need not be included.

Of the special means employed for this class of work, the Holmes-Clatworthy two-motor system will be described for the drive of printing presses, and the Harland interlock scheme for paper machines. The former was developed in 1898, and involves the use of a small worm-geared motor for producing the creeping speeds, and the smooth transference of the drive to a large direct-coupled motor when a given speed has been reached. A magnetically-operated clutch positioned between the small and large machines enables the change-over to be automatic and without shock.

A self-contained control pillar is employed embodying contactors and relays, and a motor-driven distributing switch. The latter cuts resistance into and out of the two motor circuits as required, and opens and closes the circuits for the machines themselves, so that the speed is smoothly and gradually increased as the servo-motor rotates in one direction, and similarly reduced when its rotation is reversed. The gear is operated from any point round the printing press by means of any number of push-button stations. Pressing the "Up" button accelerates the

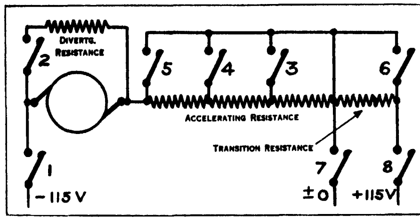

FIG. 9.—DIAGRAM OF TWO VOLTAGE CONTROL SCHEME

speed while it is held down, and the reverse is true of the "Down" button. The "Inch" unit institutes a very slow movement which ceases as soon as the button is released; while the "Lock" button prevents the machine from being started until its own "Free" button is pressed. By all these means the paper is safe-guarded from being torn, and the operators from suffering injury.

The distinguishing feature in connection with paper making is the necessity for maintaining exactly the same relative speeds between all the numerous rollers involved in the process; for great trouble is caused if the paper is either torn or becomes slack. It is nowadays customary to drive the complete machine by a number of electric motors, all of which are supplied with power by a motor-generator set. The speed of the whole process can thus be increased or diminished as required by the field regulation of the generator. The requirement is then to co-ordinate the speeds of the various "section" motors so that none of them can deviate by a fraction of 1% from the predetermined value relatively to the speeds of the other machines.

This co-ordination of speeds may be simply accomplished in the Harland equipment. A master shaft runs transversely to all the motor shafts, and is driven either by a special motor or by that of the "drier" section. One-half of a differential gear, designed on exactly the same principle as that used in a motor car back axle, is spur-geared to this shaft, while the other half is belted to the shaft of the section motor. While the two halves run at the same speed but in opposite directions, the planet wheels and frame do not move; but when movement does occur, resistance is cut into or out of the field circuit, a rheostat having about 100 steps being incorporated in the "differential" case. The most delicate regulation is thereby obtained.

MISCELLANEOUS ELECTRIFICATION

Other plant equipment, the electrification of which deserves brief notice includes the following: lifting magnets, large valves, pumps, compressors, swing bridges.

Lifting Magnets.—The control of a lifting magnet must make provision both for the potential kick that may occur when breaking circuit, and also for the residual magnetism remaining when the exciting current is switched off, which might be sufficient to retain the load. The former is dealt with by connecting a non-inductive "discharge" resistance across the coil just before the supply is cut off; and the latter by means of a momentary reversal of the magnetizing current. A scheme for effecting these steps, and giving two strengths of lifting excitation, is shown in fig. 10. Auxiliary knock-off contactors are used, operated by a drum controller.

Large Valves.—It is becoming the custom to open and close large steam and water valves electrically, to save the delay, danger and discomfort that are involved in manual operation. The motors range from about 1 to 8 h.p., and are series wound for D.C. and squirrel-cage for A.C. The greatest power is re-

quired for unseating the valve, which may be jammed or stuck in place, and the starting torque of the motor is frequently assisted by the provision of "lost motion" to impart a hammer blow. After the valve has begun opening, a series resistance is cut into the D.C. armature circuit to prevent racing. A precaution necessary during the closing operation is to stop the motor in time to pre-

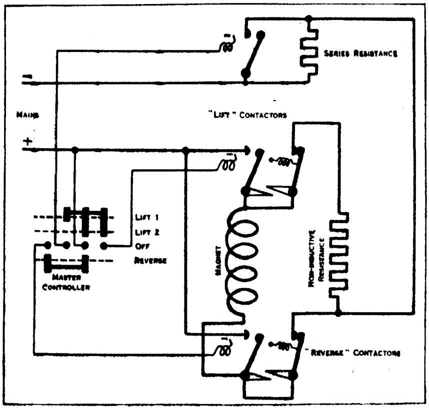

FIG. 10.—DIAGRAM OF CONTROL CONNECTIONS FOR LIFTING MAGNET

vent jamming. This is accomplished by a limit switch and the end is often assisted by a slipping clutch. Several different schemes for D.C. control to suit a manual drum controller and a contactor equipment may be used.

Pumping.—The driving of pumps, both centrifugal and reciprocating, is carried out best by D.C. compound or A.C. squirrel-cage and synchronous motors. It may be made automatic by means of contactor gear, operated by float or pressure relays, and forms an economical load, as it may easily be restricted to off-peak hours. The simplest starting schemes, such as the star-delta, stator resistance, or even direct switching, are in order for A.C. equipment, the latter being obtained by the use of "across-the-line" type of squirrel-cage and synchronous motors. It is only when a long water column has to be accelerated that special care is needed for bringing about a gradual start.

Fans and Air-compressors.—Ventilation is chiefly of importance in connection with mining, for which ventilating practice is tending more and more in the direction of absolutely continuous running, even during holidays. Conditions thus favour the use of synchronous motors, which can be over-excited to enable them to correct the power factor of the electrical installation generally. Since fan duty involves the development of the greatest starting torque just when the rotor is to be pulled into synchronism, an ordinary self-starting synchronous motor is not in order unless a friction clutch is fitted. The latter is not needed with the synchronous induction motor, which starts as a slip-ring machine and has its rotor excited with D.C. when up to speed. It is customary to employ gearing or belting between motor and fan, which can provide for a gradual increase in capacity as the mine develops by means of a change of gear ratio.

For air-compressors, which may be started at light load, the simpler self-starting synchronous motor is well adapted. An appropriate starting scheme would be one that used an auto-transformer which would reduce the initial voltage. The star-point switch is opened during starting and also just before closing the full-voltage switch.

Swing Bridges.—The operation of swing and lift bridges is effected by series D.C. or slip-ring induction motors. The control gear need not be automatic, but must be absolutely certain in its action, and must be capable of moving the very heavy masses involved without any possibility of jerking or jolting. A reliable system of interlocks, brakes and signal lamps is used to prevent all chance of mistakes.

Motors are employed for moving the span, for locking it, and for opening and closing the gates. Locking motors may be of the squirrel-cage type with high resistance rotors, and need only have a 15 min. rating. The main brakes are usually of the shunt-wound solenoid friction pattern, mounted directly on the motor shafts, and emergency brakes are also installed. The limit switches for effecting slow speed preparatory to seating are important components.

Fuller details regarding the subject dealt with above may be obtained from the author's book on *Control Gear and Electrification,* and from other technical productions. (W. WI.)

UNITED STATES

The electrification of America has progressed very rapidly. In 1900 (U.S. Census of Manufactures) there was 11,800,000 h.p. installed in the manufacturing enterprises of which but 4% was electrified. By 1925, the total had reached 35,800,000 horse-power. The American workman in 1900 utilized 2·13 h.p. of which but $\frac{1}{10}$ h.p. was electrical. In 1925, he used 4·27 h.p. of which 3·12 h.p. was electrical. Thus, it is apparent that 31 times as much electrical horse-power was used by each American workman in 1925 as was used in 1900. The economic results produced have justified this progress. The American wage-earner in 1925 produced products valued at $7,500, or nearly three times what he produced in 1900. From 1919, through 1925 there was a 26% increase in the quantity output of American factories, despite the fact that the average number of industrial workers decreased 6·7%.

There has been a very distinct trend by American industry toward the purchase from electric service companies of its power requirements. There has been marked and continued advance in the field of design and application of electrically-actuated apparatus to the many forms of machinery used in the productive industries. The use of the electric motor for individually driving power consuming machinery has been largely responsible for the increased production of products in factories. In the woodworking and textile establishments and in those industries using automatically operated machine tools, such as the automotive industry, where maintenance of the speeds of the cutting or working tools is of prime importance, individual motor drive has proved its value.

During the past few years, the "across-the-line" or "line-start" motor has been developed and has received wide application. Induction motors of this type in sizes up to about 50 h.p. may be connected directly to line voltage through a simple magnetically operated switch without exceeding N.E.L.A. specifications for starting current. The use of this motor has greatly simplified the control gear required. Synchronous motors of this type have also been developed and permit the use of simple control for heavy starting duty. Considerable attention has been given to the development and application of fan-cooled motors both for A.C. and D.C. and of fully enclosed motors designed for use in places where they are subjected to all kinds of destructive substance.

There is a decided increase in the application of high-speed motors. Squirrel cage motors operating at speeds up to 32,400 r.p.m. have been applied to regular production equipment in the ball-bearing industry through the use of frequency changers equipped with 540 cycle generators. In the woodworking industry 120 and 180 cycle motors are being used. The large majority of electrified power consuming equipment in industry is operated by A.C. motors. The predominant use of A.C. has resulted from the simplicity and ruggedness of the squirrel cage motor and its suitability for constant-speed applications. D.C. motors are used where the advantages of variable speed justify the increased cost of operation. The advance in A.C. motor design, however, has placed at the disposal of industry sufficient satisfactory types that all but very special applications may be served with A.C. motors.

Large factories usually utilize both types of current. Equip-

ment operated at constant speeds are equipped with A.C. motors and D.C. motors are used where variable speed is required. The tendency to equip main roll drives in iron and steel mills with electric drive was continued. These installations utilize mainly D.C. motors of slow speed driven from individual fly-wheel type motor-generators. Some progress has been made in the use of synchronous motors for main roll drives. D.C. mill-type motors have been placed on the market by one American manufacturer. In the rubber industry a synchronous motor having a sufficiently high starting torque to start heavy loads is now available for driving grinding mills, rolls and mixers. This motor operates as an induction motor when it drops out of synchronism and then automatically drops back into step.

A comparatively recent and valuable development has been the application of electric motor drive in the petroleum industry for driving wells in the fields and large pumps in main line pumping stations. Electrically driven drilling rigs have replaced with complete satisfaction and economy drilling equipment driven by steam and internal-combustion engines. Improvements in the design of mine-type locomotives have resulted in a continuation of the trend toward complete electrification in this industry. Depression in the industry has retarded the electrification programme but in spite of this each year sees more steam-actuated equipment replaced by electric drives. Perhaps the most fertile field for further electrification of our industrial establishments lies in the application of electricity to heating processes. Considerable progress has already been made in this direction. There is every reason to believe that some day the horse-power rating of electric heating and melting equipment in American industry will exceed the total horse-power in motors.

The brass industry for several years has made use of large induction and arc type furnaces for melting copper alloys in the comparatively few large wrought-brass mills. The development of small units (250 and 1,000 lb. capacity), practically all of which are of the single-phase type, have made possible electric melting in the smaller cast-brass establishments. Up to the year 1926 less than 15% of the brass melted in America was melted in electric furnaces. In the steel industry, the three-phase arc furnace produces such a high quality of product that "electric steel" has now become virtually a trade-mark. A few installations of this type of furnace have been made for the melting of cast iron and it is expected that this will find larger application. A high-frequency or coreless-type induction furnace has been developed for the melting of high-grade alloy steels. Each of these units consists of a motor-generator set with a single-phase high frequency generator and high-frequency capacitor units. The advantages of the electric furnace in producing very high temperatures, in allowing exact temperature adjustment and in providing the possibility of controlling the conditions of operation has established it in the large commercial field where these refinements are necessary. Some of the products in this field are artificial graphite, silicon carbide, artificial emery, metallic silicon, fused quartz, fused silica, fused silico-glass, bisulphide of carbon, zinc, phosphorus, calcium carbide, ferro-alloys and other alloys, and steel. Experimentally the electric furnace has been used to produce modifications of carbon, many metals and a great variety of other products.

When steel is made into forging, cold rolled into sheets and strips or drawn into wire, the working of the metal imparts a certain amount of hardness which must be removed by annealing, before subjecting the material to subsequent operations. Thus forgings must be softened for machining and sheets must be put in suitable condition for drawing and forming operations. Wire is annealed after each draw to reduce wear of dies and increase ductility of the metal. There is then a final anneal or heat treatment to make the wire suitable for commercial use. Until about 1922 commercial annealing was carried on in fuel-fired furnaces using coal, coke, oil or gas, and these methods are still in quite general use. The tendency at present, where maximum quality and uniformity of product are desired, is to give consideration to the electric furnace for these operations. The actual cost of the electric energy used is, in many instances, higher than the bare cost of fuel would be, but this is frequently justified by the results secured. A properly designed electric furnace operates with a very uniform distribution of heat and at no time is the temperature of the heat source much above the annealing temperature. This means that the metal is heated through to just the right degree and will have the uniform grain structure which characterizes a perfect anneal. The furnace temperature is controlled automatically and is maintained more closely and accurately than is possible with the average fuel-heated furnace and this is accomplished with a minimum of attendant labour. Usually the annealing process may be carried out overnight which permits the use of off-peak power purchased at minimum cost and often the same furnace is used during the day for other heat-treating operations.

Electricity has been applied successfully and economically to such low-temperature industrial processes, as japanning and enamelling, core baking, glue melting, firing of glassware and sherardizing. Electric furnaces operating at temperatures in excess of 1,000° F are being used for annealing, carbonizing, hardening and for vitreous enamelling. Electric heating removes all the difficulties that result from fuel combustion taking place where the heat is applied. The atmosphere in which the heating is done can be made the most suitable for the treatment given. The temperature also can be controlled exactly in all parts of the oven by the proper number and placing of the heating elements. These are the reasons for the small number of articles rejected by inspectors after electric heat treatment and consequently for the saving obtained over other processes where combustion is present and the temperature not so exactly controlled. Electric heating has also often been found to produce articles of higher quality than are produced by other methods. This is also a reason for its quite general application. The small number of rejects and the improved quality of the article are important factors in determining the cost of electric heat for various treatments in comparison with other methods.

Electric welding both by the electric arc and the resistance method is continuously finding more application and much progress has been made in the use of the automatic electric welding machine. On articles of simple shapes and in quantity production these machines are doing work cheaply and very well. The personal equation of the operator is removed and all the elements are controlled so as to produce the best weld. Semi-automatic welding machines are also finding considerable use. Here the feed of the electrode and the arc length are automatically controlled but the travel of the arc is under hand control so that the machines can be used on articles of a great variety of shapes. Welding has been used on structural steel parts in the place of rivets. If arc welding should prove, after more experimentation and experience, the best method for this work, the automatic machine will find an enormous field of application in the fabricating shop.

One of the recent forms of electric welding development has been that known as the atomic hydrogen weld. In this process an arc is maintained between two tungsten electrodes. A stream of hydrogen emerging from the electrode holder envelops the electrodes and thus prevents their oxidation and at the same time acts as the heat carrier. The hydrogen molecules are dissociated by the intense heat of the arc into the atomic state. Upon striking the relatively cool surfaces being welded, these atoms re-combine with the liberation of intense heat. The intensity of the heat and the complete shielding of the fused metal with hydrogen preventing contamination by the oxygen and nitrogen, results in the formation of an unusually sound, smooth and ductile weld. It makes possible the welding of many alloys that have not readily lent themselves to welding by other processes. Atomic hydrogen welding has found its principal application in the welding of light sections where appearance and ductility are of first consideration, and in the welding of special alloys.

The picture of electrification progress would be incomplete without some reference to the recent trend toward railroad electrification. (Details of this development are to be found in the article RAILWAYS.) Adequate lighting is to-day playing a very important part in our manufacturing processes and a description of this is

given in the article on LIGHTING. It is impossible to treat adequately the development of the electrification of industry under any one heading and the following articles should be referred to in addition to those cited above: ELECTRICAL POWER GENERATION; ELECTRICAL POWER TRANSMISSION; ELECTRICAL GENERATOR; MOTOR, ELECTRIC; ELECTRIC TRACTION; ELECTRICITY SUPPLY, COMMERCIAL AND TECHNICAL ASPECTS; ELECTRICAL POWER IN AGRICULTURE; HOUSEHOLD APPLIANCES; IRON AND STEEL; ALLOYS; METALLURGICAL FURNACES; POWER TRANSMISSION, MECHANICAL; MACHINE TOOLS; METALLURGY; PETROLEUM; and various industrial processes under their own heading.

(H. C. TH.)

ELECTROCHEMISTRY, that branch of *physical chemistry* (*q.v.*) which is concerned with the relation between electricity and chemical change. Under ordinary conditions, the occurrence of a chemical reaction is accompanied by the liberation or absorption of heat and not of any other form of energy, but there are many spontaneously occurring chemical reactions which, when allowed to proceed under special circumstances, liberate electrical energy, an electric current being generated. Conversely, the energy of an electric current can be utilized to bring about many chemical reactions which do not occur spontaneously. A process of the former type involves the direct conversion of the *chemical energy,* which is causing a reaction, into *electrical energy,* and an apparatus whereby such a process is brought about constitutes a *primary cell.* On the other hand, in processes of the latter kind, electrical energy is directly converted into chemical energy, which is stored up in the products of the reaction: such a process is one of *electrolysis*—an *electrolytic process.* In virtue of their chemical energy, the products of an electrolytic process have a tendency to react spontaneously with one another, reproducing the substances that were consumed during the electrolysis, so that, if this reaction is allowed to occur under such conditions that a primary cell is formed, a large proportion of the electrical energy used in the electrolysis may be regenerated. This possibility is made use of in *secondary cells*—also known as *accumulators* or *storage batteries.* The charging of an accumulator is a process of electrolysis, a definite chemical change being produced by the electric current passed through the cell. In discharging the cell, the reverse chemical change occurs spontaneously, the accumulator acting now as a primary cell furnishing an electric current. The "storage" of electrical energy in a secondary cell thus involves its conversion into chemical energy, which can, however, be reconverted into electrical energy when desired.

In addition to these purely electrochemical processes, it is customary to include also under the heading of electrochemistry those processes in which the energy of an electric current is first converted into heat, which then serves to bring about a chemical reaction which would not occur spontaneously at ordinary temperatures. These *electrothermal chemical processes* thus represent the indirect conversion of electrical energy into chemical energy through the medium of heat, and an apparatus in which they can occur is an *electric furnace.* Still more indirect processes, however, would not be regarded as electrochemical. Thus, in generating electricity on the large scale, the electrical energy is actually derived from the chemical energy of fuels such as coal, coke or oil, but the operation is not claimed as an electrochemical one, since the chemical energy is first converted into heat by combustion of the fuel, heat is then converted into mechanical energy by some form of heat engine, and finally mechanical energy is transformed into electrical energy by means of the dynamo. Although in this very indirect process only a fraction of the available chemical energy of the fuel can actually be obtained in the electrical form—mainly owing to the low efficiency of the heat engine stage—yet no known type of primary cell can be expected to compete with it, since in the operation of such cells relatively expensive material, usually zinc, is consumed continuously. Attempts to devise an efficient primary cell, capable of producing electrical energy directly from the chemical energy of ordinary fuels, have frequently been made, but although many difficulties have been overcome, none of the *fuel cells* yet designed have been successful on the commercial scale.

Finally, the *passage of electricity through gases* generally causes chemical changes, and this subject forms a separate branch of electrochemistry. When the current passes in the form of the so-called "silent" discharge, the chemical effects must be attributed to the direct action of the electrical energy supplied, but such a process is not an electrolysis, in the usual sense of the term. In cases where the discharge takes the form of an electric arc, much heat is liberated at very high temperatures and the chemical changes produced are the result of combined electrical and thermal conditions, *i.e.,* such processes are partly electrothermal in character.

General Principles.—Substances which are reasonably good conductors of electricity may be divided into two groups, the *metallic* or *electronic conductors* and the *electrolytic conductors.* The metals and a few substances such as graphite, manganese dioxide and lead sulphide exhibit metallic conductivity: the passage of an electric current through them produces heating and magnetic effects but no chemical changes. Electrolytic conductors or *electrolytes* comprise most acids, bases and salts, either in the molten condition or in the state of solution in water or other liquids. Plates or rods composed of a suitable metallic conductor dipping into the fluid electrolyte are employed to conduct the current into and out of the liquid, *i.e.,* to act as *electrodes.* When a current is passed through an electrolyte between suitable electrodes, not only are heating and magnetic effects produced, but also definite chemical changes occur at or in the neighbourhood of the electrodes, the process being one of electrolysis. At the negative electrode or *cathode,* the chemical change may be either the deposition of a metal, or the liberation of hydrogen and formation of a basic substance, or some other *chemical reduction* process; whereas at the positive electrode or *anode* it may be either the dissolution of the anode itself, the liberation of a nonmetal, the production of oxygen and an acidic substance, or some other *chemical oxidation* process. In some cases, these primary products of electrolysis then react with the electrolyte or with the material of which the electrodes are composed, yielding secondary products. It was shown by Faraday that the weight in grams of any of the primary products of an electrolysis liberated by Q coulombs of electricity is equal to $Qz/96{,}500$, where z is the *chemical equivalent* of that substance: hence to produce a gram-equivalent of any of the products of an electrolysis requires 96,500 coulombs of electricity.

An electrolyte, prepared either by melting a suitable substance or dissolving it in water or other liquid, owes its characteristic properties to the presence in it of electrically charged atoms or groups of atoms produced by the spontaneous splitting up or dissociation of the molecules of the substance when it is melted or dissolved. In the so-called *strong electrolytes,* most of the molecules of the original substance, or probably all of them, have undergone this process of *electrolytic dissociation* into charged particles or *ions* (*see* SOLUTION). When a potential difference is established between electrodes dipping into an electrolyte, positively charged ions move towards the negative electrode and ions bearing a negative charge towards the positive electrode, the electric current being carried through the electrolyte by this migration of the ions (*see* CONDUCTION IN LIQUIDS). When an ion actually reaches the electrode of opposite polarity, the neutralization of its charge converts it into an ordinary neutral atom or group of atoms and it is this *discharge of ions* which gives rise to the chemical changes at the electrodes. Thus, copper sulphate, $CuSO_4$, when dissolved in water forms an electrolyte, since it dissociates under these conditions into positively charged copper ions, Cu^{++}, and negatively charged sulphate ions, $(SO_4)^{--}$. When an electric current is passed through the solution by way of platinum electrodes, the copper ions move towards the cathode and on reaching it are discharged, giving metallic copper which is deposited on this electrode. At the anode the (SO_4) groups produced by the discharge of sulphate ions are unstable and react with water, producing oxygen which is evolved as bubbles of gas and sulphuric acid which accumulates in the solution around the anode. The total chemical change at the two electrodes may therefore be represented by the equation:

$$2CuSO_4+2H_2O+\text{electrical energy}\rightarrow 2Cu+2H_2SO_4+O_2.$$

A simpler case is that of an aqueous solution of copper chloride, $CuCl_2$, in which the ions are Cu^{++} and Cl^-, the latter yielding only chlorine gas when discharged at the anode. The equation for the complete electrolysis is $CuCl_2$+electrical energy→$Cu+Cl_2$ (*see* ELECTROLYSIS).

The quantity of electricity required to produce, say, 1 gram of copper by the electrolysis of either of the above solutions is 96,500/31·78=3,036 coulombs, since 31·78 is the chemical equivalent of copper in salts of this type. But the quantity of electrical energy needed for this purpose is given by the product of the quantity of electricity and the voltage which was applied across the electrodes during the electrolysis. If the current strength through a given electrolyte is to be I amperes, then the *applied voltage*, E_I, is given by: $E_I=E_0+IR+\pi$, where IR is the voltage used in overcoming the resistance, R ohms, of the column of electrolyte between the electrodes; and π denotes the *polarization* of the cell, a quantity which depends on the nature and concentration of the electrolyte, the nature of the electrodes, and the *current density, i.e.*, the ratio of I to the surface area of the electrodes in contact with the electrolyte. If the current density is large, π may be considerable, but as I is decreased π approaches zero. The minimum value of E_I which is approached as I is diminished is E_0, the *decomposition voltage* of the given electrolyte with the given electrodes. This represents the voltage which must be exceeded if electrolysis is to occur at all. For an aqueous solution of copper chloride of *normal* concentration, $E_0=1{\cdot}06$ volt. The electrical energy needed to liberate 1 gram of copper from this solution under given conditions is $3{,}036\times E$ joules, and the minimum value of this quantity under any conditions is $3{,}036\times E_0=3{,}036\times 1{\cdot}06=3{,}220$ joules. This value represents also the decrease of chemical energy when 1 gram of copper and the equivalent amount of chlorine (1·115 grams) are converted into copper chloride solution. In practice rather more electrical energy is always needed, since E_I is necessarily somewhat greater than E_0. This additional energy is used in overcoming resistance and polarization effects and is thereby converted into heat.

In virtue of their chemical energy, the products of an electrolysis tend to react with one another if allowed to come into contact. Thus, copper and chlorine interact readily, forming copper chloride and liberating a considerable quantity of heat—the *heat of reaction*. By setting up a primary cell, however, in which a copper electrode and a chlorine electrode dip into a solution of copper chloride, this same reaction can be caused to occur so as to yield electrical energy. For this purpose the copper electrode may consist of a plate of the metal, but, in order that chlorine may function as an electrode, a conductor of some material that is not attacked by chlorine must be used to act as an intermediary between the gas and the solution. A plate of platinized platinum or a rod of porous carbon kept saturated with the gas will act as a chlorine electrode. If the copper chloride solution is of normal concentration, the chlorine electrode will be found to assume a potential which is 1·06 volt more positive than the copper electrode, *i.e.*, the *electromotive force* of the cell=1·06= E_0, the decomposition voltage of the electrolyte. If now the two electrodes be connected by means of a wire outside the cell, a current will pass through the circuit formed by the electrolyte, the electrodes and the external wire. Whenever the cell is allowed to deliver a current through an external circuit, chemical changes occur at the electrodes, viz., copper dissolves from one electrode forming Cu^{++} ions and chlorine goes into solution as Cl^- ions at the other, so that, although the copper and chlorine do not actually come into contact, the total chemical reaction is

$$Cu+Cl_2\rightarrow CuCl_2+\text{electrical energy},$$

which is exactly the reverse of that occurring in the electrolysis of copper chloride solution.

For every gram of copper which dissolves during the action of the cell, 3,036 coulombs of electricity are obtained. The amount of electrical energy obtained, however, is $3{,}036\times E'_I$, where E'_I is the actual voltage or potential difference between the electrodes of the cell, when it is furnishing a current of I amperes. For a primary cell, $E'_I=E_0-IR-\pi'$, where these symbols have the same significance as above, π' being the polarization of the cell under the given conditions. If I is made very small by using an external circuit of very high resistance, π' approaches zero, E'_I approaches E_0, and the electrical energy obtainable approximates to $3{,}036\times E_0=3{,}036\times 1{\cdot}06=3{,}220$ joules per gram of copper dissolved. This quantity represents the maximum amount of electrical energy obtainable from the given chemical change and is a measure of the chemical energy which is causing the reaction to proceed. It should be noticed that the heat evolved when a reaction occurs under ordinary conditions is not generally equal to the chemical energy. Hence, in general, some heat is evolved or absorbed even when a primary cell is operated so that it is furnishing the maximum amount of electrical energy corresponding to the chemical change. Thus, a lead accumulator absorbs heat from its surroundings when it is being discharged.

Returning for a moment to the question of electrolysis, it must be pointed out that, if a copper chloride solution is electrolyzed using copper electrodes, copper is deposited on the cathode, but under these conditions copper is also dissolved from the anode at an equal rate, so that no chemical change occurs in the cell as a whole. Copper is merely transferred from the anode to the cathode and the decomposition voltage is zero. Processes of this kind are largely employed in refining metals. Using anodes of the crude metal, conditions are arranged so that impurities in these anodes do not deposit with the metal on the cathode during electrolysis. The small voltage required is merely that needed to overcome resistance and polarisation effects.

Apart from electrolytic conductivity, which has been considered above, and electronic conductivity, which is ascribed to the movements of free electrons through a metallic conductor, the *conductivity of gases* should also be mentioned. Under ordinary conditions, gases are practically insulators, the very small electrical conductivity which they do possess being attributed to the accidental presence of a few *gaseous ions* (charged atoms or molecules). When a high potential difference is established between electrodes in a gas, these ions move towards the electrode of opposite polarity with considerable velocities, so that if they collide with neutral molecules of the gas, they may be able to split up the latter into ions. With a sufficiently high voltage, this *ionization by collision* becomes important, and, as more and more ions are formed, the conductivity of the gas increases. But ions carrying charges of opposite sign may also collide with one another and form neutral molecules again. With a given voltage the current through the gas will attain a steady value when the rate of formation of ions is equal to their rate of recombination. With oxygen gas, some oxygen molecules, O_2, may be ionized into O^+ and O^-, whereas others may yield O_2^+ and a free electron. If now the ions O^- and O_2^+ collide, a molecule of ozone, O_3, may be formed. Chemical changes due to the passage of electricity through other gases arise in a similar way.

The *heating effects*, which are produced when large electric currents are driven by means of high voltages through metallic conductors or gases, are utilized in electrothermal chemical processes. Alternating currents can generally be used for this purpose.

Industrial Applications.—Electrolytic processes are employed commercially in the extraction of metals such as aluminium, magnesium, sodium, zinc and nickel from their ores; in refining metals such as gold, silver, copper, lead and tin; in electroplating with various metals and alloys; and in producing substances such as caustic soda, hypochlorites, chlorates, hydrogen and oxygen, the so-called "per-salts," etc. Electrothermal chemical processes have been applied to the smelting of ores of metals such as iron and zinc; to the production of ferro-alloys; to the refining of steel; and to the manufacture of substances such as calcium carbide, carborundum and phosphorus. The preparation of ozone and the production of nitric oxide from air (*see* NITROGEN, FIXATION OF) are processes depending on the passage of electricity through gases. Primary cells of various types, including "dry cells," are widely used for furnishing small, intermittent supplies of electricity, whilst the lead accumulator and the iron-nickel accumulator are the chief types of secondary cell employed technically

for the storage of limited quantities of electricity. For information on particular processes the reader is referred to articles on special branches of the subject, *e.g.*, BATTERIES, ELECTRIC; ELECTROMETALLURGY; ELECTRICITY, CONDUCTION OF; ELECTROTHERMICS; ELECTROPLATING; ZINC; CARBORUNDUM; OZONE; etc., which will be found under their respective titles.

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ELECTROCUTION, the popular name, invented in America, for the infliction of the death penalty on criminals by passing through the body of the condemned a current of electricity sufficient to cause death. The method was first adopted by the State of New York, a law making this method obligatory having been passed and approved by the governor on June 4, 1888. The first criminal to be executed by this method was William Kemmler, on Aug. 6, 1890, at Auburn prison. The validity of the New York law had previously been attacked in regard to this case, as providing "cruel and unusual punishment" in violation of the Constitution; but it was sustained in the State courts and finally in the Federal courts (*Re Kemmler*, 1889, 136 U.S. 436). This method of inflicting the death penalty has now (1928) been adopted in 23 States.

The death dealing apparatus consists of a stationary engine, an alternating dynamo capable of generating a current at a pressure of 2,000 volts, a "death-chair" with adjustable head-rest, binding straps and adjustable electrodes. The voltmeter, ammeter and switch-board controlling the current are located in the execution-room; the dynamo-room is communicated with by electric signals. When everything is in readiness the criminal is brought in and seats himself in the death-chair. His head, chest, arms and legs are secured by broad straps; one electrode thoroughly moistened with salt-solution is affixed to the head, and another to the calf of one leg, both electrodes being moulded so as to secure good contact. The application of the current is usually as follows: the contact is made with a high voltage (1,800–2,000 volts) for three or four seconds, reduced to 500 volts until nearly a minute has elapsed; raised to high voltage for a second or two, again reduced to a low voltage until one minute has elapsed, when it is again raised to the high voltage for a few seconds and the contact broken. A second or even a third brief contact is sometimes made, partly as a precautionary measure, but rather the more completely to abolish reflexes in the dead body. The time consumed by the strapping-in process is usually about 45 seconds, and the first contact is made about 70 seconds after the criminal has entered the death-chamber.

When properly performed the effect of the operation is believed to be painless and instantaneous death. Scientific opinion is divided on this point but there can be little doubt that circulation and respiration cease with the first contact; that consciousness is blotted out instantly and that the prolonged application of the current ensures permanent derangement of the vital functions beyond recovery. To make assurance doubly sure, the law provides for an autopsy to be performed immediately after the execution.

ELECTROLIER, a fixture, usually suspended from the ceiling, for holding electric lamps. The word is analogous to chandelier, from which it was formed, but is used to differentiate the electric from the candle sources of light (*see* CHANDELIER).

ELECTROLYSIS (ĕl-ĕk-trŏl'ĭ-sĭs). The passage of an electric current through a substance, accompanied by definite chemical changes which are independent of the heating effects of the current, is known as electrolysis (formed from Gr. λύειν, to loosen), and the substance is called an electrolyte. An example of this is a solution of a salt such as copper sulphate in water, through which an electric current is passed between copper plates, when the following phenomena are observed: (1) the bulk of the solution is unaltered, except that its temperature may be raised owing to the usual heating effect, which is proportional to the square of the strength of the current; (2) the copper plate by which the current is said to enter the solution, *i.e.*, the plate attached to the so-called positive terminal of the battery or other source of current dissolves away, the copper going into solution as copper sulphate; (3) copper is deposited on the surface of the other plate, being obtained from the solution; (4) changes in concentration are produced in the neighbourhood of the two plates or electrodes. In this case the solution becomes stronger near the anode or electrode at which the current enters, and weaker near the cathode or electrode at which it leaves the solution. If instead of copper electrodes plates of platinum are employed, copper is still deposited on the cathode, but instead of the anode dissolving, free sulphuric acid appears in the neighbouring solution, and oxygen gas is evolved at the surface of the platinum plate. With other electrolytes similar phenomena appear, though the primary chemical changes may be masked by secondary actions. Thus, with a dilute solution of sulphuric acid and platinum electrodes, hydrogen gas is evolved at the cathode, while, as the result of a secondary action on the anode, sulphuric acid is there re-formed and oxygen gas evolved. Again, with the solution of a salt such as sodium chloride, the sodium, which is primarily liberated at the cathode, decomposes the water and evolves hydrogen, while the chlorine may be evolved as such, may dissolve the anode or may liberate oxygen from the water, according to the nature of the plate and the concentration of the solution.

The distinction between electrons associated with gases and with liquids is that, in gases the electrons sometimes travel alone, but in liquids they are always attached to matter and their motion involves the movement of chemical atoms or groups of atoms. An atom with an extra corpuscle is a univalent negative ion, an atom with one corpuscle detached is a univalent positive ion. In metals the electrons can slip from one atom to the next, since a current can pass without chemical action. When a current passes from an electrolyte to a metal, the electron must be detached from the atom it was accompanying and chemical action be manifested at the electrode.

Alessandro Volta of Pavia discovered the electric battery in the year 1800, and thus placed the means of maintaining a steady electric current in the hands of investigators who, before that date, had been restricted to the study of the isolated electric charges given by frictional electric machines. Volta's cell consists essentially of two plates of different metals, such as zinc and copper, connected by an electrolyte such as a solution of salt or acid. Immediately on its discovery intense interest was aroused in the new invention, and the chemical effects of electric currents were speedily detected. W. Nicholson and Sir A. Carlisle found that hydrogen and oxygen were evolved at the surfaces of gold and platinum wires connected with the terminals of a battery and dipped in water. The volume of the hydrogen was about double that of the oxygen, and, since this is the ratio in which these elements are combined in water, it was concluded that the process consisted essentially in the decomposition of water. These observers also noticed that a similar kind of chemical action went on in the battery itself. Soon afterwards William Cruickshank decomposed the magnesium, sodium and ammonium chlorides, and precipitated silver and copper from their solutions, an achievement which led to the process of electroplating. He also found that the liquid round the anode became acid, and that round the cathode alkaline. In 1804 W. Hisinger and J. J. Berzelius stated that neutral salt solutions could be decomposed by electricity, the acid appearing at one pole and the metal at the other. In 1806 Sir Humphry Davy proved that the formation of acid and alkali when water was electrolysed was due to saline impurities in the water. He had shown previously that decomposi-

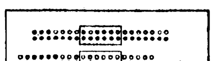

FIG. 1.—DIAGRAM SHOWING THAT THE RATIO OF SALT LOST AT THE ANODE AND THE CATHODE IS EQUAL TO THE RATIO OF THE VELOCITIES OF THE CATION AND THE ANION (WHITE CIRCLES)

In the bottom figure, the anion travels twice as fast as the cation, and the amount of salt lost at the anode is correspondingly less

tion of water could be effected even if the two poles were placed in separate vessels connected by moistened threads. In 1807 he decomposed potash and soda, previously considered to be elements, by passing the current from a powerful battery through the moistened solids, and thus isolated the metals potassium and sodium.

Faraday's Laws.—The first exact quantitative study of electrolytic phenomena was made about 1830 by Michael Faraday (*Experimental Researches*, 1833), who examined the relation between the flow of electricity round the circuit and the amount of chemical decomposition. He found that, for the same current, the amount of chemical action was independent of the size of the electrodes and proportional to the time that the current flowed. The results of all these experiments may be summed up in the statement that the amount of chemical action is proportional to the quantity of electricity which passes through the cell.

Faraday's next step was to pass the same current through different electrolytes in series. He found that the amounts of the substances liberated in each cell were proportional to the chemical equivalent weights of those substances. Thus, if the current be passed through dilute sulphuric acid between hydrogen electrodes, and through a solution of copper sulphate, it will be found that the mass of hydrogen evolved in the first cell is to the mass of copper deposited in the second as 1 is to 31·8. Now this ratio is the same as that which gives the relative chemical equivalents of hydrogen and copper, for 1 gm. of hydrogen and 31·8 gm. of copper unite chemically with the same weight of any acid radical such as chlorine or the sulphuric group, SO_4. Faraday examined also the electrolysis of certain fused salts such as lead chloride and silver chloride. Similar relations were found to hold and the amounts of chemical change to be the same for the same electric transfer as in the case of solutions. We may sum up the chief results of Faraday's work in the statements known as Faraday's laws:—The mass of substance liberated from an electrolyte by the passage of a current is proportional (1) to the total quantity of electricity which passes through the electrolyte, and (2) to the chemical equivalent weight of the substance liberated.

Since Faraday's time his laws have been confirmed by modern research, and in favourable cases have been shown to hold good with an accuracy of at least one part in a thousand. The principal object of this more recent research has been the determination of the quantitative amount of chemical change associated with the passage for a given time of a current of strength known in electromagnetic units. The mean result of the best determinations shows that when a current of 1 ampere is passed for 1 second, a mass of silver is deposited equal to 0·001118 gm. So accurate and convenient is this determination that it is now used conversely as a practical definition of the ampere, which (though defined theoretically in terms of magnetic force) is defined practically as the current which in one second deposits 1·118 mg. of silver. If, as is now usual, we take the equivalent weight of oxygen as our standard and call it 16, the equivalent weight of silver is 107·88, that of hydrogen being 1·008, and its electrochemical equivalent $1{\cdot}036 \times 10^{-5}$. The electrochemical equivalent of any other substance may be found by multiplying its chemical equivalent by $1{\cdot}036g \times 10^{-5}$. If, instead of the ampere, we take the c.g.s. electromagnetic unit of current, this number becomes $1{\cdot}036 \times 10^{-4}$.

It was pointed out by Helmholtz in 1881 that Faraday's law forms one of the most important reasons for assuming that electricity has an atomistic structure since it must be assumed that every valence bond in an atom or radical involves a definite quantity of electricity, just as in the formation of a chemical compound several atoms or radicals are able to unite with one another. Further according to Helmholtz if the assumption is made that simple substances are composed of atoms, the conclusion cannot be avoided that electricity, positive as well as negative, decomposes into definite elementary particles which behave as electrical atoms. If Avogadro's number N (the number of molecules in a gram-molecule) is known, the size of the elementary charge of electricity e_0, is given in accordance with Faraday's law by the relation $e_0 = \frac{96{,}500}{N}$ coulombs (or ampere seconds) $= \frac{9{,}650}{N}$ absolute electromagnetic units (e.m.u) $= \frac{28{\cdot}95 \times 10^{13}}{N}$ absolute electrostatic units (e.s.u.).

Chemical Nature of the Ions.—A study of the products of decomposition does not necessarily lead directly to a knowledge of the ions actually employed in carrying the current through the electrolyte. Since the electric forces are active throughout the whole solution, all the ions must come under its influence and therefore move, but their separation from the electrodes is determined by the electromotive force needed to liberate them. Thus, as long as every ion of the solution is present in the layer of liquid next the electrode, the one which responds to the least electromotive force will alone be set free. When the amount of this ion in the surface layer becomes too small to carry all the current across the junction, other ions must also be used, and either they or their secondary products will appear also at the electrode. In aqueous solutions, for instance, a few hydrogen (H) and hydroxyl (OH) ions derived from the water are always present, and will be liberated if the other ions require a higher decomposition voltage and the current be kept so small that hydrogen and hydroxyl ions can be formed fast enough to carry all the current across the junction between solution and electrode.

The issue is also obscured in another way. When the ions are set free at the electrodes, they may unite with the substance of the electrode or with some constituent of the solution to form secondary products. Thus the hydroxyl mentioned above decomposes into water and oxygen, and the chlorine produced by the electrolysis of a chloride may attack the metal of the anode.

Early Theories of Electrolysis.—The obvious phenomena to be explained by any theory of electrolysis are the liberation of the products of chemical decomposition at the two electrodes while the intervening liquid is unaltered. To explain these facts T. Grotthus (1785–1822) in 1806 put forward an hypothesis which supposed that the opposite chemical constituents of an electrolyte interchanged partners all along the line between the electrodes when a current passed. Thus, if the molecule of a substance in solution is represented by AB, Grotthus considered a chain of AB molecules to exist from one electrode to the other. Under the influence of an applied electric force, he imagined that the B part of the first molecule was liberated at the anode, and that the A part thus isolated united with the B part of the second molecule, which, in its turn, passed on its A to the B of the third molecule. In this manner, the B part of the last molecule of the chain was seized by the A of the last molecule but one, and the A part of the last molecule liberated at the surface of the cathode. Chemical phenomena throw further light on this question. If two solutions containing the salts AB and CD be mixed, double decomposition is found to occur, the salts AD and CB being formed till a certain part of the first pair of substances is transformed into an equivalent amount of the second pair. A freedom of interchange is thus indicated between the opposite parts of the molecules of salts in solution, and it follows reasonably that with the solution of a single salt, say sodium chloride, continual interchanges go on between the sodium and chlorine parts of the different molecules.

These views were applied to the theory of electrolysis by R. J. E. Clausius. He pointed out that it followed that the electric forces did not cause the interchanges between the opposite parts of the dissolved molecules but only controlled their direction. Interchanges must be supposed to go on whether a current passes or not, the function of the electric forces in electrolysis being merely to determine in what direction the parts of the molecules shall work their way through the liquid and to effect actual separation of these parts (or their secondary products) at the electrodes. This conclusion is supported also by the evidence supplied by the phenomena of electrolytic conduction. (*See* ELECTRICITY, CONDUCTION OF: *In Liquids*.) If we eliminate the reverse electromotive forces of polarization at the two electrodes, the conduction of electricity through electrolytes is found to conform to Ohm's law; that is, once the polarization is overcome, the current is proportional to the electromotive force applied to the bulk of the liquid. Hence there can be no reverse forces of polarization inside the liquid itself, such forces being confined to the surface

of the electrodes. No work is done in separating the parts of the molecules from each other. This result again indicates that the parts of the molecules are effectively separate from each other, the function of the electric forces being merely directive.

Migration of the Ions.—The opposite parts of an electrolyte which work their way through the liquid under the action of the electric forces were named by Faraday the ions—the travellers. The changes of concentration which occur in the solution near the two electrodes were referred by W. Hittorf (1853) to the unequal speeds with which he supposed the two opposite ions to travel. It is clear that, when two opposite streams of ions move past each other, equivalent quantities are liberated at the two ends of the system. If the ions move at equal rates, the salt which is decomposed to supply the ions liberated must be taken equally from the neighbourhood of the two electrodes. But if one ion, say the anion, travels faster through the liquid than the other, the end of the solution from which it comes will be more exhausted of salt than the end towards which it goes. If we assume that no other cause is at work, it is easy to prove that, with non-dissolvable electrodes, the ratio of salt lost at the anode to the salt lost at the cathode must be equal to the ratio of the velocity of the cation to the velocity of the anion. This result may be illustrated by fig. 1.

The black circles represent one ion and the white circles the other. If the black ions move twice as fast as the white ones, their distribution after the passage of a current will be represented by the lower part of the figure. Here the middle part of the solution is unaltered and the number of ions liberated is the same at either end, but the amount of salt left at one end is less than that at the other. On the right, towards which the faster ion travels, five molecules of salt are left, being a loss of two from the original seven. On the left, towards which the slower ion moves, only three molecules remain—a loss of four. Thus, the ratio of the losses at the two ends is two to one—the same as the ratio of the assumed ionic velocities.

Transport Numbers.—It should be noted, however, that another cause would be competent to explain the unequal dilution of the two solutions. If either ion carried with it some of the unaltered salt or some of the solvent, concentration or dilution of the liquid would be produced where the ion was liberated. There is reason to believe that in certain cases such complex ions do exist, and interfere with the results of the differing ionic velocities. For certain concentrated solutions the transport number is found to be greater than unity; thus for a normal solution of cadmium iodide its value is 1·12. (One litre of a *normal* solution contains one gram equivalent of the dissolved substance; *see* EQUIVALENT.) This is best explained by the formation of structures represented by some such chemical formula as I (CdI_2). It is found that, in such cases as this, where it seems necessary to imagine the existence of complex ions, the transport number changes rapidly as the concentration of the original solution is changed. Thus, diminishing the concentration of the cadmium iodide solution from normal to one-twentieth normal changes the transport number from 1·12 to 0·64. Hence it is probable that in cases where the transport number keeps constant with changing concentration the hypothesis of complex ions is unnecessary, and we may suppose that the transport number is a true migration constant from which the relative velocities of the two ions may be calculated in the manner suggested by Hittorf. This conclusion is confirmed by the results of the direct visual determination of ionic velocities (*see* ELECTRICITY, CONDUCTION OF: *In Liquids*), which, in cases where the transport number remains constant, agree with the values calculated from those numbers. Many solutions in which the transport numbers vary at high concentration often become simple at greater dilution.

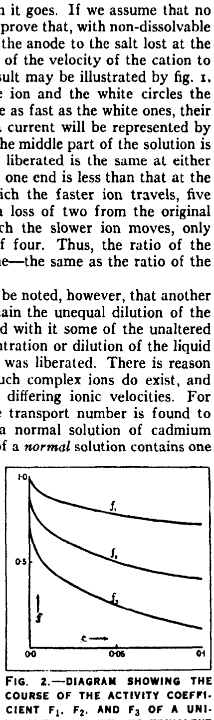

FIG. 2.—DIAGRAM SHOWING THE COURSE OF THE ACTIVITY COEFFICIENT F_1, F_2, AND F_3 OF A UNIVALENT, BIVALENT AND TRIVALENT IN PRESENCE OF A UNI-UNIVALENT SALT (AS KCL) OF THE CONCENTRATION C (IN MOLS. PER LITRE), MAKING F_1. IN 0·1 KCL ABOUT 70% F_1, IN AN ION-FREE MEDIUM, WHILE F_3 IN 0·1 KCL FALLS TO 10%

F. Kohlrausch in 1879 provided the next important step in the theory of the subject. Kohlrausch formulated a theory of electrolytic conduction based on the idea that, under the action of the electric forces, the oppositely charged ions moved in opposite directions through the liquid, carrying their charges with them. If we eliminate the polarization at the electrodes, it can be shown that an electrolyte possesses a definite electric resistance and therefore a definite conductivity. On the view of the process of conduction described above, the amount of electricity conveyed per second is measured by the product of the number of ions, (known from the concentration of the solution), the charge carried by each of them and the velocity with which on the average they move through the liquid. The concentration is known, and the conductivity can be measured experimentally; thus the average velocity with which the ions move past each other under the existent electromotive force can be estimated, and is found to be equal to the sum of their individual velocities, which can therefore be calculated. From Hittorf's transport number, in the case of simple salts in moderately dilute solution, we have the ratio between the two ionic velocities. Hence the absolute velocities of the two ions can be determined, and we can calculate the actual speed with which a certain ion moves through a given liquid under the action of a given potential gradient or electromotive force.

DISSOCIATION THEORY

The verification of Kohlrausch's theory of ionic velocity verifies also the view of electrolysis which regards the electric current as due to streams of ions moving in opposite directions through the liquid and carrying their opposite electric charges with them. There remains the question how the necessary migratory freedom of the ions is secured. As we have seen, Grotthus imagined that it was the electric forces which sheared the ions past each other and loosened the chemical bonds holding the opposite parts of each dissolved molecule together. Clausius extended to electrolysis the chemical ideas which regarded the opposite parts of the molecule as always changing partners independently of any electric force, and regarded the function of the current as merely directive. Still, the necessary freedom was supposed to be secured by interchanges of ions between molecules at the instants of molecular collision only; during the rest of the life of the ions they were regarded as linked to each other to form electrically neutral molecules.

Arrhenius.—In 1887 Svante Arrhenius put forward a new theory which supposed that the freedom of the opposite ions from each other was not a mere momentary freedom at the instants of molecular collision, but a more or less permanent freedom, the ions moving independently of each other through the liquid. The evidence which led Arrhenius to this conclusion was based on van't Hoff's work on the osmotic pressure of solutions (*see* SOLUTION). If a solution, let us say of sugar, be confined in a closed vessel through the walls of which the solvent can pass but the solution cannot, the solvent will enter till a certain equilibrium pressure is reached. This equilibrium pressure is called the *osmotic pressure* (*q.v.*) of the solution, and thermodynamic theory shows that, in an ideal case of perfect separation between solvent and solute, it should have the same value as the pressure which a number of molecules equal to the number of solute molecules in the solution would exert if they could exist as a gas in a space equal to the volume of the solution, provided that the space was large enough (*i.e.*, the solution dilute enough) for the intermolecular forces betwen the dissolved particles to be inappreciable. Van't Hoff pointed out that measurements of osmotic pressure confirmed this value in the case of dilute solutions of cane sugar.

Thermodynamic theory also indicates a connection between the osmotic pressure of a solution and the depression of its freezing point and its vapour pressure compared with those of the pure solvent. The freezing points and vapour pressures of solutions of sugar are also in conformity with the theoretical numbers. But when we pass to solutions of electrolytes we find that the observed

values of the osmotic pressures and of the allied phenomena are greater than the normal values. Arrhenius pointed out that these exceptions would be brought into line if the ions of electrolytes were imagined to be separate entities each capable of producing its own pressure effects just as would an ordinary dissolved molecule. Two relations are suggested by Arrhenius's theory. (1) In very dilute solutions of simple substances, where only one kind of dissociation is possible and the dissociation of the ions is complete, the number of pressure-producing particles necessary to produce the observed osmotic effects should be equal to the number of ions given by a molecule of the salt as shown by its electrical properties. Thus the osmotic pressure, or the depression of the freezing point of a solution of potassium chloride should, at extreme dilution, be twice the normal value, but of a solution of sulphuric acid three times that value, since the potassium salt contains two ions and the acid three. (2) As the concentration of the solutions increases, the ionization as measured electrically and the dissociation as measured osmotically might decrease more or less together.

Depression of Freezing Point.—Measurements of freezing point are at present more convenient and accurate than those of osmotic pressure, and we may test the validity of Arrhenius's relations by their means. The theoretical value for the depression of the freezing point of a dilute solution per gram-equivalent of solute per litre is 1·857° C. Completely ionized solutions of salts with two ions should give double this number or 3·714° C, while electrolytes with three ions should have a value of 5·57° C. The following results are given by H. B. Loomis for the concentration of 0·01 gram-molecule of salt to 1,000 gm. of water. The salts tabulated are those of which the equivalent conductivity reaches a limiting value indicating that complete ionization is reached as dilution is increased. With such salts alone is a valid comparison possible.

Molecular Depressions of the Freezing Point

Electrolytes with Two Ions

Potassium chloride	3·60	Nitric acid	3·73
Sodium chloride	3·67	Potassium nitrate	3·46
Potassium hydrate	3·71	Sodium nitrate	3·55
Hydrochloric acid	3·61	Ammonium nitrate	3·58

Electrolytes with Three Ions

Sulphuric acid	4·49	Calcium chloride	5·04
Sodium sulphate	5·09	Magnesium chloride	5·08

At the concentration used by Loomis the electrical conductivity was considered to indicate that the ionization is not complete, particularly in the case of the salts with divalent ions in the second list. The measurements of freezing points of solutions at the extreme dilution necessary, on the basis of the theory to secure complete ionization is a matter of great difficulty, but in researches where this difficulty has been overcome results have been obtained for solutions of sugar, where the experimental number is 1·858, and for potassium chloride, which gives a depression of 3·720. These numbers agree very closely with those indicated by theory, viz., 1·857 and 3·714, and establishes very definitely the case for complete dissociation of dilute salt solutions.

The Action of Ions.—It is necessary to point out that the dissociated ions of such a body as potassium chloride are not in the same condition as potassium and chlorine in the free state. The ions are associated with very large electric charges, and, whatever their exact relations with those charges may be, it is certain that the energy of a system in such a state must be different from its energy when unelectrified. Again, water, the best electrolytic solvent known, is also the body of the highest specific inductive capacity (dielectric constant), and this property, to whatever cause it may be due, will reduce the forces between electric charges in the neighbourhood, and may therefore enable two ions to separate. This view of the nature of electrolytic solutions at once explains many well-known phenomena. Other physical properties of these solutions, such as density, colour, optical rotatory power, etc., like the conductivities, are *additive, i.e.*, can be calculated by adding together the corresponding properties of the parts. This again suggests that these parts are independent of each other.

Electrolytes possess the power of coagulating solutions of colloids such as albumen and arsenious sulphide. The mean values of the relative coagulative powers of sulphates of mono-, di- and tri-valent metals have been shown experimentally to be approximately in the ratios 1:35:1,023. The dissociation theory refers this to the action of electric charges carried by the free ions. If a certain minimum charge must be collected in order to start coagulation, it will need the conjunction of $6n$ monovalent, or $3n$ divalent, to equal the effect of $2n$ trivalent ions. The ratios of the coagulative powers can thus be calculated to be $1:x:x^2$, and putting $x=32$ we get 1:32:1,024, a satisfactory agreement with the numbers observed.

An interesting relation appears when the electrolytic conductivity of solutions is compared with their chemical activity. The readiness and speed with which electrolytes react are in sharp contrast with the difficulty experienced in the case of non-electrolytes. Moreover, a study of the chemical relations of electrolytes indicates that it is always the electrolytic ions that are concerned in their reactions. The tests for a salt, potassium nitrate, for example, are the tests not for KNO_3, but for its ions K' and NO_3', and in cases of double decomposition it is always these ions that are exchanged for those of other substances. If an element be present in a compound otherwise than as an ion, it is not interchangeable, and cannot be recognized by the usual tests. Thus neither a chlorate, which contains the ion ClO_3', nor monochloracetic acid, shows the reactions of chlorine, though it is of course present in both substances; again, the sulphates do not answer to the usual tests which indicate the presence of sulphur as sulphide. The chemical activity of a substance is a quantity which may be measured by different methods. For some substances it has been shown to be independent of the particular reaction used. It is then possible to assign to each body a specific coefficient of affinity. Arrhenius has pointed out that the coefficient of affinity of an acid is proportional to its electrolytic ionization.

Affinities of Acids.—These have been compared in several ways. W. Ostwald (*Lehrbuch der allg. Chemie,* vol. ii., 1893) investigated the relative affinities of acids for potash, soda and ammonia, and proved them to be independent of the base used. The method employed was to measure the changes in volume caused by the action. His results are given in column I. of the following table, the affinity of hydrochloric acid being taken as one hundred. Another method is to allow an acid to act on a salt soluble only with difficulty, and to measure the quantity which goes into solution. Determinations have been made with calcium oxalate, $CaC_2O_4+H_2O$, which is easily decomposed by acids, oxalic acid and a soluble calcium salt being formed. The affinities of acids relative to that of oxalic acid are thus found, so that the acids can be compared among themselves (column II.). If an aqueous solution of methyl acetate be allowed to stand, a slow decomposition goes on. This is much quickened by the presence of a little dilute acid, though the acid itself remains unchanged. It is found that the influence of different acids on this action is proportional to their specific coefficients of affinity. The results of this method are given in column III. Finally, in column IV. the electrical conductivities of normal solutions of the acids have been tabulated. A better basis of comparison would be the ratio of the actual to the limiting conductivity, but since the conductivity of acids is chiefly due to the mobility of the hydrogen ions, its limiting value is nearly the same for all and the general result of the comparison would be unchanged.

Acid	I.	II.	III.	IV.
Hydrochloric	100	100	100	100
Nitric	102	110	92	99·6
Sulphuric	68	67	74	65·1
Formic	4·0	2·5	1·3	1·7
Acetic	1·2	1·0	0·3	0·4
Propionic	1·1	..	0·3	0·3
Monochloracetic	7·2	5·1	4·3	4·9
Dichloracetic	34	18	23·0	25·3
Trichloracetic	82	63	68·2	62·3
Malic	3·0	5·0	1·2	1·3
Tartaric	5·3	6·3	2·3	2·3
Succinic	0·1	0·2	0·5	0·6

It must be remembered that the solutions not being of quite the same strength these numbers are not strictly comparable, and that the experimental difficulties involved in the chemical measurements are considerable. Nevertheless, the remarkable general agreement of the numbers in the four columns is quite enough to show the intimate connection between chemical activity and electrical conductivity.

Ostwald's Dilution Law.—On the basis of the theory of partial dissociation of electrolytes at intermediate concentrations the ordinary laws of chemical equilibrium have been applied to the case of the dissociation of a substance into its ions. Let x be the number of molecules which dissociate per second when the number of undissociated molecules in unit volume is unity, then in a dilute solution where the molecules do not interfere with each other, xp is the number when the concentration is p. Recombination can only occur when two ions meet, and since the frequency with which this will happen is, in dilute solution, proportional to the square of the ionic concentration, we shall get for the number of molecules re-formed in one second yq^2 where q is the number of dissociated molecules in 1 cu. centimetre. When there is equilibrium, $xp = yq^2$. If μ_c be the molecular conductivity, and μ_∞ its value at infinite dilution, the fractional number of molecules dissociated will be μ_c/μ_∞, which we may write as α. The number of undissociated molecules is then $1-\alpha$, so that if V be the volume of the solution containing 1 gram-molecule of the dissolved substance, we get

$$q=\alpha/V \quad \text{and} \quad p=(1-\alpha)/V,$$

hence
$$x(1-\alpha)V = y\alpha^2/V^2,$$

and
$$\frac{\alpha^2}{V(1-\alpha)} = \frac{x}{y} = \text{constant} = K.$$

This constant K gives a numerical value for the chemical affinity, and the equation should represent the effect of dilution on the molecular conductivity of binary electrolytes.

In the case of substances like ammonia and acetic acid, where the dissociation is very small, $1-\alpha$ is nearly equal to unity, and only varies slowly with dilution. The equation then becomes $\alpha^2/V=K$, or $\alpha=\sqrt{VK}$, so that the *molecular conductivity* is proportional to the square root of the dilution V. Ostwald has confirmed the equation by observation on a large number of weak acids (*Zeits. physikal. Chemie*, 1888, 1889). Thus in the case of cyanacetic acid, while the volume V was changed in stages by doubling from 16 to 1,024 litres, the values of $K\times 10^5$ were 376, 373, 374, 361, 362, 361, 368. The mean values of $K\times 10^5$ for other common acids were: formic, 2·14; acetic, 1·80; monochloracetic, 155; dichloracetic, 5,100; trichloracetic, 121,000; propionic, 1·34. From these numbers we can by help of the equation calculate the conductivity of the acids for any dilution. The value of K, however, does not keep constant so satisfactorily in the case of highly dissociated substances. The anomalies in the dilution law when applied to strong electrolytes, have now been elucidated by means of the theory of complete dissociation.

Degree of Dissociation.—According to the law put forward by Kohlrausch of the independent migration of ions, it follows that the equivalent conductivity of an electrolyte is given by the expression:

$$\Lambda_0=(u+v)F,$$

where Λ_0 is the equivalent conductivity at the limiting dilution when the electrolyte is completely dissociated, u and v are the velocities of anion and cation respectively in cm. per sec. for a potential gradient of 1 volt per cm. and F is the faraday or number of units of current associated with 1 gm. equivalent of matter. In accordance with the theory of partial dissociation for a degree of dissociation α, the quantity of electricity transported by the ions will be given by $\Lambda_c=(u+v)\alpha F$, where Λ_c is the equivalent conductivity for the concentration c. This law has been found to be closely followed in that the conductivity of any given ion is independent of the nature of an ion of opposite polarity with which it is associated. On dividing this equation by the preceding one, we obtain

$$\alpha=\Lambda_c/\Lambda_0,$$

or the degree of dissociation is expressed in terms of the *equivalent conductivity ratio*. In this derivation, however, it is assumed that the velocities of the ions are independent of the concentration.

The *viscosity* of the electrolyte may, however, change with the concentration and accordingly the velocities will require the foregoing expression to be modified to

$$\alpha=\Lambda_c/\Lambda_0, \quad \eta_c/\eta_0,$$

where η_c and η_0 represent the viscosity of the solution and the solvent respectively. To correct for the effect of varying viscosity Washburn (*J. Amer. Chem. Soc.*, 1911) suggests for calculating ionization the equation

$$\Lambda/\Lambda_0\,(\eta/\eta_0)^m,$$

and shows that the value of m never differs from unity by more than 0·2. The calculation of ionization from the equivalent conductivity ratio or the equivalent conductivity-viscosity ratio may be affected by the influence on mobility exerted by the electric charge on the ions as is discussed below, or by changes in the chemical composition of the ions. A decrease in the hydration of the ions takes place in many cases at high concentration and this will presumably cause an increase of the mobility.

Hydrolysis.—A further important chemical change is hydrolysis, which takes place especially with salts of weak acids or bases. The following table shows the percentage hydrolysis (100 h) calculated by the approximate mass-action equation,

$$\frac{h^2}{1-h} = \frac{K_w}{c\,K_{A \text{ or } B}}$$

where K_w, K_A and K_B are the ionization (or dissociation) constants of water, acid and base respectively. The value of K_w is taken as 10^{-14}.

K_A or K_B	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}
0·1 N . . .	0·0032	0·0100	0·0316	0·100	0·316
0·01 N . . .	0·0100	0·0316	0·100	0·316	0·995
0·001 N . . .	0·0316	0·100	0·316	0·995	3·11
0·0001 N . . .	0·100	0·316	0·995	3·11	9·51

Another uncertainty of a different nature involved in the calculation of variation from the equivalent conductivity ratio arises from the fact that the maximum value of Λ is not fully attained even at the smallest concentrations at which accurate measurements have so far been made and that therefore, Λ_0 must be obtained by extrapolation from the Λ values at higher concentrations. In this derivation it is necessary to assume that the fractional relation between equivalent conductivity and concentration, which is found empirically to hold at higher concentrations, continues to hold down to zero concentration.

Change of Equivalent Conductivity.—To express the change of equivalent conductivity with concentration use has generally been made of the function $c(\Lambda_0-\Lambda)=K(c\Lambda)^n$ which corresponds to the ionization relation $(c\alpha)^n/c(1-\alpha)=K$. It is found, however, that the values of n for the concentration intervals 0·1–20 and 10–200 milli-equivalents per litre as a rule differ considerably, showing that the function $(c\Lambda)^n=Kc(\Lambda_0-\Lambda)$, or its equivalent $(c\alpha)^n=Kc(1-\alpha)$ with a single value of the exponent, does not express the change of equivalent conductivity satisfactorily through the range of concentration from 0·0001 to 0·2 normal. At lower concentrations, however, the values of n become nearly identical and equal to about 1·5 for both mono- and divalent salts. A relation found by Kohlrausch to apply closely for many univalent salts between the concentrations 0·001 and 0·1N is of the form $\Lambda=B-KC^{\frac{1}{2}}$. It is found that by correcting for viscosity the term Λ_n/η_0 is closely proportional to the concentration for uni-univalent salts between the concentrations of 1 and 200 millinormal but that considerable deviations occur with uni-bivalent salts.

THEORY OF COMPLETE DISSOCIATION

The classical theory of Arrhenius may be summarized as

having correlated the experiments of Kohlrausch and van't Hoff, postulated a very considerable degree of dissociation in aqueous solutions of salts at ordinary concentrations, and provided a method of calculating the degree of dissociation. The theory accounted for and correlated three common properties of acids, bases and salts, namely, (1) the practically instantaneous exchange of radicals, as compared to the slow reactions of organic chemistry, (2) the increase in equivalent conductivity with dilution to a finite limit set by the mobilities of the ions, (3) van't Hoff's observation that the osmotic properties of this class of substances always exceeded that predicted by his gas law equation $\pi = cRT$, which he had demonstrated was valid for non-electrolytes in dilute solution.

The net results of recent research have shown that the behaviour of the typical strong electrolytes in solvents of high dielectric constant is best explained by the assumption of a complete, or at least practically complete, ionization, while the ionization theory retains its original form in all essential details when applied to weak electrolytes (*cf.* J. N. Brönsted and V. K. La Mer, *J. Amer. Chem. Soc.*, 1924; V. K. La Mer, *Trans. Amer. Electrochem. Soc.*, 1927). In the Arrhenius theory, the degree of dissociation α is, as shown above, calculated from either the conductivity ratio μ_c / μ_0 or Λ_c / Λ_0, where Λ_c is the equivalent conductivity at the concentration c, or from van't Hoff's factor i in the osmotic equation for electrolytes

$$\pi = ic\,RT \tag{1}$$

for according to Arrhenius i is to be interpreted as the quotient of the number of particles present divided by the number which would be present if no dissociation had occurred. If each individual particle behaved independently of its neighbours, *i.e.*, obeyed the gas laws as given by van't Hoff's law then Arrhenius's interpretation of the meaning of i would be valid. However, as is discussed later, the electric charges upon the ions set up electrostatic fields, which do not allow the ions to behave independently as demanded by the gas laws. The effects of these interionic attractions were neglected in the development of the classical theory, whereas, according to the modern point of view, the anomaly of strong electrolytes is to be attributed entirely to their operation. If Arrhenius's assumption in regard to the interpretation of i were correct we should obtain for a salt dissociating into ν ions that

$$\alpha = \frac{i-1}{\nu-1} \tag{2}$$

and from Ostwald's dilution law, as shown previously, we should find that

$$K = \frac{\alpha^2 c}{1-\alpha} = c\,\frac{\left(\dfrac{\Lambda_c}{\Lambda_0}\right)^2}{1-\left(\dfrac{\Lambda_c}{\Lambda_0}\right)} \tag{3}$$

In the following tables the first summarizes the results from conductivity measurements upon the typical weak electrolyte acetic acid.

Values of K for acetic acid in water at 25° C

V is the volume containing 1 mol. Data by Kendall

Approx. Conc.	V	Λ_c	$K \times 10{,}000$
1·00	0·989	1·443	0·1405
0·50	1·977	2·211	0·1652
0·25	3·954	3·221	0·1759
0·13	7·908	4·618	0·1814
0·06	15·816	6·561	0·1841
0·03	31·63	9·260	0·1846
0·016	63·26	13·03	0·1846
0·008	126·52	18·30	0·1847
0·004	253·04	25·60	0·1843
0·002	506·1	35·67	0·1841
0·0001	1012·2	49·50	0·1844
0·0005	2024·4	68·22	0·1853
0·0000	∞	387·9	. .

Values of K from Conductivity Data at 18° C

c	K KCl	K HCl
0·00001	0·00518	. .
0·0001	0·0147	. .
0·001	0·0474	0·189
0·01	0·1542	0·366
0·1	0·5052	. .
1·0	2·14	1·11

Since an approximately constant value of K is obtained for solutions up to 0·1M, the applicability of the Arrhenius theory must be regarded as established for this class of electrolyte to the concentration indicated. On the other hand the second table shows that large deviations occur in the value of K for the typical strong electrolytes potassium chloride and hydrogen chloride, and the Ostwald dilution law breaks down completely for other strong electrolytes. For instance in the case of high valence salts, like $K_4F_e(CN)_6$ and $La_2(SO_4)_3$, K varies about one-million-fold for the same range of concentration.

Explanations of Deviations from Ostwald's Law.—Attempts were for many years made to reconcile these deviations by assuming changing viscosity of the solution, solvation of ions, and compound formation between solvent and solute. The difficulty has, however, only been overcome by adopting a separate theoretical treatment for strong and weak electrolytes. One reason for the reluctance in abandoning the classical view of a considerable, yet substantially incomplete, dissociation of strong electrolytes was that, the values of α calculated from the conductivity ratio and those calculated from the freezing point measurements using equation (2) usually agreed very closely. However, more accurate data recently obtained, particularly with the higher valence types of salts, has shown that the agreement is in general not good. The best experimental data indicate that for 0·1N HCl

$$\frac{\Lambda_c}{\Lambda_0} = 0{\cdot}9207, \qquad \frac{i-1}{\nu-1} = 0{\cdot}917 \text{ (from freezing point)}$$

while the electromotive force measurements upon $H_2-HCl-AgCl$ cells would indicate a value of 0·804. G. N. Lewis has shown that very close agreement is obtained between data from freezing point determinations when treated by strict thermodynamic methods, and e.m.f. data but not with that derived from the conductivity ratio.

The main theories which have adopted the assumption first put forward by Sutherland (*Phil. Mag.*, 1902, 1906) that complete dissociation occurs with strong electrolytes are those of Bjerrum, Milner, Ghosh and Debye and Huckel. Bjerrum was led to this point of view from the observation that the optical properties of solutions of the complex chromium salts are practically independent of the concentration. Milner (*Phil. Mag.*, 1912, *Trans. Faraday Soc.*, 1919) first put forward the theory that the fall in conductivity with increasing concentration is due to a decrease in the mobility of the ions through the influence of inter-ionic forces which cause an increase in the occurrence of the association of the ions. The term *virial* is used to denote the electrostatic forces of an ion multiplied by the distance over which it acts. Values for the molecular lowering of the freezing point are accounted for quantitatively by the theory but no expression has been derived by it to enable the evaluation of conductivity as a function of concentration.

In a theory of Ghosh (*Trans. Chem. Soc.*, 1918), a new departure is made in the representation of the properties of electrolytes. Complete ionization of electrolytes is assumed, and from a consideration of the electrostatic energy of an ionized electrolyte, simple equations are derived to express electrolytic conductivity in aqueous and non-aqueous solutions. On the basis of this hypothesis, the following expressions are derived to express the relation between conductivity and the physical properties of the solution: For binary electrolytes:

$$\frac{Ne^2\sqrt[3]{2N}}{D\sqrt[3]{V}} = 2RT\log_e\frac{\mu_0}{\mu_c}$$

and for ternary electrolytes:

$$\frac{3Ne^2\, 2\sqrt[3]{2N}}{D\sqrt{3}\sqrt[3]{V}} = 3RT\log_e\frac{\mu_0}{\mu_c}$$

where N is Avagadro's number ($6{\cdot}16\times 10^{23}$), e the charge on a univalent ion ($4{\cdot}7\times 10^{-10}$ e.s.u.), D the dielectric constant of the solvent and V its molecular dilution, R the gas constant $= 8{\cdot}315\times 10^{-7}$ in c.g.s. units. These expressions have been found applicable to a large number of aqueous and non-aqueous solutions.

Further considerations that support the theory of complete dissociation are such general observations as the fact that aqueous solutions of the halogen acids exhibit no appreciable vapour pressure of the hydrogen halide below a concentration of 3M., and experiments which have shown that the salt $AgClO_4$ is completely extracted by water from benzene in which it is quite soluble. The studies of the Braggs (W. H. Bragg and W. L. Bragg, *X-ray and Crystal Structure,* 1924) and others on the structure of crystals by means of X-rays furnishes more conclusive evidence for the new point of view. They find that no molecules of NaCl are present in the solid salt; instead the crystal structure consists of sodium and chlorine ions arranged in a cubic lattice, such as that each sodium ion is surrounded at equal distances by six chlorine ions and similarly each chlorine ion by six sodium ions. That the forces holding a crystal of salt together are due to the electrostatic forces between the charged ions has since been established by the calculations of Born, Debye and Scherrer, Fajans, Madelung, and others upon the magnitude of the so-called space lattice energy.

The Activity Coefficient.—(*Cf.* A. A. Noyes and D. A. MacInnes, *J. Amer. Chem. Soc.,* 1920.) The term activity is defined by G. N. Lewis as the quantity which, when substituted for the concentration of the substance in mass-action expressions, will express its effect in determining the equilibrium. Thus the activity of the substance is its effective concentration from this mass action viewpoint and determines the equilibrium of all chemical reactions between salts, acids and bases, and also the magnitude of many physical properties thermodynamically related to the activities. The relative activities of a substance in solution at different concentrations may be determined from its vapour pressure where this is appreciable. A method of more general applicability which has also a thermodynamical basis, is by e.m.f. measurements which are determined by the expression

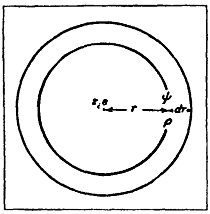

FIG. 3.—DIAGRAM ILLUSTRATING THE DENSITY OF ELECTRIC CHARGE, ρ PRODUCED BY AN ION OF VALENCY z_i AND CHARGE z_ie AT DISTANCE r

$$-\Delta F = RT\log\frac{\xi_1^+\xi_1^-}{\xi_2^+\xi_2^-}$$

where ΔF is the change of e.m.f. with a change of concentration and ξ_1^+, ξ_1^-, ξ_2^+, ξ_2^-, the activities of the ions at the two concentrations. The activity ξ can be replaced by the product cf, in which the quantity f, called the ***activity coefficient,*** is the factor by which the total concentration c, of the substance must be multiplied to give the activity of the ion, or $f=\xi/c$.

With dilute solutions of electrolytes, the value of f (solute) may be regarded on the basis of the Arrhenius theory as the thermodynamic or true degree of dissociation. Measurements of activity coefficients made with sodium, potassium and hydrogen chlorides show that the activity coefficient decreases with increasing concentration much more rapidly than does the equivalent conductivity—viscosity ratio (*i.e.,* the ratio Λ_c/Λ_0 multiplied by the ratio η_c/η_0 of the viscosity of the solution to that of water). With all substances except potassium chloride the activity coefficient, unlike the equivalent conductivity-viscosity ratio, passes through a pronounced minimum in the neighbourhood of 0·5 molal (gram-molecules per litre), afterwards increasing rapidly at the higher concentrations and in some cases exceeding the value of unity. Potassium chloride has a minimum activity coefficient in the neighbourhood of 2N. The activity coefficient, even at moderate concentrations, varies considerably with the nature of the substance; thus its value at 0·5M is 65% for potassium chloride, 73% for lithium chloride and 77% for hydrogen chloride and for potassium hydroxide.

The activity of a component in a solution can be defined most simply by the relation

$$\bar{F} = RT\ ln\ \xi + \bar{F}^0, \tag{4}$$

where ξ is the activity and $\bar{F}$ is the partial molal free energy or Gibbs chemical potential. The activity is consequently a thermodynamic quantity having the dimensions of a concentration, and is determined by the work which is necessary to transport reversibly a gram mol. of the component at constant temperature from some standard reference state, whose partial molal free energy is represented by $\bar{F}^0$, to the given state under consideration.

Since van't Hoff demonstrated that the behaviour of any solute, regardless of its specific characteristics, continuously approaches and finally obeys the gas laws when its concentration in a given solvent approaches a zero value, the most convenient reference state for solutes is one for which the activity of the solute becomes equal to the concentration at infinite dilution. In the case of strong electrolytes where independent means of determining the true concentration of the undissociated molecule are lacking, the standard state of the undissociated molecule is chosen such that the dissociation constant K becomes unity.

Fig. 2 summarizes the general results of the course of the activity coefficient with concentration f_1, f_2, and f_3 refer to the activity coefficient of a univalent, bivalent and trivalent ion or, what amounts to the same thing, the mean (geometric) activity coefficient of the ion comprising a uni-univalent, bi-bivalent or a tri-trivalent salt. A *uni-univalent salt* is one in which both ions are univalent, *e.g.,* sodium chloride. In this figure the salt or ion is present in very small amount in a solution of a uni-univalent salt of concentration c expressed in gram mols. per litre. When a univalent ion is dissolved in 0·1M KCl its activity coefficient is about 70% of its value in an ion-free-medium, while in the case of a trivalent ion the activity coefficient falls to 0·10 at $c=0{\cdot}1$M. This means that the solubility of a tri-trivalent salt is ten times as great in 0·1N KCl as in pure water. We also find as the concentration decreases that the limiting tangent for f assumes an infinite value, just as it did for the osmotic coefficient discussed previously. Obviously, the same objections to the classical theory hold for the activity coefficient of an ion (or salt) as for the osmotic coefficient, since the classical theory demands a finite limiting slope.

Ionic Strength.—When the salt acting as the solvent is of a valency type higher than the uni-univalent or when it is composed of a mixture of salts of different valence types the problem becomes more complex. From a study of the data available in 1921 Lewis and Randall, however, were able to formulate a remarkably simple law which holds in the majority of cases studied thus far; namely that in dilute solutions the activity coefficient of a given strong electrolyte is the same in all solutions of the same ionic strength. The ionic strength μ is defined as one-half the sum of the stoichiometric molar concentration of each ion multiplied by the square of its valency or charge. Thus:

$$\mu = \tfrac{1}{2}(m_1z_1^2 + m_2z_2^2 + m_3z_3^2 + \cdots) = \tfrac{1}{2}\Sigma_1^i m_iz_i^2, \tag{5}$$

where z is the valency and m the molar concentration. That is to say, if $MgCl_2$ were employed as the solvent salt in fig. 2 instead of NaCl we should use the ionic strength of the solution instead of the molar concentration, which in this particular case multiplies the concentration scale by the factor 3. If a (2–2) or (3–1) solvent salt had been used the corresponding factors would be 4 or 6 respectively. If the concentration of the ions or the salt whose activity coefficient is measured is present in appreciable amounts, it must be included in the summation in

addition to the solvent salts to determine the ionic strength. The generalization that the activity coefficient of an ion is determined in dilute solution solely by its valency and the numbers and valencies of all the surrounding ions, and not by specific individual properties as is the case in weak electrolytes, constitutes the strongest evidence for the theory that in strong electrolytes the anomalies are due to electrical effects and not to incomplete dissociation.

Interionic Attraction.—In the theory of Debye and Hückel the properties of electrolytes are elucidated by a consideration of the interionic attraction principle of ionized solutes (Debye, *Phys. Zeit.*, 1924; La Mer *loc. cit.;* A. A. Noyes, *J. Amer. Chem. Soc.*, 1924). The main idea underlying the calculations is that, owing to electrical attractions, an ion of a given sign will on the average be surrounded by more ions of unlike sign than by ions of like sign. The extent of the deviation of the gas laws in terms of the activity coefficient of the ions, or the osmotic deviation of the solvent, is calculated from the following standpoint. When a solution is diluted to a very large volume the ions become separated to such an extent that their mutual electrostatic attractions are no longer of significance, and a uniform random distribution thus prevails, or in other words the gas laws are valid. A determination is then made of the excess electrical work which is involved in this isothermal dilution, due to the rearrangement of the relative position of the ions.

A derivation is made of the energy effect due to electrical forces between the ions by means of two general principles. One, the so-called Boltzmann's principle, is borrowed from the kinetic theory, and the other, known as Poisson's equation, is derived from the laws of electrostatics and involves Coulomb's law. The following considerations will become clearer by reference to fig. 3. In this figure the dot at the centre represents an ion of valency $+z_i$ and charge $+z_ie$, and this produces in a shell of volume dv situated between the distances r and $r+dr$, a potential ψ and a density of electric charge ρ.

The *Boltzmann principle* may be stated as follows: When a large number of molecules possessing an average kinetic energy $\frac{3}{2}kT$ are distributed throughout a region in which there prevail at different points different fields of force (and therefore, different electric potentials) whereby any kind of molecule A in any given volume-element dv acquires a potential energy E, the number of such molecules will equal the number n_A per unit volume in a place where this energy is zero, multiplied by the factor $\epsilon^{-E/kT}$ and by the volume dv.

The following expression for a uni-univalent electrolyte is obtained for the density of free electricity ρ in a unit of volume (1 cu.cm.) of solution;

$$\rho = ne(\epsilon^{-e\psi/kT} - \epsilon^{+e\psi/kT}) = -2ne\left(\frac{e\psi}{kT}\right) \tag{6}$$

where n is the total number of ions present. The electrical potential ψ and the density of electricity ρ are connected by the *Poisson equation* of electrostatics; viz.:

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\psi}{dr}\right) = \frac{d^2\psi}{dr^2} + 2\frac{d\psi}{rdr} = -\frac{4\pi\rho}{D}, \tag{7}$$

where r is the distance, and D the dielectric constant. This differential equation shows how the potential gradient, or field strength, $d\psi/dr$ varies with the electric density ρ and the distance r. From this equation Debye and Hückel derive the expression:

$$\rho = -\frac{e\psi}{kT}\Sigma nz_i^2 \tag{8}$$

Substituting this value of ρ in equation (7) and writing a single constant χ^2 in place of the resulting coefficient of ψ we have

$$\chi^2 = \frac{4\pi e^2}{DkT}\Sigma n_i z_i^2. \tag{9}$$

By integration, the following expression is derived for the total potential

$$\psi = \frac{e}{Da_i} - \frac{e\chi}{D}\cdot\frac{1}{1+\chi a} \tag{10}$$

where a_i is the average apparent diameter, or closest distance of approach of the ions. The first member in (10) represents the potential of an ion in an ion-free medium of dielectric constant D, where it is not influenced by surrounding ions, the second number consequently represents the potential ψ_i at the surface of the ion, due to the presence of the surrounding atmosphere of ions. When the concentration is small, χ is small and equation (10) reduces to

$$\psi_i = -\frac{e}{D}\chi. \tag{11}$$

In the general case the potential at the surface of an ion due to the ionic atmosphere is given by

$$\psi_i = \frac{z_ie\chi}{D}\cdot\frac{1}{1+\chi a_i} \tag{12}$$

which at low concentrations reduces to

$$\psi_i = \frac{-z_ie\chi}{D}. \tag{13}$$

From equation (9) it is seen that $1/\chi$ has the dimensions of distance, and by its use Debye and Hückel avoid the introduction of an average distance between ions based upon the cube root of the concentration. They show further that the use of such an average distance is incorrect, since the ions are not restricted to oscillating above fixed points as in a crystal, but are free to move about. $1/\chi$ which corresponds to the thickness of the Helmholtz double layer is therefore called a *characteristic or probability distance*, and is more exactly defined as the distance at which the potential difference has fallen to $1/\epsilon$ of its value due to the distribution of the surrounding ions. For aqueous solutions (9) yields for a uni-univalent salt

$$\chi = 0{\cdot}327\times10^{-8}\sqrt{m}\ \text{cm.}^{-1}, \tag{14}$$

where m is the molar concentration and may be replaced by the ionic strength μ. In general

$$\chi = 0{\cdot}327\times10^{-8}\sqrt{\mu}\ \text{cm.}^{-1} \tag{15}$$

$1/\chi$ is about ten times the diameter of an ion at $0{\cdot}01\mu$ but of the same order of magnitude as an ion for a $1{\cdot}0\mu$ solution.

Having determined ψ_i the potential at the surface of an ion due to the ionic atmosphere, Debye (*Physik Z.*, 1924), shows that the electrical work of dilution is equal to the work required to build up at a finite concentration the Boltzmann distribution, by charging the ions isothermally and reversibly from zero potential to ψ_i. The electrical free energy of dilution F_e then becomes

$$F_e = \sum_{i=1}^{s}\tfrac{1}{2}\cdot n_iez_i\psi_i = -\frac{kT\chi^3}{12\pi} \tag{16}$$

where $\sum_{i=1}^{s}$ represents the summation of the different types of ions present of. the number per cu. cm., $n_1 \cdots n_i \cdots n_s$. By adding the quantity F_e to the classical expression for the free energy of an ideal solution we obtain the free energy F of an ionic solution.

The activity of a component in a solution can be defined most simply by the relation of G. N. Lewis

$$\overline{F} = RT\ ln\ \xi + \overline{F}_0,$$

where ξ is the activity, $\overline{F}$ is the partial molal free energy, or Gibbs chemical potential, and $\overline{F}_0$ is the partial molal free energy of some standard reference state, such as that of a high degree of dilution when the gas laws are obeyed. The activity coefficient f_i for an ion of the i^{th} sort may be defined by the relation

$$\overline{F}_e = \frac{\delta F_e}{\delta n_i} = kT\ ln\ f_i$$

where $\overline{F}_e$ is the partial molal electrical free energy of that ion. From the above and equation (16) we have

$$-ln\ f_i = \frac{z_ie^2}{2DkT}\chi. \tag{17}$$

When the concentration is expressed as the ionic strength (*cf.* equation 5) in mol. per litre, and χ is replaced by equation (14) the following simple limiting expression is obtained for the activity coefficient of an ion in aqueous solution at 25° C;

$$-\log_{10} f_i = \frac{3\alpha}{2\cdot 3} z_i^2 \sqrt{\mu}, \tag{18}$$

which is valid for high dilutions where the individual properties, such as ionic size, may be neglected,

$$\alpha = N^2 e^3 \sqrt{2\pi}/(10 R D_0 T)^{3/2}, \tag{18a}$$

N being the Avagadro number and R the gas constant per gram. mol. For the usual case of a salt composed of two kinds of ions of valencies z_1 and z_2 respectively the equations of Debye and Hückel yield finally

$$-\log_{10} f_{(ion)} = \frac{3}{2\cdot 3}\alpha z_i^2 \sqrt{\mu} = 0{\cdot}5 z_i^2 \sqrt{\mu} \text{ in aqueous solution} \tag{19}$$

$$-\log_{10} f_{(salt)} = \frac{3}{2\cdot 3}\alpha(-z_1 z_2)\sqrt{\mu} = 0{\cdot}5 z_1 z_2 \sqrt{\mu} \text{ in aqueous solution.} \tag{20}$$

In place of the activity coefficient, use is frequently made of the *osmotic coefficient* which may be derived from the relation $\phi = i/\nu$, where i is defined in equation (1) and ν is the number of ions into which the salt dissociates. The osmotic coefficient is thus the factor necessary to convert the ideal (van't Hoff) osmotic pressure $\bar{\pi}$ to the observed value π, or, in terms of freezing-point measurements, it is the ratio of the observed molal lowering to the theoretical value for the molal lowering.

Thus: $$\pi = \phi\bar{\pi} = \phi cRT$$

or $$\frac{\bar{\pi} - \pi}{\bar{\pi}} = 1 - \phi = \text{osmotic deviation.}$$

From the square root dependence of $ln\, f$ upon the concentration the following relation obtains

$$-ln\, f = 3(1-\phi)$$

Accordingly from (14)

$$1 - \phi = \alpha(-z_1 z_2)\sqrt{\mu} = 0{\cdot}38(-z_1 z_2)\sqrt{\mu} \text{ in aqueous solution} \tag{21}$$

The above deductions have so far related only to ideal salt solutions in which the dimensions of the ions are negligible in comparison with the characteristic distance $1/\chi$. When the concentration becomes of the order of $0{\cdot}01\mu$ or greater it is no longer permissible to neglect the factor $1/(1+\chi a_i)$ in the expression (12) for the potential. In the evaluation of the activity coefficient the factor involving a retains the same form, and instead of (20) we have

$$-\log_{10} f = 0{\cdot}5(-z_1 z_2)\sqrt{\mu}\,\frac{1}{1+0{\cdot}327 a\sqrt{\mu}}. \tag{22}$$

As an expression valid for more concentrated solutions, a is an average value for all the individual a_i values expressed in A.U. (10^{-8} cm.) units and may be considered as the distance of closest approach of two ions. A consideration of these equations shows that if we plot either $-\log_{10} f$ or $1-\phi$ against the square root of the concentration, the data should fall upon a straight line the slope of which is determined solely by the valencies, the dielectric constant of the solution and the absolute temperature.

The simplest and most useful method of testing the relation expressed in equation (14) in very dilute solutions consists in determinations of the solubility of very sparingly soluble salts in solutions of other salts of varying concentration. It follows from thermodynamical principles that the activity of a solute in a saturated solution must always equal the activity of the solid solute. If in a saturated solution the ions of the saturating salt have the mobilities m_1 and m_2, the numbers per molecule of the ions n_1 and n_2 and the corresponding activity coefficients f_1 and f_2, then the equation $m_1^{n_1} m_2^{n_2} f_1^{n_1} f_2^{n_2}$ = constant holds thermodynamically at constant temperature. If various foreign substances (either electrolytes or non-electrolytes) are added to a solution in equilibrium with a solid phase, the stoichiometric solubility (s) changes but the activity of the dissolved particles saturating the solution remains the same, *i.e.*,

$$f_0 s_0 = fs$$

where f_0 is the activity coefficient and s_0 the solubility in what is otherwise pure water, while f and s refer to these values in a solvent prepared by adding foreign substances to the solution. In the ideal region and for no ion in common, the relation becomes

$$ln\, s/s_0 = ln\, f_0 - ln\, f = \alpha z_1 z_2(\sqrt{\mu} - \sqrt{\mu_0}) \tag{23}$$

where μ and μ_0 are the ionic strengths in the two media. The limiting laws have been tested at high dilutions by Brönsted and La Mer by determining the increase in solubility of certain difficultly soluble colbaltammine salts ($s_0 = 0{\cdot}00054$ to $0{\cdot}00005$M) on the addition of small amounts ($0{\cdot}0005$ to $0{\cdot}01$M) of foreign salts which do not interact chemically with the saturating salt. Fig. 4 where $-\log_{10} f$ is plotted against $\sqrt{\mu}$ summarises the results for very high dilutions.

These data verify the theory in the following respects: (1) The value of α as calculated by the theory is correct within the limits of error for which D is known for pure water since the slope of line (1) equals 0·50. (2). The valence factor $z_1 z_2$ (z_i^2 for a single ion) is correct, since the slopes of the lines are in the corresponding ratios 1:2:3:9. (3) The principle of ionic strength is valid for the simpler types considered, since the values of f when compared for different solvent salts at the same ionic strength agree among themselves for a saturating salt of a given valence type. The theory as developed above deals only with the so-called ideal salt solutions, where the properties of the solution depend simply upon the numbers and valencies of the ions. With rising concentration the activity coefficient depends to an increasing degree upon the chemical character of the ions in solution and particularly on the influence of ionic size. For these solutions the expression given in equation (22) is applicable. Further confirmation of the validity of the Debye theory is obtained from the concordance in the values of a, the mean effective diameter of the ions, as determined from freezing point and from solubility measurements.

The simple form of the Debye theory has been extended by Hückel to more concentrated solutions by introducing the assumption that the dielectric constant is a linear function of the concentration of ions. The following equation is derived:

$$-\log_{10} f = \frac{(-z_1 z_2)\alpha\sqrt{\mu}}{1+0{\cdot}327 a\sqrt{\mu}} + B2c,$$

where B is a function depending on the dielectric constant and c is the concentration in molecules per litre. This expression differs from equation (22) by the added term $B2c$. This equation has been found to give a good representation of the data for a number of solutions.

Ion Association.—Bjerrum has developed a hypothesis according to which a state of association is to be regarded as existing between two ions when their distance of separation is less than a certain critical minimum. The law of mass action is considered applicable to the association equilibrium. A consideration which arises from this hypothesis is whether this view of ion-association merely states the classical view of incomplete dissociation in its converse form. However although an associated ion pair may be regarded as physically identical with an undissociated molecule of salt, a distinction between the two views is to be made from the standpoint of the molecular forces involved. The forces which produce ion-association obey Coulomb's law and vary as the inverse square of the distance, whereas the forces involved in a true dissociation equilibrium must vary according to a much higher inverse power of the distance. A discrete energy difference must exist between undissociated molecules and their ions, while the difference in energies between associated and free ions will vary continuously, depending on the distance of separation.

It seems logical to assume that even with a completely ionized salt such as potassium chloride, occasionally a K′, and Cl′ ion may collide under such favourable circumstances that a rearrangement in electron orbits occurs, whereby a true undissociated molecule

possessing a pair of shared electrons is formed. The reciprocal of the dissociation constant of the mass action function is a measure of the number of such molecules. With hydrogen and acetate ions it is very frequent, since $K = 1{\cdot}8 \times 10^{-5}$. With the strong electrolytes the probability would be vanishingly small and in an ideal strong electrolyte zero. It has been computed by different methods that the true dissociation constant of HCl in water is of the order of 10^6 to 10^7. This means that the probability of the existence of an undissociated molecule of HCl is only about one in a million when the total concentration is one molar. Knight and Hinshelwood (*J. Chem. Soc.*, 1927) from the distribution of HCl between benzene and water find that the transition to the non-polar form occurs at about 13 molar in water. In the case of most salts the probability that its ions will share an electron pair is without doubt much less, so small in fact, that it is a question of no immediate practical importance whether we consider potassium chloride to be completely ionized or whether we say it is only practically completely ionized.

MODERN THEORY OF POLARITY

Until recently the source of the opposite electric charges on the ions of dissociated compounds remained obscure, but their origin has now been satisfactorily explained from a consideration of the physical theories which have been developed to account for the structure of the atom. According to present theories which have been developed by J. J. Thomson (*Phil. Mag.* 1914), Kossel (*Ann. Physik,* 1916), G. N. Lewis (*J. Amer. Chem. Soc.*, 1916), and I. Langmuir (*Ibid.*, 1920), the atom consists of a nucleus which remains unaltered in all ordinary chemical changes, and possesses an excess of positive charges corresponding in number to the ordinal number of the group in the periodic table to which the element belongs (*see* PERIODIC LAW). The nucleus is surrounded by negative charges or electrons which, on the Lewis-Langmuir theory are maintained in definite positions through the equilibrium between the opposing influences of the electro-static attraction of the central charge and the mutual repulsion of the ions (*see* VALENCY). A further factor which operates in this equilibrium is a force of repulsion which appears between nucleus and ion at very short intervals of separation. The number of electrons in

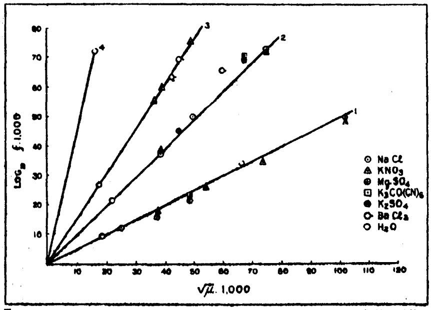

FIG. 4.—GRAPHS SHOWING THE RELATION BETWEEN SOLUBILITY AND IONIC STRENGTH OF SLIGHTLY SOLUBLE COBALTAMINE SALTS OF DIFFERENT VALENCE TYPES IN THE PRESENCE OF SECOND SALTS OF VARYING VALENCIES; NO. 1.—$Z_1=1$; $Z_2=1$: NO. 2.—$Z_1=1$: $Z_2=2$: NO. 3.—$Z_1=1$; $Z_2=3$: NO. 4.—$Z_1=3$; $Z_2=3$

the outer layers are, in the neutral atom, equal in number to the excess of positive charge of the nucleus, but the number of electrons in the shell may vary during chemical change between 0 and 8. A group of eight electrons forms a complete shell and, according to the number of these shells, gives one of the inert elements, helium, neon, argon, krypton or xenon. All atoms tend to attain the electron configuration of the inert gases, because these configurations are the most stable; therefore all atoms attempt, either to give up all the valence electrons (electro-positive valence) so that each arrives at the electron number of the proceeding inert gas, or to take on so many electrons that the outer electron group will be brought up to the number of electrons of the next higher inert gas. Chemical attraction between two atoms may accordingly arise from one or two mechanisms. (1) The tendency of one atom to complete its shell of electrons at the expense of a second atom, thus leaving one atom with an excess of positive charges and the second with an excess of negative charges. The electrostatic attraction thus produced maintains the combination. The number of electrons which may be detached or acquired by this process is a measure of the valency of the element. This type of union occurs in such a compound as hydrogen chloride, the hydrogen having released its single electron to supplement the seven electrons around the chlorine and complete its octet. On account of the unsymmetrical nature of the hydrogen atom the electron is readily lost, leaving the residue a positively charged hydrogen ion. (2) The atoms may orientate themselves in such a manner that from one to four electrons of each atom may be shared or held in common in the structure of both atoms. In this way the shells of electrons are completed to form stable groups without disturbing the electrical neutrality of the system.

In the first type of combination the valence electron is almost completely removed from the one atom and enters the assemblage of the other. Such compounds, which are said to be ***hetero-polar or polar***, and decompose with relative ease into ions, are held together mainly by Coulombian electrostatic forces. In the second type, sometimes known as covalency, the valence electrons describe such orbits in the compound that they belong equally to both atoms; since these atoms have the same electric charge, such compounds are called *homopolar or non-polar.* They show no tendency to dissociate into ions. A large portion of the chemical compounds can be classified in these two limiting groups without much difficulty. Rigorously homo-polar compounds exist only in the union between the two atoms of the same species such as in H_2, O_2 N_2. As soon as different kinds of atoms combine, some dissymmetry in the division of the electric charges can always be observed by such means as the existence of an infra-red spectrum. The difference between the above two types can thus only be regarded as one of degree and not of kind.

According to a representation of Lewis and Randall (*J. Amer. Chem. Soc.*, 1921), if we have a uni-univalent electrolyte whose cation is M and whose anion is X, the molecule may be represented by the formula $M{:}\ddot{\underset{..}{X}}{:}$, where the pairs of dots represent the valence electrons, or the electrons of the outer shells. The pair lying between the atomic nuclei M and X constitutes the chemical bond. In the weak electrolytes, like acetic acid or mercuric chloride, this approximates to the typical bond of organic chemistry, but as we pass to stronger electrolytes the nucleus of the cation draws away from this bonding pair until, in the limit, this electron pair may be regarded as the property of the anion alone. Then the positive ion, which is the nucleus M is held to symmetrical anion ${:}\ddot{\underset{..}{X}}{:}$ only by the fact that they are oppositely charged. When an electrolyte in a strongly polar or electrophilic medium approximates this condition it may be classified as a strong electrolyte.

Polarity.—The property of solutions of forming electrolytic conductors is associated with a classification which may be drawn between compounds according to whether they may be regarded as polar or non-polar. The distinction between these two classes is one of degree only and not of type, and depends not only on the constitution of the compound but on the medium in which it is dissolved. In comparison with non-polar compounds, the polar compounds are characterized by possessing a high degree of ionization or a good ionizing power as solvents, high dielectric constants, power of association, tautomerism, being electrophilic and forming molecular complexes.

Polarity of a molecule arises from the fact that in a molecular structure formed by interchange of electrons, although the charge of the nucleus is balanced by the surrounding electrons, yet on account of the unsymmetrical structure of the molecule the centre of the positive charges does not necessarily coincide with that of the negative ones, so that the molecule has a definite electric

moment. There is thus a stray field of force around the molecule and a bipole is formed, one side of the molecule being more positive or negative than the other. The molecule will thus attract and be attracted by other molecules. If the molecules of solvent possess a similar property, the negative side of one molecule will be attracted by the positive side of another and a definite electrostatic attraction exhibited which is shown as residual valency. When displacement of an electron occurs, and the charged parts of the molecule are separated by an appreciable distance, a bipole (or multi pole) of high electric moment is obtained and its force of attraction for another molecular bipole will be felt over a considerable intervening distance.

The part played by the solvent in dissociation is shown in that a bipole of small molecular moment which would scarcely attract a similar molecule, will be very appreciably attracted by a polar molecule or bipole of high moment and may form with it a double molecule. In general, if two molecules combine or even approach one another, each weakens the constraints which hold together the charge of the other, and the electrical moment of each is increased. This effect is cumulative in that, when two molecules by their approach or combination become more polar they draw other molecules more strongly towards them and this increases still further their polar character. The polar character of a substance thus depends not only upon the specific properties of the individual molecules but also upon what may be termed the strength of the polar environment.

According to the octet theory of valency, strong bases such as potassium hydroxide, barium hydroxide and all typical salts are to be regarded as completely ionized even in the solid condition. In the hydrochloric acid molecule the properties may be explained by regarding the hydrogen nucleus as sharing a pair of electrons with the chlorine atom. Anhydrous liquid hydrogen chloride is, therefore, a non-conductor of electricity since there are no free ions. In contact with water, however, separation of the molecule into ions occurs, which may be explained either from a consideration of the dielectric effect of the solvent, or else by regarding the hydrogen nucleus as attaching itself more easily to the unshared pairs of electrons in the octets of the water molecules than to the chlorine atoms, since the nuclei of the oxygen atoms have smaller positive charges than those of the chlorine atoms. The result is that the hydrogen nuclei become hydrated hydrogen ions, and the chlorine ions remain in solution. With a weak acid such as hydrogen sulphide, the tendency for the hydrogen nucleus to separate from the octet is very much less, which may be explained by the smaller positive charge on the nucleus of the sulphur atom causing the hydrogen nucleus to be much more firmly held. From this viewpoint, acids are thus to be regarded as substances from whose molecules hydrogen nuclei are readily abstracted, while bases are substances whose molecules can easily take up hydrogen nuclei.

Dielectric Constant.—The difference between polar or highly-ionized and non-polar or slightly ionized compounds is reflected in the dielectric constant which measures the number of free charges in the substance multiplied by the average distance through which these charges move under the influence of a definite electric field. It was enunciated by J. J. Thomson and independently by Nernst in 1893 that the ionizing power of a solvent is closely connected with its dielectric constant. This effect follows from Coulomb's law in which $f = \frac{1}{D} \frac{e_1 e_2}{l^2}$ where f represents the attracting or repelling force of unlike or like charges of electricity, e_1 and e_2 the electric charges which are separated by the distance l and D the dielectric constant.

In a detailed investigation made by Walden (*Z. Physik. Chem.*, 1903, 1906) the dissociating power of a very large number of organic liquids for the solute tetra ethyl ammonium iodide was measured, and it was found that a close parallelism exists between the dielectric constant of the solvent and the percentage dissociation of the solute. An empirical relation which was found to apply is given by the equation $D \sqrt[3]{\frac{1}{c}} =$ constant where c is the concentration at which the degree of ionization of the solute has a definite value in any solvent. It was found by Walden that the value of the dielectric constant of liquids is determined by certain groups. By the substitution of the following groups the magnitude of the increase of dielectric constant becomes greater in the following order:—

I, Br, Cl, F, NH_2, CN, CO_2H, CHO, CO, NO_2, OH.

According to the theory of Debye and Huckel the magnitude of inter-ionic effects is proportional to $D^{-\frac{3}{2}}$ as shown in equation (18a), and consequently should be most marked in solvents of low dielectric constant. The solvent cyclohexanol, for instance, has a dielectric constant of 15, so that $1-\phi$ and $-ln\ f$ should be $(88/15)^{-\frac{3}{2}} = 14{\cdot}2$ times greater than in water. Lithium salts are sufficiently soluble in cyclohexanol to determine the freezing-point depression, and the molar freezing-point constant (38·3°C) is twenty times that of water (1·86°). The results obtained are in close agreement with those required by the theory.

Voltaic Cells.—When two metallic conductors are placed in an electrolyte a current will flow through a wire connecting them, provided that a difference of any kind exists between the two conductors in the nature either of the metals or of the portions of the electrolyte which surround them. A current can be obtained by the combination of two metals in the same electrolyte, of two metals in different electrolytes, of the same metal in different electrolytes or of the same metal in solutions of the same electrolyte at different concentrations. In accordance with the principles of energetics (*q.v.*), any change which involves a decrease in the total available energy of the system will tend to occur, and thus the necessary and sufficient condition for the production of electromotive force is that the available energy of the system should decrease when the current flows.

In order that the current should be maintained and the electromotive force of the cell remain constant during action, it is necessary to ensure that the changes in the cell, chemical or other, which produce the current should neither destroy the difference between the electrodes, nor coat either electrode with a non-conducting layer through which the current cannot pass. As an example of a fairly constant cell we may take that of Daniell, which consists of the electrical arrangement—zinc | zinc sulphate solution | copper sulphate solution | copper—the two solutions being usually separated by a pot of porous earthenware. When the zinc and copper plates are connected through a wire a current flows, the conventionally positive electricity passing from copper to zinc in the wire and from zinc to copper in the cell. Zinc dissolves at the anode, an equal amount of zinc replaces an equivalent amount of copper on the other side of the porous partition, and the same amount of copper is deposited on the cathode.

It is necessary to observe that the condition for change in a system is that the total available energy of the whole system should be decreased by the change. Thus in the Daniell cell the dissolution of copper as well as of zinc would increase the loss in available energy. But when zinc dissolves, the zinc ions carry their electric charges with them, and the liquid tends to become positively electrified. The electric forces then soon stop further action unless an equivalent quantity of positive ions are removed from the solution. Hence zinc can only dissolve when some more easily separable substance is present in solution to be removed *pari passu* with the dissolution of zinc. The mechanism of such systems is well illustrated by an experiment devised by W. Ostwald. Plates of platinum and pure or amalgamated zinc are separated by a porous pot, and each surrounded by some of the same solution of a salt of a metal more oxidizable than zinc, such as potassium. When the plates are connected together by means of a wire no current flows and no appreciable amount of zinc dissolves, for the dissolution of zinc would involve the separation of potassium and a gain in available energy. If sulphuric acid be added to the vessel containing the zinc, these conditions are unaltered and still no zinc is dissolved. But on the other hand if a few drops of acid be placed in the vessel with the platinum, bubbles of hydrogen appear and a current flows, zinc dissolving at the anode, and hydrogen being liberated at the cathode. In order that positively electrified ions may enter a solution, an equivalent

amount of other positive ions must be removed or negative ions be added, and for the process to occur spontaneously the possible action at the two electrodes must involve a decrease in the total available energy of the system.

Concentration Cells.—As stated above, an electromotive force is set up whenever there is a difference of any kind at two electrodes immersed in electrolytes. In ordinary cells the difference is secured by using two dissimilar metals, but an electromotive force exists if two plates of the same metal are placed in solutions of different substances or of the same substance at different concentrations. In the latter case the tendency of the metal to dissolve in the more dilute solution is greater than its tendency to dissolve in the more concentrated solution, and thus there is a decrease in available energy when metal dissolves in the dilute solution and separates in equivalent quantity from the concentrated solution. An electromotive force is therefore set up in this direction, and if we can calculate the change in available energy due to the processes of the cell we can foretell the value of the electromotive force. Now the effective change produced by the action of the current is the concentration of the more dilute solution by the dissolution of metal in it, and the dilution of the originally stronger solution by the separation of metal from it. We may imagine these changes reversed in two ways. We may evaporate some of the solvent from the solution which has become weaker, and thus reconcentrate it, condensing the vapour on the solution which had become stronger. By this reasoning Helmholtz showed how to obtain an expression for the work done. On the other hand we may imagine the processes due to the electrical transfer to be reversed by an osmotic operation. Solvent may be supposed to be squeezed out from the solution which has become more dilute through a semi-permeable wall, and through another such wall allowed to mix with the solution which in the electrical operation had become more concentrated. Again, we may calculate the osmotic work done, and if the whole cycle of operations be supposed to occur at the same temperature, the osmotic work must be equal and opposite to the electrical work of the first operation.

The result of the investigation shows that the electrical work Ee is given by the equation

$$Ee=\int_{p_1}^{p_2} v\,dp$$

where v is the volume of the solution used and p its osmotic pressure. When the solutions may be taken as effectively dilute, so that the gas laws apply to the osmotic pressure, this relation reduces to

$$E=\frac{n^{\nu}RT}{ey}\log_e\frac{c_1}{c_2}$$

where n is the number of ions given by one molecule of the salt, r the transport ratio of the anion, R the gas constant, T the absolute temperature, y the total valency of the anions obtained from one molecule, and c_1 and c_2 the concentrations of the two solutions. If we take as an example a concentration cell in which silver plates are placed in solutions of silver nitrate, one of which is ten times as strong as the other, this equation gives

$$E=0{\cdot}060\times10^8 \text{ c.g.s. units}$$
$$=0{\cdot}060 \text{ volts.}$$

W. Nernst, to whom this theory is due, determined the electromotive force of this cell experimentally, and found the value 0·055 volt.

The logarithmic formulae for these concentration cells indicate that, theoretically, their electromotive force can be increased to any extent by diminishing without limit the concentration of the more dilute solution, log c_1/c_2 then becoming very great. This condition may be realized to some extent in a manner that throws light on the general theory of the voltaic cell. Let us consider the arrangement—silver | silver chloride with potassium chloride solution | potassium nitrate solution | silver nitrate solution | silver. Silver chloride is a very insoluble substance, and here the amount in solution is still further reduced by the presence of excess of chlorine ions of the potassium salt. Thus silver, at one end of the cell in contact with many silver ions of the silver nitrate solution, at the other end is in contact with a liquid in which the concentration of those ions is very small indeed. The result is that a high electromotive force is set up, which has been calculated as 0·52 volt, and observed as 0·51 volt. Again, Hittorf has shown that the effect of a cyanide round a copper electrode is to combine with the copper ions. The concentration of the simple copper ions is then so much diminished that the copper plate becomes an anode with regard to zinc. Thus the cell—copper | potassium cyanide solution | potassium sulphate solution—zinc sulphate solution | zinc—gives a current which carries copper into solution and deposits zinc. In a similar way silver could be made to act as anode with respect to cadmium.

It is now evident that the electromotive force of an ordinary chemical cell such as that of Daniell depends on the concentration of the solutions as well as on the nature of the metals. In ordinary cases possible changes in the concentrations only affect the electromotive force by a few parts in a hundred, but by means such as those indicated above it is possible to produce such immense differences in the concentrations that the electromotive force of the cell is not only changed appreciably but even reversed in direction. Any reversible cell can theoretically be employed as an accumulator, though in practice conditions of general convenience are more sought after than thermodynamic efficiency (*see* ACCUMULATOR.) The reversibility of a cell is in general modified by the phenomenon of polarization (*see* ELECTRO-CHEMISTRY).

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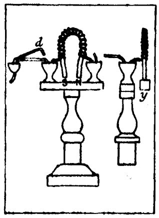
ELECTROLYTE. A solution which conducts electricity (*see* ELECTROLYSIS).

ELECTROMAGNET. Soon after the discovery, by Oersted in 1820, of the directive action of an electric current on a magnetic needle, it was found that a wire carrying an electric current also possessed the power of magnetizing pieces of steel and iron placed near it. This discovery was made by D. F. J. Arago (*Ann. de Chim. et de Physique*, 1820), who announced that a copper wire conveying an electric current could magnetize steel needles placed across it, and could attract iron filings. In October of the same year these facts were discovered independently by Sir Humphry Davy (*Phil. Trans. R. S.*, 1820). In one of Davy's experiments a number of steel needles were fastened to a silver wire in different directions, some being parallel and others transverse to the wire. When the ends of the wire were connected to a battery the needles parallel to the wire attracted iron filings in much the same way as did the wire itself, and they lost this power when the connection with the battery was broken. Each of the needles placed across the wire, however, acquired two magnetic poles, and retained its magnetism after the current was broken. Pieces of iron wire placed across the silver wire also became magnetized, and they lost their magnetism when the battery connection was broken. About the same time Arago and A. M. Ampère magnetized a steel needle which was wrapped in paper and placed within a helical coil of wire carrying a current.

It was a short but extremely important step from these preliminary discoveries to the production of the electromagnet, a combination of coil of wire and iron core which was destined to become one of the principal elements in the successful development of the technical applications of electricity. The step was taken by William Sturgeon, a native of Whittingham, in Lancashire, where he was born in 1783. He was a shoemaker by trade and for 18 years a private soldier in the Royal Artillery, entirely self-taught, but an enthusiastic experimenter in electricity. Sturgeon's electromagnet, front and side views of which are shown in fig. 1, was described by him in a communication to the Society of Arts in 1825 (*Trans. Society of Arts*, 1825). It consisted of

a bent bar of soft iron, about a foot long and half an inch in diameter, coated with varnish, on which was wound a coil of bare copper wire of 18 turns. The ends of the wire dipped into mercury cups, mounted on a wood stand, for leading in the electric current. When a current was passed through the wire the bar became a strong magnet, and could support a heavy iron mass applied to its ends, as at *y*, fig. 1. When the connection at *d* was broken, the weight immediately fell. The weight of the bent iron core of Sturgeon's electromagnet was 7 oz., and when excited by the current from a single cell it supported a weight of 9 lb. Sturgeon's experiments soon attracted the attention of other investigators, among them Joseph Henry in the United States, who in 1831 described an important improvement which he had effected (*Silliman's Journal*, 1831). Instead of insulating the iron bar he covered the wire with silk, and wound a great number of turns of it round the bar in the same direction. A horseshoe-shaped electro-magnet which he made in this way for Princeton lifted 750 lb. when excited by the current from a small battery, and another one, for Yale college, supported 2,086 lb. Henry also found that his electromagnets could be operated by a battery at a considerable distance, and actually succeed by this means in establishing an electromagnetic telegraph in 1831.



BY COURTESY OF ROYAL SOCIETY OF ARTS FROM THE "TRANSACTIONS OF THE SOCIETY"

FIG. 1.—FRONT AND SIDE VIEWS OF STURGEON'S ELECTROMAGNET, THE FIRST TO BE INVENTED (1825)

In 1838 Sturgeon removed to Manchester, where he came into contact with J. P. Joule, who afterwards became famed for his researches on the equivalence of heat and mechanical work. During the two following years Joule devoted much attention to the study of the lifting power of electromagnets. One form which he constructed consisted of a thick-walled tube of wrought iron, cut longitudinally into two unequal parts. The larger part was wound longitudinally with insulated copper wire, and the smaller part acted as keeper. This electromagnet, the iron of which weighed 15 lb., was found to be capable of supporting a weight of 2,090 lb. In another form of lifting magnet designed by Joule, a number of flat pieces of iron were bolted to one side of a strong brass ring, and had rectangular grooves cut in them of width equal to the spaces between them. A bundle of insulated copper wires was bent to and fro in the grooves and the spaces. A similar set of pieces of iron, but without grooves, was bolted to another brass ring, and applied to the first set, as armature, so that the grooves in the first covered the spaces in the second. A "zigzag ring of iron" was thus formed, and with the current from 16 cells a weight of 2,710 lb. was supported, the weight of the iron pieces being in all 11·575 lb. (*See* Joule's *Scientific Papers* published by the Physical Society of London.)

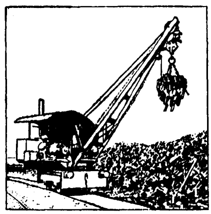
Lifting magnets are now much used for lifting steel ingots, tubes, girders, scrap iron, etc., and for handling metal when it is at a high temperature. They are also made watertight so that they can operate under water. Modern lifting magnets are usually of the bell or mushroom form, the magnetizing coil being placed round the central core, and the poles being therefore at the centre and the rim. In fig. 2 is shown a lifting magnet in operation, and the steam engine and dynamo for generating the current supplied to the magnet. A magnet of this type, 66in. in diameter, and weighing nearly 3 tons, can support ten times its weight of iron.

Owing to the great normal pressure between strongly magnetized surfaces in contact, a large amount of friction may be called into play, and this force, which is easily controllable, is put to practical use in electromagnetic clutches, chucks and brakes. Electromagnets are also used, for a great variety of purposes, in producing movement at a distance from the operator, as in electric bells, telephone receivers and wireless loud speakers. The electromagnet provides, in fact, by far the most convenient means of producing such effects. Probably the most important practical applications of the electromagnet, however, are found in the dynamo and the electric motor, where it is used for producing the electric field in which the armature rotates, and in the transformer, where a varying field is caused to induce current in a secondary circuit.

In addition to its practical uses, the electromagnet has also played a part in several important scientific discoveries. It was used by Faraday in his discovery of the rotation of the plane of polarization of light in a magnetic field, and other investigations in magnetism. One of Faraday's electromagnets is still preserved at the Royal Institution. The Kerr magnetic effect, a rotation of the plane of polarization of light reflected from the polished pole piece of a magnet, was discovered by Dr. John Kerr with an electromagnet now in the Natural Philosophy department of the University of Glasgow. An electromagnet was also used by Zeeman in his great discovery of the effect now known by his name, a splitting of the spectral lines of a source of light placed in a magnetic field. The practical and scientific applications of electromagnets are almost innumerable. All we can here attempt is to make a broad classification of them, and to give an outline of the principles underlying the action of electromagnets, and the design of electromagnets for the various purposes which they are intended to serve.

The Magnetic Circuit.—Every electromagnet includes an electric circuit linked with a magnetic circuit in which there is a certain amount of magnetic flux, or number of tubes of magnetic induction. The relation between the electric current and the magnetic flux is expressed by the equation of the magnetic circuit, which is based upon the two fundamental principles:—(1) The line integral of the magnetic force H taken round any closed curve, known as the magnetomotive force in the curve, is equal to $4\pi ni$, where n is the number of turns of wire linked with the curve, and i is the current in the wire in c.g.s. units. (2) Just as the electric current is the same in all parts of the electric circuit, so the total magnetic flux is the same in all parts of the magnetic circuit.

The relation between the magnetomotive force and the flux in a magnetic circuit is expressed in terms of a quantity known as the magnetic reluctance of the circuit. This quantity depends upon the dimensions of the circuit and upon the magnetic quality of the materials of which it is composed. Its value may be derived in the following manner. In any portion of the circuit of mean length l and cross section S, let the mean value of the magnetic force be H, and let N denote the total flux. Then the mean value of the flux density, or magnetic induction, B, is N/S, and from the definition of magnetic permeability μ $H=B/\mu=N/\mu S$, and therefore $Hl=Nl/\mu S$. Forming similar equations for the other portions of the circuit and adding them together, bearing in mind that N is the same in all parts of the circuit, we have, on the left-hand side of the resulting equation, the magnetomotive force in the circuit, and, on the right hand side, the product of the flux and the sum of the quotients $l/\mu S$ for all parts of the circuit. This sum is what is known as the magnetic reluctance of the circuit. It may also be expressed as the sum of the quantities $l\rho/S$ for all parts of the circuit, where ρ is the reluctivity of the material, *i.e.*, the reciprocal of the permeability.



BY COURTESY OF WITTON-KRAMER ELECTRIC TOOL & HOIST WORKS

FIG. 2.—LIFTING MAGNET, "MUSHROOM" FORM, CAPABLE OF SUPPORTING TEN TIMES ITS OWN WEIGHT OF IRON. THE DYNAMO FOR GENERATING THE CURRENT IS DRIVEN BY A STEAM ENGINE

If the current is expressed in amperes, the magnetomotive force is $4\pi ni/10$, or $1{\cdot}257ni$. Thus the equation of the magnetic circuit is $1{\cdot}257 \times$ampere-turns $(ni)=N\times$magnetic reluctance. This equation is analogous to that which expresses Ohm's law for an electric circuit; viz., electromotive force=current$\times$resistance. An important difference between the electric circuit and the mag-

netic circuit arises from the fact that, whereas the electric resistance of a solid or liquid conductor is independent of the current so long as the temperature and other physical conditions are constant, the magnetic reluctance varies with the magnetic flux, and for its determination a knowledge of the permeability of the materials at different flux densities is required. From the permeability curves of the materials the magnetic reluctance of each portion of the magnetic circuit can be calculated, and hence the ampere-turns required to produce a given flux in the circuit.

As an example, suppose that a ring of iron has a mean diameter of 10cm. and a cross section of 2sq.cm., and a transverse cut or air gap made in it 1mm. wide. Let us inquire the ampere-turns required on the ring to create in it a total flux of 24,000 c.g.s. units. The length of the iron part of the circuit is $10\pi - 0{\cdot}1$cm., and as its section is 2sq.cm., the flux density in it is 12,000 c.g.s. units. Assuming that the permeability of pure iron at this flux density is 2,760, we find that the reluctance of the iron portion of the circuit is $(10\pi - 0{\cdot}1)/2 \times 2{,}760$, or about 0·0057 c.g.s. unit. The length of the air gap is 0·1cm., its section 2sq.cm., and its permeability unity. Hence the reluctance of the air gap is $0{\cdot}1/2 = 0{\cdot}05$ c.g.s. Consequently the number of ampere-turns required to produce the flux is $ni = \frac{24{,}000}{1{\cdot}257}(0{\cdot}0057 + 0{\cdot}05) = 1060$ (nearly).

We may therefore say that the part of the magnetomotive force required to overcome the reluctance of the air gap is about nine times that required for the iron alone. In reality, when there is an air gap in a magnetic circuit, the flux does not all pass straight across it, as we have assumed in the above example, but it spreads out beyond the edge of the gap. The flux within the gap is less than the mean flux in the iron. If it were required to produce a certain flux in the air gap, extra ampere-turns would be necessary to allow for this spreading. The correction in such cases is determined by the use of what are called leakage co-efficients, *i.e.*, numbers representing the ratio of the mean flux in the iron portion of the circuit to the flux in the gap. The practical application of the principle of the magnetic circuit to the predetermination of the field windings of dynamo magnets was first made by J. and E. Hopkinson (*Phil. Trans.*, 1886). (*See* ELECTRIC GENERATOR.)

Iron and Steel for Electromagnets.—There are many methods for determining the permeability of magnetic materials at various values of the flux density, for an account of which reference may be made to the article MAGNETISM. In Table I. are given values of *B* and *H*, found by Ewing by the ballistic method, for two magnetic materials which are used in the construction of electromagnets (*Proc. Inst. C.E.*, 1896). The figures under heading (*a*) refer to a sample of forged ingot iron for dynamo magnets, those under (*b*) to an unforged steel casting made by the Siemens process. The values of the magnetizing force *H*, and the flux density *B*, are given in c.g.s. units.

TABLE I.

H	*B*		*H*	*B*	
	(*a*)	(*b*)		(*a*)	(*b*)
5	12,300	9,600	50	17,500	16,900
10	14,920	13,050	60	17,750	17,180
15	15,800	14,600	70	17,970	17,400
20	16,280	15,310	80	18,180	17,620
30	16,810	16,000	90	18,390	17,830
40	17,190	16,510	100	18,600	18,030

Table II. shows values of *H*, *B*, and the permeability μ, obtained by J. A. Fleming for a typical cast iron, by the ballistic method.

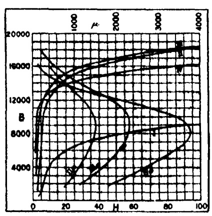
TABLE II.

H	*B*	μ	*H*	*B*	μ	*H*	*B*	μ
0·19	27	139	8·84	4,030	456	44·65	8,071	181
0·41	62	150	10·60	4,491	424	56·57	8,548	151
1·11	206	176	12·33	4,884	396	71·98	9,097	126
2·53	768	303	13·95	5,276	378	88·99	9,600	108
3·41	1,251	367	15·61	5,504	353	106·35	10,066	95
4·45	1,898	427	18·21	5,829	320	120·60	10,375	86
5·67	2,589	456	26·37	6,814	258	140·37	10,725	76
7·16	3,350	468	36·54	7,580	207	152·73	10,985	72

The metal of which the tests are given in Table II. contained 2% of silicon, 2·85% of total carbon, and 0·5% of manganese. In fig. 3 the flux density and the permeability for other typical samples of commercial iron and steel for electromagnets (from data in Miles Walker, *Specification and Design of Dynamo Electric Machinery*, 1918), are shown in the form of curves. Curve I. is the magnetization curve, or (*B*, *H*) curve of a sample of cast-iron. Curve II. is the magnetization curve of an annealed steel casting, unforged, containing 0·2% of carbon. Curve II.*a* shows the permeability (upper horizontal scale) of this material for various values of *B* shown on the vertical scale. Curves III. and III.*a* are the magnetization and permeability curves for an annealed sample of forged ingot iron. Curves IV. and IV.*a* similarly show the magnetic properties of a sample of silicon steel containing 4·8% of silicon and 0·2% of carbon. Ingot iron is probably the purest iron which can be obtained commercially in large quantities. The sample the magnetic properties of which are shown in curves III. and III.*a*, fig. 3, contained 0·15% of carbon, but in some samples the total foreign matter, including carbon, manganese, sulphur, does not amount to this percentage of the whole. Owing to its relatively high permeability at all values of the flux density, this material is very suitable for the cores of dynamo magnets. It is, however, not very suitable for electromagnets supplied with alternating currents, owing to its low specific resistance, or resistivity, and the consequent losses in it due to eddy currents. The maximum permeability of the specimen represented in curves III. and III.*a*, fig. 3, is 2,320 at the flux density $B = 10{,}000$ c.g.s.

Magnet cores of cast steel (mild steel) are less costly than those of forged metal, and, as shown in the foregoing tables and curves, mild steel is little inferior to the latter in its magnetic quality. Steel castings are therefore much used for the cores and yokes of dynamo magnets. As indicated in Table II. and curve I, fig. 3, the magnetic properties of cast iron are much inferior to those of the low-carbon steels. Cast iron is, however, used for the yokes and frames of dynamo machines, being easily cast and inexpensive, but it is less used now than it was formerly.

It was discovered in 1903 by Sir Robert Hadfield that certain iron-silicon alloys have very high permeability at low values of the flux density. This property is illustrated by curves IV. and IV.*a* in fig 3, the maximum permeability for the specimen represented being 3,790 at the induction 8,000 c.g.s. In stronger fields, however, the presence of the silicon lowers the permeability. Silicon steel is not suitable for the cores of electromagnets in which high flux density is required, but, owing to the comparatively small dissipation of energy in this material when the flux is alternating, it is largely used in the form of thin sheet for the cores of alternate current transformers. The best qualities of silicon steel contain 3·5 to 4·5% of silicon, and practically no other foreign matter. With much larger proportions of silicon the material tends to become brittle, and the permeability in strong fields is further diminished. With smaller proportions of silicon this material is also used for the armatures of dynamos, but for this purpose stampings of dynamo sheet-steel, containing less than 1% of silicon are more suitable, owing to the higher permeability of this material at high flux densities.



FROM "DICTIONARY OF APPLIED PHYSICS," VOL. II

FIG. 3.—MAGNETIZATION CURVES
Curves showing flux-density and permeability for different irons and steels used in the construction of electromagnets

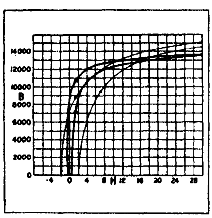
When sheet-steel is used in electro-magnets it should be placed so that as far as possible the direction of magnetization is parallel to the grain, *i.e.*, the direction in which the sheet has been rolled. The magnetic properties in a direction at right-angles to the grain are usually inferior to those in the grain direction. The maximum permeability of a material may be considerably increased by careful re-annealing. Values as high as 12,000 have been found by

Gumlich in iron-silicon alloys as the result of this treatment. The effect of preparing and annealing iron and iron-silicon alloys *in vacuo* has been studied by Yensen (*Proc. Am. I.E.E.*, 1915, 1916), who found great increase in the maximum permeability, the effect being due to a reduction in the impurities, especially carbon.

The remarkable magnetic properties of two other alloys may be referred to briefly. The material known as "permalloy," a very pure nickel-iron alloy containing about 78·5% of nickel, shows very high permeability in weak magnetizing fields. Under a magnetic force of $\frac{1}{20}$ c.g.s. unit the induction in permalloy may be as great as 5,000 c.g.s units the permeability being therefore 100,000. If a straight copper wire of diameter 1mm., carrying a current of 1/800 ampere, were closely surrounded by a sheath of permalloy, the induction in the innermost layer of the sheath might be about 5,000 c.g.s. The self-inductance of the wire would thus be greatly increased. It is for "loading" a wire in this way that permalloy is at present chiefly useful in connection with telegraph and telephone cables. In strong fields the permeability of permalloy is inferior to that of good cast iron. A very different property is possessed by the cobalt-iron alloy containing about 34·5% of cobalt. This alloy was shown by P. Weiss to have remarkably high magnetization in strong fields, the saturation induction $B-H$ being about 12% higher than that of pure iron. This material is very suitable for the pole-pieces of electromagnets used in producing very intense magnetic fields.

Core Losses.—In iron or other magnetic material in which the flux is rapidly alternating there are two sources of dissipation of energy which it is desirable to reduce as much as possible, viz., hysteresis and eddy currents. Hysteresis is the name given by Ewing to that property of magnetic materials which causes the flux density, at any change from increasing to diminishing magnetization or vice versa, to follow a different path in relation to the magnetizing force. The induction "lags behind" the force at such changes. The practical importance of hysteresis lies in the fact that, as shown by E. Warburg and Ewing, in any cyclic process of magnetization, there is energy dissipated, the amount of which is proportional to the area of the corresponding "hysteresis loop." In transformer cores, which are subject to rapid alternations of magnetization, the hysteresis loss per second, being proportional to the rate of alternation, may become serious. It is, therefore, important that the material of the cores should be chosen so that the area of the loop corresponding to the range of induction employed should be as small as possible.

Much attention has been devoted to the study of the hysteresis loss as affected by the maximum flux density in the cycle and by the nature and state of the material, and various practical methods of measuring hysteresis have been devised. The results may be expressed in ergs per cycle per cubic centimetre of the material, or in watts per pound at some stated frequency of alternation and at some maximum flux density, say, at 50 cycles per second and 10,000 c.g.s units of flux density. The relative qualities in regard to hysteresis of two kinds of sheet-steel are illustrated in fig. 4, which shows the upper portions of their hysteresis loops as determined by H. Hoffmann (*Arch. f. Elektrot.*, 1913). The full line curve refers to an annealed specimen of silicon steel, the broken line curve to a sample of ordinary sheet steel. The superiority of the silicon steel is shown by the relative smallness of the area of its hysteresis loop, and the consequent low value of the hysteresis loss in this material. Silicon steel of good quality is also practically free from the defect known as "ageing," *i.e.*, the increase in the hysteresis loss which occurs in ordinary iron or steel when subjected for prolonged periods to temperatures in the neighbourhood of 100° C.



FROM "DICTIONARY OF APPLIED PHYSICS"

FIG. 4.—HYSTERESIS CURVES
"B–H" curves showing comparative hysteresis of an annealed silicon steel (thick line), and of an ordinary sheet steel (thin line)

Various empirical formulae have been proposed to express the hysteresis loss in terms of the maximum flux density in the cycle. The best known of these is that of Steinmetz, which represents the hysteresis loss by the expression $hB^{1.6}$, h being a constant. The value of h is very small in the iron-silicon alloys (*see* MAGNETISM). For the specimen represented by the full-line curve in fig. 4 the value of h was 0·001, when the hysteresis loss is expressed in ergs per cycle per cubic centimetre. For the sample of ordinary sheet-steel represented in fig. 4 the value of h was 0·0024. In a very pure annealed specimen of alloyed steel 0·5mm. thick, containing 4·09% of silicon and 0·07% of carbon, Gumlich found the value 0·0006 for h.

The other core loss in alternating current cores (often more than one half of the total core loss) arises from the eddy currents induced in the cores by the changes of flux, and it is for the purpose of reducing this loss that the cores of alternating current electromagnets are made of thin sheets of material, insulated from one another, and so disposed that their planes are parallel to the direction of the flux. The theory of eddy-currents in laminated cores was given by J. J. Thomson (*Electrician*, 1892), who showed that the energy dissipated owing to this cause per second per cubic centimetre of the material is proportional, when the quantity $\pi d\sqrt{n\mu\sigma}$ is small, to $d^2n^2B^2/\sigma$, where d is the thickness of each sheet, n is the frequency of alternation, B the maximum induction, and σ the specific resistance of the material. In low-frequency alternations therefore the eddy-current loss diminishes as the specific resistance of the material increases. The specific resistance of alloyed steel may be five or six times as great as that of ordinary steel sheet, and the eddy-current loss is therefore smaller in the former material. This is another reason why silicon steel is a superior material to ordinary sheet-steel for transformer and other alternating current cores. (*See* TRANSFORMERS.) It will be noted that the eddy-current loss per second is proportional to the square of the frequency, and this fact forms the basis of one of the chief methods of separating the eddy-current loss from the hysteresis loss, the latter being proportional to the frequency. In commercial silicon steel plates of good quality 0·5mm. thick, at a maximum induction of 10,000 c.g.s. units and frequency 50 per second, the combined hysteresis and eddy-current losses amount to less than 1 watt per pound of the material.

Electromagnets for Producing Intense Magnetic Fields.—The problem of producing a very intense magnetic field in a small air gap in a magnetic circuit is very different from that of producing a large amount of total flux in the armature of a dynamo. In the latter case great concentration of the flux is not desired. The flux density in the air gaps separating the pole-pieces from the armature of a dynamo does not usually exceed about 15,000c.g.s. units, but in electromagnets used for the purpose of examining the magnetic properties of iron and other magnetic materials in very strong fields, and for many physical experiments, a much greater degree of concentration of the flux is required.

The magnetic field in the air gap may be regarded as made up of two parts; viz., that due to the magnetic poles on the sides of the gap, and that due directly to the magnetic action of the current in the magnetizing coils. Unless this current is extremely strong the magnetic field which it produces in the gap is very small in comparison with that due to the magnetism on the pole-faces. We conclude, therefore, that, if the pole-faces are parallel planes extending across the whole cross section of the core, the magnetic field in the gap between them cannot much exceed the saturation flux density of the iron, which is about 21,600 c.g.s. units. It is clear that, in the case of the gap with plane parallel sides, the poles near the periphery of the gap do not contribute much to the magnetic field at the centre. They might be expected to contribute more if they were laid back, away from the gap, so that they could produce greater magnetic force in the axial direction at the centre of the gap. This is found to be the case experimentally, and conical pole-pieces, having surfaces in the form of truncated cones, are generally used in electromagnets for producing very intense fields. The angles which the cones

should have in order to produce the most concentrated field was calculated by Stefan and by Ewing in 1888 on the assumption that the pole-pieces are uniformly magnetized to saturation in the axial direction. The calculation showed that the pole-faces should take the form of cones of semi-vertical angle 54° 44′, and that with this angle the value of the field at the vertex of the cones is given by the expression $0{\cdot}886(B\text{–}H)\ \log_{10}\frac{b}{a}$ where b is the radius of the base of the cones, and a is the radius of the cone at the narrow end, *i.e.*, the radius of the gap. Assuming the saturation value 21,600 for $B\text{–}H$ this gives $19{,}140\ \log_{10}\frac{b}{a}$ as the maximum field strength produced by conical pole-faces. To this must be added the field due to the magnetism on the narrow plane ends of the cones (unless the gap is bridged across by a narrow neck or "isthmus"), and the field due to the magnet coils. In practice the angle of the cores for maximum concentration should, as pointed out by Ewing, be rather greater than 54° 44′, owing to the fact that the magnetization of the pole-pieces is not quite uniform. The question of the best form of pole-piece was examined experimentally by du Bois, who found that for maximum concentration the angle should also increase slightly towards the base of the cone. The coils should be placed on the electromagnet so as to produce, by the direct action of the current, the greatest possible field in the gap, that is, their end windings should be as near the gap as possible. In this position the coils will also have their greatest effect in saturating the pole-pieces.

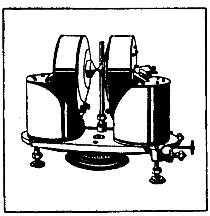
In 1891 du Bois designed a large electromagnet in which the core was a ring of Swedish iron of mean diameter 50cm. and diameter of section 10cm. The coils contained 2,400 turns of wire which could carry 50 amperes. The weight of this electromagnet was about 5cwt. With conical pole-pieces the electromagnet gave a maximum field of 40,000c.g.s. units (or gauss) in a gap 1mm. wide and 6mm. in diameter. Subsequently du Bois designed a more convenient form of electromagnet, known as the half-ring type, which is now much used in experimental and testing work. The latest type of du Bois half-ring electromagnet is illustrated in fig. 5 (from the *Zeitschrift fur Instrumentenkunde,* 1911), where it is shown mounted on a turn-table so that it can be rotated easily about a vertical axis. In this type each of the two curved cores of cast-steel forms about one-third of a complete ring, the diameter of the core section increasing towards the base. The form of the coils is such as to allow optical or other apparatus to be brought close up to the borings in the cores, and extra polar coils are provided which can be slipped over the pole-pieces so as to be in the most effective position for increasing the field. A copper tube also surrounds the upper end of each core, to carry a current of water for cooling. This electromagnet is made in several sizes. In one model, weighing 7cwt., the maximum field in a gap 1mm. wide and 6mm. diameter is 50,000 gauss. With a smaller gap of 0·5×3mm. and with ferro-cobalt pole-tips the field is 59,000 gauss. A larger model weighing 27cwt. and having cores 20cm. in diameter at the upper end, gives in the 0·5×3mm. gap a field of 65,000 gauss.

Very powerful electromagnets have also been designed by P. Weiss (*Journ. de Phys.,* 1907) who has adopted and improved upon the well known Ruhmkorff pattern. In this type the coils are carried by two horizontal coaxial cores supported by a massive yoke. In the Weiss electromagnets very adequate arrangements are made for cooling the coils, one method being to immerse the windings in oil cooled by water circulating in a spiral tube. A magnet of this type weighing 25½cwt., excited by a current of 60 amperes, gave a field of 46,000 gauss in a 2×6mm. gap. In a later and still larger model (*Arch. des Sciences,* 1917) the current of 100 amperes is carried by 1,440 turns of copper tubing which also conveys the current of cooling water. The ten sections into which the coils are divided are connected in series for the electric current, and in parallel for the current of cooling water. A very large electromagnet of this type has recently been completed at Paris, where it is installed at the Office of Research and Inventions. It is said to have cores over one metre in diameter at the base, to be wound with 5,000 metres of copper tube and to weigh over 100 tons.

The general effect of increase of dimensions of an electromagnet on the field which it produces may be gathered from the principle of similarity, stated by Lord Kelvin, which may be expressed as follows:—If the linear dimensions of an electromagnet are increased in any ratio, and if the current in the coils is increased in the same ratio, the flux density at corresponding points will be unaltered. If, for example, the linear dimensions of an electromagnet were all doubled, and the current also doubled, the field intensity in the gap would be the same as before. The linear dimensions of the gap between the pole-tips would, however, be twice as great as before, and if the gap were reduced to its former size there would be an increase of field intensity equal to about $19{,}140\ \log_{10}2$, that is about 5,740 gauss, assuming the pole-pieces to be saturated. It is clear therefore that no very great increment of field intensity can be expected as the result of any reasonable increase in the dimensions of a large electromagnet of the ordinary type, in which the field is mainly due to the magnetism of the pole-pieces. There remains, however, the possibility of increasing the current in the magnet coils so greatly that the field due directly to the current becomes a large fraction of the total field.

This procedure was adopted in 1914 by Deslandres and Perot (*Comptes Rendus,* 1914) who, with a current of 5,000 amperes flowing in a water-cooled spiral of silver ribbon, and without an iron core, produced a field intensity of 49,900 gauss. When the spiral was provided with an iron core a field intensity of 63,700 c.g.s. units was attained. The method of producing intense magnetic fields by means of very strong currents has been much developed, at Cambridge, by P. Kapitza (*Proc. Roy. Soc.,* A, 1924). In his earlier experiments Kapitza, using specially constructed accumulator batteries and switch gear, passed currents up to 8,000 amperes (measured by a shunted oscillograph) through a coil for short intervals of time. In a coil of 1mm. internal diameter, fields of the order 500,000 gauss for 0·003 second were obtained in this way. In his later experiments (*ibid.,* 1927) still stronger currents were produced by short-circuiting an alternating current generator of special construction, and a field of 320,000 gauss in a volume of 2cu.cm. was obtained for ·01 second.

Mechanical Forces Produced by Electromagnets.—Electromagnets are used in different ways for exerting mechanical force on bodies placed near them. The force causing a bar of iron to adhere to the poles of a horseshoe magnet, known as the *tractive force* of the magnet, follows a different law from that of the force acting on a small magnetic body placed in the field of a magnet. In another class of applications, the most important example of which is found in the electric motor (*see* MOTORS, ELECTRIC), the field of an electromagnet is used for exerting force upon a wire in which a current of electricity is flowing. The law of the tractive force of electromagnets, first announced correctly by Clerk Maxwell, states that the normal traction between two plane pole-faces, placed in contact and magnetized uniformly in a direction at right angles to their common interface, is equal to $B^2A/8\pi$ where B is the flux density and A is the area of the surface of contact. The expression $B^2A/8\pi$ represents the total normal traction exerted across the area A, and in some cases this may be considerably greater than the force required to pull the surfaces apart. For example, if two iron bars of cross section A are passed through the borings of the electromagnet depicted in fig. 5, and placed so that the plane of contact of their ends is midway between the pole-pieces, the force required to separate



FROM H. DU BOIS, "NEUE HALBRING-ELEKTROMAGNETE"

FIG. 5.—THE DU BOIS ELECTROMAGNET, WHICH IS MOUNTED ON A TURN-TABLE, AND CAN BE EASILY ROTATED ABOUT A VERTICAL AXIS

the bars is approximately $(B^2-H^2)A/8\pi$, the difference $H^2A/8\pi$ representing a portion of the attraction between the pole-pieces, which is of course not overcome when the bars are pulled apart. In an experiment conducted on these lines with the du Bois ring electromagnet, the area of the cross section of the bar was 0·1896 sq.cm., the value of B was 39,260, and that of H was 17,690 c.g.s units. The value of $B^2A/8\pi$ was 11·86, that of $H^2A/8\pi$ was 2·386, both expressed in kilogrammes weight. Thus $(B^2-H^2)A/8\pi$ was 9·474, which agrees well with the observed pull which was 9·43kg. weight. In another experiment the pull between the bars was 1,634lb. weight per square inch of their cross section.

In ordinary cases, such as that of a horseshoe or mushroom-shaped electromagnet supporting an iron mass attached to its poles, the lifting force is represented by $B^2/8\pi$ per unit area of contact surface, and both poles are of course to be taken into account. From this expression we can find the effect of a change of dimensions of a lifting magnet, with proportional change of current and consequently no change of flux density, on the lifting power. Since the weight which it can support is proportional to the area of the contact surfaces, that is, to the square of the linear dimensions, while the weight of the magnet itself is proportional to their cube, it follows that the ratio of the lifting power of a magnet to the weight of the magnet itself is inversely proportional to the linear dimensions. Thus, in proportion to their weight, small magnets can lift more than large ones. One of Joule's electromagnets weighed only half a grain and it could support 1,417 grains, or 2,834 times its own weight.

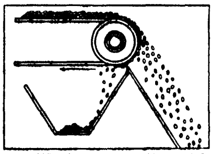
Turning now to the question of the force acting on a small magnetized body placed in a magnetic field, we find in the first place that if the field is uniform there is no resultant force on the body since its two poles are subjected to equal and opposite forces. The resultant force on the body must therefore depend upon the non-uniformity of the field. It acts in the direction in which the spatial variation of the field is greatest, urging magnetic bodies towards the stronger, and diamagnetic bodies towards the weaker parts of the field. (*See* MAGNETISM.)

The force here considered has been put to practical use in the surgical electromagnets used for extracting small particles of iron or steel from the eye or other parts of the body. The same forces are employed in magnetic separators used for separating iron from other materials. In one machine the electromagnet is formed by the separator pulley, which contains a number of coaxial coils, the windings of which are near the curved surface of the pulley. The coils are separated from one another by steel discs, the rims of which, lying in the surface of the pulley, form the poles. The diagram in fig. 6 shows the mode of action of the separator pulley. The particles of magnetic material adhere to the belt where it is in contact with the pulley, but leave it after contact with the pulley is broken.

The force due to non-uniformity of the field is also used in certain scientific experiments, for example, in the determination of the magnetic susceptibility of weakly magnetic substances by Curie's method, and in the experiments of Gerlach and Stern for measuring the magnetic moments of atoms. (*See* MAGNETISM.)

Electromagnetic Mechanisms.—There have been invented a very large number of devices in which there is a small movement of a piece of iron forming part of the magnetic circuit of an electromagnet due to causing the current to flow in the exciting coils. The movable iron usually forms the armature of the electromagnet, held by a spring near the poles but not in contact with them. In purely electromagnetic systems the armature is attracted when the current flows in either direction. In many of these devices the electric circuit includes a contact breaker so arranged that the movement of the armature towards the electromagnet causes the circuit to be interrupted; the core then becomes demagnetized and the armature is drawn back by the spring. In this way vibratory movement of the armature can be maintained by the current which is rendered intermittent by the movement. This combination of electromagnet and contact breaker is used in electric bells, electromagnetic hammers and electric motor horns. In all such mechanisms the movement produced by the magnetic action is such as to diminish the reluctance of the magnetic circuit. The magnitude of the attraction per unit area of the surface of the armature, where the normal flux density is B, is represented approximately by $B^2/8\pi$.

There are several devices in which the range of movement of the iron is greatly increased. One of these is the "coil and plunger" arrangement, in which a movable bar of iron, having one end within a coil, is drawn further within the coil when the current flows in either direction. If, instead of a bar of iron, a bar of permanently magnetized steel is employed, the arrangement becomes a "polarized system," in which the movement is reversed by a reversal of the current. In telephone receivers and wireless loud speakers the current supplied is in the form of very feeble alternating current, and the attraction on the armature, being proportional to B^2, would be very small if the system were purely electromagnetic. If, however, the cores form polar extensions of a permanent magnet, by which they are magnetized to a suitable flux density B, the displacement of the armature due to a weak current in the coils, producing a proportional change δH in the magnetizing force, is proportional to $\delta B^2/\delta H$, *i.e.*, to $B.\delta B/\delta H$. The displacement is thus proportional to the product of the flux density B and its rate of variation with magnetizing force $\delta B/\delta H$. The value of $B.\delta B/\delta H$ depends upon the permeability and hysteresis of the cores, since we are here dealing with small cycles of flux superposed upon the constant flux due to the permanent magnet. Materials of high permeability, such as silicon steel, are found to have the greatest values of $B.\delta B/\delta H$, and in some telephone receivers the cores and the diaphragm (which here forms the armature) are made of this material. The factor $\delta B/\delta H$ also depends upon the reluctance of the air gaps and other parts of the magnetic circuit traversed by the alternating flux, and to produce the greatest sensitiveness the reluctance must be kept as small as possible. In this respect the presence of the steel magnet in the magnetic circuit is not very favourable.



BY COURTESY OF IGRANIC ELECTRIC CO., LTD.
FIG. 6.—DIAGRAM SHOWING ACTION OF MAGNETIC SEPARATOR PULLEY, USED FOR SEPARATING MAGNETIC FROM NON-MAGNETIC METALS

Another type of mechanism has come into use (especially in loud speakers) in which the received and amplified alternating current, instead of flowing through coils fixed on the cores of a magnet, flows through a movable coil placed in the annular gap of an electromagnet of suitable form. Details of this "moving coil" system will be found in the article TELEPHONE.

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ELECTROMAGNETIC THEORY OF RADIATION. About 1855 Clerk Maxwell discovered equations which govern the behaviour of electromagnetic oscillations. He was able to show that these equations were equally applicable to light. It was in consequence of this discovery that he put forward the theory (the electromagnetic theory of light) that light was an electromagnetic phenomenon. (*See* ELECTRICITY and LIGHT).

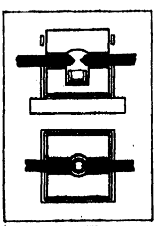
ELECTROMETALLURGY. As different methods of producing electric currents in increasing magnitude were discovered, one of the earliest applications made, in every case, was the study of their effects on chemical change both by electrolytic action and, on account of the high temperatures attainable, by their electrothermal effects. Thus Davy in 1810, using a voltaic pile of 1,000 plates, isolated the alkali metals and aluminium by electrolysis, and conducted experiments on the fusion of iron wire. Pepys, in 1815, by means of an electrically heated iron rod demonstrated

the cementation of iron by absorption of carbon. The experiment was conducted by bending a piece of soft iron, cutting a longitudinal groove at the bend, and filling with diamond dust. The wire was then mounted between wider metal poles, and, after covering with talc to protect from oxidation, was heated by the passage of an electric current when the diamond was absorbed and the iron converted into steel.

Despretz in 1849 carried out experiments in which high temperatures produced electrically were utilized. The earlier work forms the subject of a paper entitled "The Fusion and Volatilization of some Refractory Bodies: Notes on some experiments carried out with the triple acid of the voltaic pile, the sun, and the blow-pipe" (*Comptes Rendus*, 1849, xxviii. 755). In later experiments an apparatus is described which consists of a tube of sugar-charcoal about ¼ in. wide and ½ in. long closed by two charcoal plugs which, with its contents, was raised to a high temperature by the passage of an electric current.

H. Wilde, in 1886, by means of a current from one of the earliest types of magneto-electric machines, was able to melt a bar of platinum 6 mm. thick and 2 ft. long. William von Siemens, in 1878, designed several forms of arc furnaces which contained all the important features of modern types. One, referred to in many textbooks, has a carbon electrode adjusted to the distance necessary to maintain an arc with the desired current by a magnetic solenoid operated by the main current passing through a surrounding coil. The crucible is insulated by surrounding it with carbon packed in a wider container. In place of a carbon electrode an adjustable water-cooled iron electrode, was also employed, as being more effective. One of the earliest electric furnace processes to be brought into commercial operation was that of the Cowles Brothers which was installed at Milton, Staffordshire, in 1886 (*Industries*, 1888, vol. v., 237). The process consisted of the reduction of alumina by carbon in the presence of iron or other metals, resulting in the formation of aluminium alloys. The furnaces were rectangular in shape, constructed of fireclay, and provided at either end with an inclined cast-iron pipe, through which the electrode was introduced. Heating was brought about by the formation of an arc between the carbon electrodes.

Each electrode consisted of a bundle of from seven to nine carbons (each 2½ in. diam.) held together by a cylindrical head of metal which was connected to the flexible cables leading in the current. The charge consisted of a mixture of corundum (Al_2O_3), metal and charcoal. A current of 5,000 amp. at 60 volts was passed and a period of one and a half hours was required for the reduction ot each charge. The furnace was covered with a cast-iron case provided with a hole in the centre, through which the gases generated during the process escaped. The reduced aluminium and alloying metal were volatilized, and the ascending vapours became condensed in the upper and cooler layers of charcoal. Combination occurred here and the liquid alloy flowed to the base of the furnace and was run off through a tap-hole. The daily output at Milton amounted to about 20 cwt. of ferro-aluminium or aluminium bronze containing 15 to 17% aluminium. The current was obtained from a Crompton dynamo of 300 kw. capacity, and its capacity constituted at that time a record in electric generators.



FROM PRING, "THE ELECTRIC FURNACE"

FIG. 1.—MOISSAN ELECTRIC ARC FURNACE

An arc is formed in a limestone block cavity, a little above the substance to be treated

In 1887 Héroult, in France, and Hall in America, devised an electrolytic process for the production of aluminium and the Cowles process suspended operation.

Moissan, commencing in 1892, carried out a series of experimental researches with the high temperatures obtained by means of an electric arc furnace. Metals such as chromium tungsten, molybdenum, uranium and titanium were thus obtained in a fused state for the first time. The method adopted, as illustrated in fig. 1, consisted in placing a powerful arc in a cavity of minimum size in a limestone block and at a certain distance above the substance to be heated. In this way, actual contact with the carbon vapour from the arc is avoided and at the same time the thermal action of the current is separated from any electrolytic effect. The current generally used by Moissan was about 450 amp. at 60 volts. This type of furnace, which is still suitable for many laboratory experiments, consists of two slabs of lime carefully cut and superposed. The lower slab has a long groove in which the electrodes rest, and in the middle is a small cavity which serves to hold a small carbon crucible containing the substance to be heated. The electrodes are easily rendered movable by means of two adjustable supports, or better, by using two sliders which rest on a bed-plate. The freedom of motion of the electrodes enables an adjustment of the length of the arc to be conveniently made. The arc at first is less than 1 cm. long, but towards the end of the experiment the length usually increases to from 2 to 2·5 cubic metres. If the furnace is filled with a good conducting metallic vapour (*e.g.*, aluminium), the electrodes may be 5 to 6 cm. apart. The length of the arc will thus be regulated so that an approximately constant resistance can be maintained.

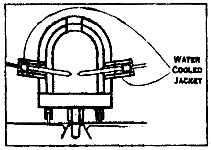
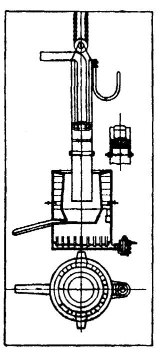


FIG. 2.—STASSANO ROTATING FURNACE

Heating is effected by downward radiation from an arc formed between three equidistant electrodes

Electric Smelting of Iron Ore and Production of Steel.—The principle of the Moissan furnace was applied by Stassano in Turin in 1903 for the smelting of iron ore and production of steel. A type of furnace arranged to rotate about an inclined axis which was finally adopted is illustrated in fig. 2, which shows a vertical section through two electrodes. Three equidistantly-spaced electrodes are employed in the larger units in order to utilize three-phase current. The electrodes are surrounded by water-cooled jackets. Gases from the reaction pass out through a vent at the head of the enclosure and the furnace is provided with a charging hopper and tapping spout not shown in the diagram. The furnace was originally employed for the smelting of magnetite and haematite whereby malleable iron was produced directly, and later for the production of steel from cast-iron and turnings.

Large-scale experiments on the electric smelting of iron ore and the production of ferro alloys were undertaken at Sault Ste. Marie, Canada, by a commission appointed by the Canadian Government in 1903. The furnace consisted, as seen in fig. 3, of an iron casing, bolted to a base plate of cast-iron. Rods of iron were then cast into the plate to secure a good contact with the carbon paste rammed into the lower part of the furnace and lining the bottom and sides of the crucible. One end of the electrode was planed to fit into a steel shoe and was held tight by means of wedges. A pipe was put in the electrode holder, through which a current of air was circulated on to the holder. The power applied was 200 kw. single phase alternating current at a mean value of 5,000 amp. at 40 volts. By the use of charcoal as reducing agent it was shown that magnetic ores could be smelted efficiently in this form of electric furnace, though the ore is too high in sulphur to be treated by the usual blast-furnace process. It was also shown that a ferro-nickel pig could be produced practically free from sulphur and of fine quality from roasted nickeliferous pyrrhotite.

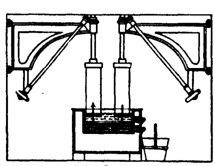


FROM PRING, "THE ELECTRIC FURNACE"

FIG. 3.—FURNACE FOR ELECTRIC SMELTING OF IRON ORE AND THE PRODUCTION OF FERRO ALLOYS

For the production of steel the main advantages which have been gained by the employment of electric furnace operation is

that a product can be obtained which is equal to the best grade of crucible steel at a considerably lower cost and on a much larger scale than is possible with the crucible process. The advantage is mainly due to the higher temperature of operation which is possible in the electric furnace and this gives more latitude in the composition of the slags which are employed for the removal of sulphur and phosphorus. Access of nitrogen to the metal which has a deleterious action, can moreover be more completely excluded by the electric furnace, and manganese and other metals employed in the purification can be added with less loss through oxidation.



FROM PRING, "THE ELECTRIC FURNACE"
FIG. 4.—HÉROULT DIRECT-ARC FURNACE
Arcs are formed between the surfaces of the charge and carbon electrodes suspended vertically over the furnace

The three main types of electric steel furnaces now in use are (1) the direct arc type, (2) the radiation arc type and (3) the induction furnace.

Direct Arc Furnace.—The main example of this type is the Héroult furnace, the principle of which is illustrated in the diagram in fig. 4.

This furnace is operated by forming arcs between the surface of the charge and carbon electrodes which are suspended vertically above the furnace and connected to the poles of an alternating current supply.

Formerly only single-phase current was used together with two electrodes joined in series, but the larger furnaces now in use are operated with three-phase current and contain three electrodes. In all cases when the furnace charge is molten, the current, as shown in fig. 4 passes in the form of an arc from the electrode to the surface of the slag, through the slag to the metal, and horizontally through the surface layers of the metal to the adjacent electrode where a second arc is formed. A zone of very high temperature is thus produced in the slag in the neighbourhood of the electrodes, and rapidly brings about the chemical reactions involved in the purification of the iron and its conversion into steel.

These furnaces are all fitted with a tilting mechanism and a spout so as to enable the fused slag or metal to be poured.

A variation in the design of the Héroult furnace is shown in the Snyder furnace, which as originally designed for single-phase current is illustrated in fig. 5.

The main features of the furnace are a hinged roof which enables the roof, electrodes and all overhead gear to be removed by a pivoted mechanism. This device facilitates charging and enables mechanical charging to be employed. With the single-phase type, the current enters by the cables shown at the base which lead to the central carbon electrode at the top and after forming an arc between the electrode and the surface of the bath, the current leaves the furnace through a water-cooled metal contact at the base. A number of advantages are obtained by the use of single-phase units chiefly due to the central distribution of the current. Single-phase units are, however, limited to sizes of a capacity of about one ton. For larger furnaces a system has consequently been adopted which makes use of three-phase current, two phases being connected to two top or movable carbon electrodes, while the third is connected to the metal electrode through the hearth.

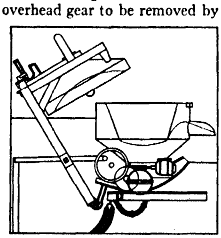
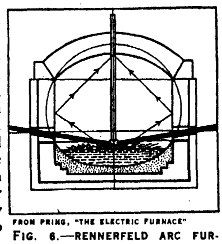


FIG. 5.—SYNDER FURNACE
In this furnace a hinged roof enables the roof, electrodes and all overhead gear to be removed by a pivoted mechanism

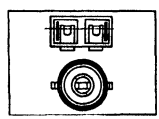
Radiation Arc Furnace.—The chief example of this type of furnace is that of Stassano, which is described above. A modification of this is in the Rennerfeld arc furnace. In this system the electrodes are arranged so that the arc is deflected downwards away from the roof and on to the charge in the furnace. As shown in fig. 6 the two side electrodes are arranged slightly inclined to the horizontal, while the third electrode is suspended vertically in the centre of the furnace in a position equidistant from the ends of the side electrodes. By means of the so-called Scott-connections the electrodes are joined to a three-phase current supply in such a way that the middle or vertical electrode forms the common return for the two phases, and thus carries about 40% more current than the side electrodes. The electro-magnetic action of the current arranged in this way causes the flame of the arc to strike downwards and spread over the surface of the thinned slag. The furnace is supported on trunnions and arranged to tilt. The usual size of a Rennerfeld furnace is three tons, though 12 ton and larger units have been designed. The current supply for a three-ton furnace is usually 3,750 amp.$\times$100 volts$\times$2$=$750 k.v.a.



FROM PRING, "THE ELECTRIC FURNACE"
FIG. 6.—RENNERFELD ARC FURNACE
Electrodes are so arranged that arc is deflected downwards away from roof and on to charge in furnace

Induction Furnaces.—In the usual type of induction furnace the crucible holding the metal under treatment is in the form of a ring or loop and constitutes the single-turn secondary of a transformer. The iron core or yoke of the transformer passes through and interlinks the primary coil with the single-turn secondary and thus provides the necessary close coupling between the two. The first example of an induction furnace was designed by Ferranti (Eng. Pat. 700 of 1887), while the first practical type to be brought into industrial use was constructed by Colby in America in 1890. This contained a double-yoked magnetic core and a primary winding which in an early type was arranged outside the metal bath as shown in fig. 7, but in a later development the primary winding was placed in the centre of the metal ring, as in the Kjellin furnace. A unit of 130 k.v.a. capacity holding about 190 lb. of steel was installed in Philadelphia about 1906 for the manufacture of high-grade steels. The primary consisted of 28 turns of copper tube cooled by water circulation and arranged to utilize 540 amp. at 240 volts.

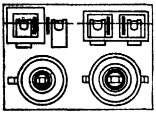
The main advantages obtained by induction furnaces are the absence of contamination of the metal by contact with carbon electrodes; better exclusion of furnace gases from the metal; convenience in introduction of current in that a high potential circuit can be supplied without the use of transformers or copper cables of large cross-section; fluctuations of the current do not occur as in other types, and a much steadier load is therefore offered to the power supply. Tappings are obtained which are very large compared with the contents of a crucible, and the steel produced is stated to be of better quality than that given in crucibles from the same raw material. The alternating current, through its electro-magnetic action, causes an efficient circulation of the metal. One disadvantage, however, in the original type of furnace, containing a ring of metal of uniform section, is that the temperature could not be taken to the same high degree as in the direct arc type, and the powerful reducing action which is accompanied by the formation of calcium carbide is thus not secured. On account of this lower temperature the furnace could not be applied for carrying out any extensive refining, but rather a melting which required the use of pure materials in order to yield a high grade of steel. However, in more recent types of the induction furnace attempts are made to overcome this limitation by arranging a narrowing of the channel of a portion of the circuit, or by other means causing an increased resistance and higher temperature to be obtained locally. A good



FROM PRING, "THE ELECTRIC FURNACE"
FIG. 7.—COLBY INDUCTION FURNACE
This contains a double-yoked magnetic core and a primary winding arranged outside a metal bath

circulation of the metal is in all cases ensured in the induction type of furnace through the operation of electro-magnetic forces.

The Kjellin furnace was introduced in 1899, and as seen in figs. 8 and 9 contained either a single or double yoke core with one primary winding in the centre. The Kjellin furnace was erected at Gysinge in Sweden and applied to the production of steel in 1900. Larger units of this furnace were later installed at the Röchling steel works at Völklingen, Essen, Germany. Furnaces of 750 kw. capacity were operated with single-phase current of five periods at 4,500 to 4,900 volts. The circular crucible of this furnace, which had a capacity of 85 tons, was built up from masonry and lined with a suitable basic material as used in the Bessemer converters or Siemens-Martin furnace. During operation the annular crucible is roofed over by covering with segmental iron plates. The furnace is arranged to tilt and is provided with a pouring spout for emptying. The Kjellin furnace has proved to be very suitable for making the highest class of steel from pure raw materials, and has been able to compete with the crucible process for this purpose, even when the power is generated from coal.



FROM PRING, "THE ELECTRIC FURNACE"

FIGS. 8 & 9.—KJELLIN FURNACES, CONTAINING EITHER SINGLE OR DOUBLE YOKED CORES

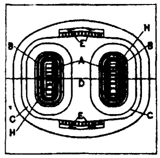
The main disadvantages of the Kjellin furnace are the inconvenient shape and narrow width of the annular crucible which prevents the hearth from being readily accessible and easily surveyed, and the specially low frequency of the alternating current required in the larger furnaces, which involves the construction of special expensive generators. The above disadvantages have for the most part been overcome in the modified type of induction furnace devised by Röchling and Rodenhauser, and this has now generally replaced the earlier type of Kjellin furnace.

Röchling-Rodenhauser Furnace.—The Röchling-Rodenhauser furnace was first brought into operation in Germany in 1906 for the final refining of fluid steel which had first been treated in the Bessemer converter. The chief features which distinguishes it from the Colby-Kjellin type is that the crucible, instead of being in the form of a plain ring, is arranged in the shape of a figure 8, with a wide central space. Heating is effected by a combination of two systems. Firstly, by induction currents, whereby the furnace acts like two combined ordinary induction furnaces, and secondly, by an auxiliary circuit in which by means of a separate winding around the primary coil an induced current is applied to the metal bath through electrodes consisting of plates of soft cast-steel covered by grids of refractory oxides which become conducting by electrolytic action at high temperature. A diagram of the furnace as designed for single-phase current is shown in fig. 10 in horizontal plan. Like the ordinary induction furnace, this furnace is essentially a transformer with a single primary winding A around both cores H of the transformer. The secondaries are two in number, one is the molten bath C in the form of a figure 8, the channel D between the two cores being comparatively broad and the other consists of extra windings B surrounding the primary coils and conducting currents to the metallic plates E which are inserted in the furnace walls, and are raised to a high temperature by the passage of the current to the metal bath. During operation the molten charge is kept in good circulation by the electromagnetic influence of the current. The whole furnace is built as a tilting furnace by mounting on rollers, and in general design is similar to the Siemens-Martin open-hearth furnace.

The disadvantage attending the generation of single-phase current has been overcome by a three-phase induction furnace, which in units of from 3 to 15 tons capacity is operated with a frequency of 50 periods, and thus makes possible the use of standard three-phase generators.

The hearth shown in the 1·5-ton furnaces is 1 ft. 7 in. wide, and 4 ft. 9 in. long. The three transformer cores are surrounded by heating channels. At the places in which two such channels enter into the main hearth, special electrode plates are arranged with great care in the general form of rectangular black slots built in the furnace walls. These electrodes are embedded in the furnace wall and separated from the fused charge by a refractory wall which becomes conducting when heated. Each of the three transformer cores is provided with a primary winding, and above each primary winding a secondary winding is also arranged. While one end of the latter is connected to a bus-bar, the other ends of the three windings are connected to the three electrodes.

At the Röchling steel works in Germany, the procedure most generally adopted is a "triplex" treatment, in which the steel is first "blown" in a convertor, further purified in a basic open hearth, and then subjected to a final refining treatment in the electric furnace. At present the largest application of electric steel furnaces is in combination with the older fuel-heated furnaces to give the final refining to molten steel which has undergone a preliminary treatment in the convertor or open-hearth furnace.



FROM PRING, "THE ELECTRIC FURNACE"

FIG. 10.—RÖCHLING-RODENHAUSER FURNACE

Crucible is arranged in form of a figure 8, with a wide central space

Electrolytic Processes with Fused Electrolytes.—The procedure in all instances in the production of metals from fused components consists in utilizing the property these compounds possess of becoming conductors at high temperatures. Electrolytic dissociation is thus brought about as in aqueous solutions at ordinary temperatures. By the application of a suitable potential, the cation is then separated in the metallic condition on the surface of the cathode. During the electrolysis, the necessary high temperature may be maintained through heat generated by the passage of the current.

Aluminium.—In all methods which have so far received practical application, the preparation of aluminium is brought about by dissolving alumina in the halogen compounds of the alkalis, alkaline earths or of aluminium, and separating the aluminium by electrolysis.

The raw materials employed consist almost exclusively of bauxite, which is a hydrate of alumina of the formula $Al_2O_3{\cdot}3H_2O$ and cryolite which has the composition $3NaF{\cdot}AlF_3$. An addition is generally made to the bath of an excess of aluminium fluoride, calcium fluoride, sodium chloride or other compounds in order to reduce the melting point of the electrolyte and diminish its density so as to facilitate the sinking of the aluminium to the bottom of the bath.

It is necessary to submit the alumina employed to a careful purification and to prepare it in a physical condition which enables solution to take place rapidly in the molten bath. During the electrolysis, aluminium is liberated at the cathode and oxygen at the anode which reacts with the carbon to form carbon monoxide. At the same time small amounts of fluorine are sometimes liberated, the decomposition voltage of the fluoride being only slightly above that of alumina. It is necessary to adjust any loss of fluorine from the bath by the addition of aluminium fluoride. Alumina is replaced as the electrolysis proceeds and the composition of the bath remains constant. This method, based on the power of electricity to split metal salts into their components had been discovered many years before it was possible to apply it commercially. Early attempts to electrolize aqueous solutions had failed because the aluminium produced at once recombined with water. Robert Bunsen, 1854, passed a current through a molten mixture of aluminium chloride and common salt, splitting the former into chlorine, which escaped, and aluminium which he collected as metallic beads.

Héroult Process.—In this process electrolysis was at first attempted by the use of alumina alone as the charge. In this case the high temperature necessary for the reaction resulted, when using a carbon cathode, in the formation of aluminium carbide. Cathodes of copper and other metals were accordingly applied and aluminium alloys prepared. Later, by the use of cryolite as a flux or solvent, the separation of aluminium metal was found possible when using a cathode either of iron or carbon. The anode, in this apparatus, consisted of a bundle of carbon poles fastened together by copper bands so as to form a block 1 m. long and 0·25

sq.m. section. The type of furnace adopted later and installed at Neuhausen is shown in fig. 11. The anode consists of a bundle of rectangular plates of carbon which are cemented together by means of a mixture of carbon with tar and molasses or glucose solution. The cathode consists of a carbon block contained in an enclosing metal case. The roof of the furnace is covered with graphite plates k, furnished with openings for the admission of the anode in the centre and the charge at C. The temperature of the bath is from 800° to 1,000° and the most favourable composition a mixture of cryolite with 10% alumina. The aluminium collects on the bed of the cell from whence it can be removed by tapping. The specific gravity of the molten metal is 2·54 while that of the fused bath is 2·35.

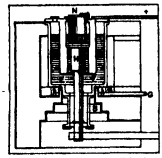


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FIG. 12.—CASTNER SODIUM CELL

An iron cylinder, suspended in fused electrolyte above the cathode, collects the liberated sodium

Sodium.—The industrial preparation of sodium was developed by Castner, through investigations begun in 1888, on the electrolysis of fused sodium hydroxide. The apparatus designed by Castner consists, as shown in fig. 12, of a cast-iron case A of about 14 in. diam., the upper part being 24 in. high and provided at the base with an extension tube B of 3½ in. diam. and 32 in. long. The cathode H consists of a copper bar secured at the base of the surrounding case by a wooden plug, in the space above which fused sodium hydrate is filled and allowed to solidify. The electrolyte in the space above can be heated by means of the gas-ring burner G.

Directly above the cathode is suspended an iron cylinder, closed by the lid N which is provided with an opening for the escape of hydrogen, while from the lower part, a wire gauze cylinder extends so as to form a diaphragm between the electrodes and prevent the sodium after separation from diffusing to the anode. The anode E was originally made of an alloy of nickel and silver which was found resistant against corrosion.

The sodium liberated at the cathode H together with the hydrogen rises into the cylinder N, and is periodically removed by means of a perforated ladle which allows its separation from the fused electrolyte to take place.

Calcium.—In a process in operation at the Bitterfeld electrochemical works in Germany calcium is prepared from the fused chloride by means of an electrical process in which a cathode, which is kept cold, is, at its base so arranged as to make contact with the surface of an electrolyte of fused calcium chloride. On passing the current, calcium is separated in globular form, adheres to the cathode and solidifies. The electrode and adhering calcium are slowly raised from the bath so that a cylindrical rod of calcium is then gradually built up, and by means of the thin coating of chloride which adheres, is protected against oxidation.

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ELECTROMETER, an instrument for measuring electrification, or, more generally, electric potential. (*See* INSTRUMENTS, ELECTRICAL.)

ELECTROMYOGRAM: *see* MUSCLE.

ELECTRON, THE. One of the most important generalizations of all time is that of the electrical constitution of matter, for this conception underlies practically the whole of 20th century physics. It is customary to consider that it was introduced during the last half of the last decade of the 19th century; yet, to choose any particular year, or even decade, for the introduction of this idea is to sacrifice accuracy, for, in general, advances in science do not take place at any given time. It is as difficult to determine when a particular conception arises as it is to fix the instant at which the babe acquires consciousness. The progress of science takes place, for the most part, by a process of infinitesimal accretion. It is a process of growth, each experimenter adding a little to the structure reared by his predecessors. There is nothing in the history of science that illustrates this process more beautifully than does the history of the development of the idea of the electrical constitution of matter.

GROWTH OF THE ELECTRICAL THEORY OF MATTER

Franklin.—In the year 1756 Franklin, upon contemplating the phenomenon of electrostatic induction, said with amazing insight, "The electric matter consists of particles extremely subtle since it can permeate common matter, even the densest, with such freedom and ease as not to receive any appreciable resistance." And yet, for fully a hundred years, electric *particles* were hardly again mentioned.

Faraday.—In 1833 Faraday led one and the same electrical current simultaneously through a solution of a silver salt and through an acid solution (*i.e.*, a solution in which the positive ion was hydrogen) and found that the number of atoms of silver that came out of the one solution was exactly the same as the number of atoms of hydrogen that came out of the other, thus showing conclusively that one and the same quantity of electricity was associated in the electrolytic process with the atom of hydrogen and the atom of silver—a relation that holds for all univalent atoms. And yet Faraday himself, by his discovery of the effect of the medium about a conductor in changing the electrical forces emanating from it, was responsible for starting the period in which electrical phenomena were thought of almost exclusively in terms of stresses and strains in the medium surrounding the electrified body—a period in which Maxwell himself, one of the most outstanding intellects of the 19th century, and the follower and interpreter of Faraday and his work, said, "It is extremely improbable that when we come to understand the true nature of electrolysis we shall retain in any form the theory of molecular charges, for then we shall have secured a sure basis upon which to form a true theory of electrical currents and so become independent of these provisional hypotheses." So that Faraday's experiments certainly did not convince the world of the general correctness of the atomic theory of electricity.

Weber.—Wilhelm Weber (*Werke* iv., 1871) built up his whole theory of electromagnetism on what was essentially an electron foundation. The hypothetical amperean currents, long before assumed to be circulating around molecules and thus producing the effects of magnetism, he explained as due to the rotation of light, positively charged, particles about a heavy negative nucleus. And yet this idea was not taken up again until the time of Lorentz, and it surely did not get into the consciousness of mankind at the time of Weber.

Crookes.—In 1879 Sir William Crookes, in view of his experiments on cathode rays—in which he had both proved their ability to set wheels in rotation and to be deflected by a magnet, reached the definite conclusion that these rays consisted of a flying swarm of charged particles. Indeed, he said, "In studying this state of matter we seem to have at last in our grasp and obedient to our control little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe." (Fournier d'Albe, *Life of Sir William Crookes*, 1924.) And yet his experiments were not convincing to the great body of German physicists who, as late as 1896, were asserting, in view of the great penetrating power which Lenard had shown the cathode rays to possess, that they were clearly of ethereal origin and not corpuscles at all.

Stoney.—In the year 1891, when Dr. G. Johnston Stoney (*Scientific Transactions of the Royal Dublin Society*, iv., 1891, 11th series) introduced the word *electron* to designate the elementary electrical charge, and actually computed the value of the electron by a method which is quite comparable in accuracy with any that was used up to 1909. The following quotations bear remarkable testimony to his insight:—"Attention must be given to Faraday's Law of Electrolysis, which is equivalent to the statement that in electrolysis a definite quantity of electricity, the same in all cases, passes for each chemical bond that is ruptured." The author called attention to this form of the law in a communication made to the British Association in 1874 and printed in the *Scientific Proceedings of the Royal Dublin Society*, of February 1881 and in the *Philosophical Magazine* for May 1881. It is there shown

that the amount of this very remarkable quantity of electricity is about the twentiethet (that is $\frac{1}{10^{20}}$) of the usual electromagnetic unit of electricity, *i.e.*, the unit of the Ohm series. This is the same as 3 eleventhets ($\frac{3}{10^{11}}$) of the smaller C.G.S. electrostatic unit of quantity. A charge of this amount is associated in the chemical atom with each bond. There may accordingly be several such charges in one chemical atom, and there appear to be at least two in each atom. These charges, which it will be convenient to call "electrons," cannot be removed from the atom, but they become disguised when atoms chemically unite. If an electron be lodged at the point *P* of the molecule which undergoes the motion described in the last chapter, the revolution of this charge will cause an electromagnetic undulation in the surrounding aether.

Also the following remarkable sentences are found in the same paper:—"Finally nature presents us with a single definite quantity of electricity which is independent of the particular bodies acted on. . . . This definite quantity of electricity I shall call E_1. If we make this our unit of electricity, we shall probably have made a very important step in our study of molecular phenomena. Hence we have very good reason to suppose that in V_1, G_1 and E_1, we have three of a series of systematic units that in an eminent sense are the units of nature, and stand in an intimate relation with the work which goes on in her mighty laboratory."

It will be noticed from this quotation that the word "electron" was introduced to denote simply a definite elementary quantity of electricity without any reference to the mass or inertia which may be associated with it, and Prof. Stoney implies that every atom must contain at least two electrons, one positive and one negative, because otherwise it would be impossible that the atom as a whole be electrically neutral. As a matter of fact, the evidence is now altogether convincing that the hydrogen atom does indeed contain just one positive and one negative electron. And yet, despite the clearness of Stoney's vision, the theory of the electrical constitution of matter certainly did not come into general acceptance in his time.

J. J. Thomson.—In 1897 J. J. Thomson proved the electrostatic as well as the magnetic deflectability of cathode rays, and showed by this work that the mass of the particles constituting these rays was of the order of a thousandth of the mass of the hydrogen atom. Indeed, it was at this time, and largely as a result of J. J. Thomson's experiments in England and Lenard's similar experiments in Germany in 1898, combined with the nearly simultaneous discovery of the Zeeman effect by Zeeman and Lorentz in Holland (1897), that the theory of the electrical constitution of matter began to be fairly generally accepted, and it is because of this fact that it is customary and proper to fix the birth of the electron theory at about this time; and yet, as late as 1905 or 1906, as eminent an authority as Roentgen would have nothing to do with the electron theory because he regarded it as an unproven and highly speculative hypothesis. What was actually proved in these experiments of Thomson's and Lenard's was that cathode rays are corpuscular in nature, and that if the charge on these corpuscles *be assumed* to be invariable, and equal to that carried by a hydrogen ion in electrolysis—a natural and, as later experiments proved, a correct assumption—then the mass of each one of them is of the order of one-thousandth of the mass of the hydrogen atom. These experiments also proved that these same cathode rays come out of all kinds of substances, when these different substances are made cathodes, in the passage of a discharge through highly exhausted tubes.

Later experiments by Wien (1898), Thomson (1913) and Aston (1922 and 1926), of precisely this same sort, on the masses or inertias of positive rays instead of cathode rays have shown that the positive electron, while it is a charge of equal amount but opposite sign to the negative, is always associated with a *mass* about 1,845 times greater. The positive electron is sometimes called the proton, and the word electron, when used without any qualifying adjective, is usually understood to refer to the negative electron, but it is important to remember that historically, derivatively and logically the word *electron* means, as indicated above, the unit *charge,* and carries no implication as to mass.

Early Work on the Electron.—Even earlier than the work referred to in the preceding paragraph, a beginning toward the determination of the value of the electron, the unit charge, or the atom of electricity, had been made by G. Johnston Stoney in 1881. The next attempt was made by Townsend in 1897, a third by Sir J. J. Thomson in 1898, a fourth by H. A. Wilson in 1903 and a fifth by Millikan and Begeman in 1908. But all of these workers used methods which involved such uncertain assumptions that no precision of measurement was or could be claimed. Nor were the results themselves thus far of appreciably greater certainty than could be obtained from the Faraday constant ($Ne = 9649{\cdot}4$) and kinetic theory estimates of the number of molecules N in a given molecule, which yielded a value of about 3×10^{-10} electrostatic units. Indeed, up to this point there was no method available that could yield anything more than the *mean* charge on a great number of particles, generally the particles of electrified clouds, and it is now known that the particles of such clouds carry in general widely varying charges, so that there was no certainty at all that this mean charge was the electron itself, and no *direct* proof that electrons were all exactly alike in charge. This proof was furnished, however, by the development of a technique that was first used in 1909, a technique with the aid of which the electron itself was first isolated and accurately measured, its value being soon fixed at $4{\cdot}774 \times 10^{-10}$ absolute electrostatic units of electricity. This means that the electron is so small a quantity of electricity that it takes $\frac{1}{4{\cdot}774 \times 10^{-10}}$, or about two thousand million of them to make up the very minute unit of electricity defined in the next paragraph.

ISOLATION OF THE ELECTRON

Definition of Positive and Negative Electric Charges.—It will probably be agreed that the most unambiguous single bit of evidence for the atomicity of electricity is found in the "oil-drop experiment," which puts the proof both of the unitary nature of electricity and of the electrical constitution of matter into such simple and unquestionable form that one needs, as a background, little more than a bare definition of electricity in order to see that both results follow from the experimental facts.

What, then, is electricity? Of its ultimate nature we know very little, precisely as we know very little of the ultimate nature of matter, or of the ether, or of mind, or, indeed, of the ultimate nature of anything. Science does not deal with ultimates, but rather with relations between observed or observable phenomena. Our ignorance of ultimates, however, does not prevent us from setting up a sharp, quantitative definition of an electric charge which anyone can understand. Everyone knows that, if he combs his hair with an ebonite comb, both the comb and his hairs acquire strange new properties of such sort that the hairs violently repel one another and are equally violently attracted by the comb. The forces thus called into play are enormously stronger than the gravitational forces acting upon the hairs. Merely for the sake of having a name by which we can describe and remember them we call them *electrical forces,* and the bodies that exhibit them are *by definition* said to possess *charges of electricity.* Again, since a glass rod that has been rubbed with silk violently repels hairs or other light electrified bodies that are violently attracted by ebonite that has been passed through hair or been "rubbed with cat's fur," we arbitrarily say that any electrified body that is repelled by a glass-rod-rubbed-with-silk possesses a charge of *positive* electricity, and any body that is repelled by an ebonite-rod-rubbed-with-cat's-fur possesses a charge of *negative* electricity. These are then altogether unambiguous and easily intelligible definitions of positive and negative electricity.

Further, we quite naturally measure *the amount of electricity* on a given body by the amount of the force exerted upon it at a given distance by some glass rod or other body which has been rubbed or treated in some standard way. Quite specifically, we define unit electric charge as that charge which, placed upon a minute spherical pithball, will repel with a force of one dyne

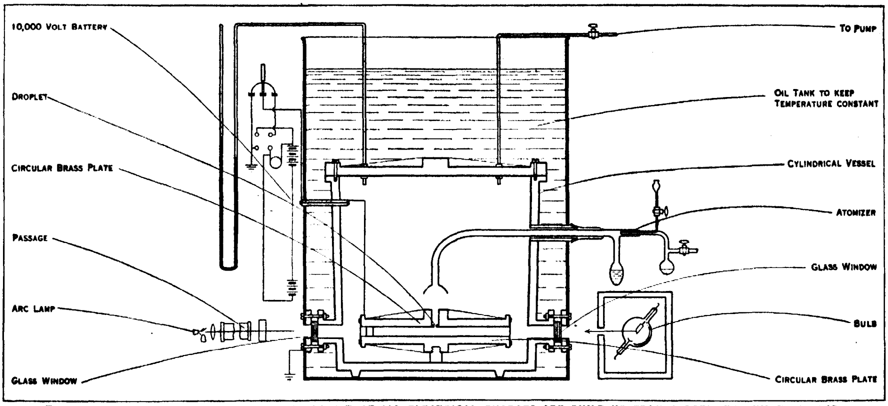

FIG. 1.—DIAGRAM OF APPARATUS MADE TO PROVE THAT ALL ELECTRICAL CHARGES ARE BUILT UP FROM A DEFINITE NUMBER OF DISCRETE UNITS (ELECTRONS), ALL EXACTLY ALIKE
Droplets of oil are placed in a strong electrical field, the changes of force experienced by them being measured

(about a milligram weight) another similar pith ball, charged in exactly the same way and placed one centimetre away from it. This is the definition of the so-called *absolute electrostatic unit of electricity* spoken of in the preceding section.

Criterion for Atomicity.—If, now, we wish to put to nature the exceedingly important and very fundamental question, is electricity something that exists in discrete elements or particles, as Franklin imagined it to be, and, if so, are these particles all alike—*i.e.*, is electricity atomic in structure?—it is quite obvious from the foregoing definitions that the simplest and most direct way possible of proceeding in the attempt to get the answer is to take the very smallest obtainable body which can be made to acquire an electrical charge, to measure the electrical force exerted upon it at a given distance by some standard body of invariable charge, then to change the charge on this very small body by the smallest possible amounts, and finally to see whether the forces exerted upon it by the standard body in the course of these changes show any *unitary* properties, *i.e.*, whether they increase by unit steps or do not so increase. If they do so increase, then the charges here dealt with will have been definitely shown to be multiples of a unit charge. If they do not so increase, we shall not yet be able to deny the atomic or unitary structure of electricity, but we shall be certain that, if it has a structure at all, it must be a much finer grained structure than corresponds with the minute changes of charge which we have in these experiments been able to use.

Oil-drop Experiment.—Experiments of this kind were first undertaken in the year 1909. The very minute bodies, the changes in charge of which were to be observed, were the minute droplets of oil in an oil-spray such as is formed by an ordinary toilet atomizer. These were chosen, first, because it was necessary to obtain minute bodies which would not evaporate (modern clock and watch oils represent a hundred years of effort in the development of non-evaporable and non-gumming, lubricants) and, secondly, because these droplets of oil-spray were as minute spherical bodies as anyone could ever hope to obtain and still have them visible; so that the changes in the force exerted upon them by a constant electrical field could be accurately measured. The constant electrical field was obtained by attaching the terminals of a ten-thousand volt battery to the circular brass plates (fig. 1) held about 16mm. apart by three insulating posts. This arrangement produced an altogether uniform and constant electrical field between the plates, and a charged oil drop in that field would have imparted to it, by the field, a speed which, according to the well-known laws of motion of a small body through a resisting medium, would be strictly proportional to the charge upon the drop. The actual procedure was first to disconnect the battery from the brass plates, short-circuiting them in so doing so that no field existed between them, then to send a puff of air through the atomizer, thus producing a cloud of oil droplets above the minute pin-hole in the middle of plate. One or more of these droplets would then find its way through this pin-hole into the space between the plates. This droplet was rendered visible by passing a powerful beam of light from an arc between the plates and looking through a short-focus telescope at the droplet in a direction nearly at right angles to the beam. In this beam the droplet appeared like a bright star floating slowly downward toward the lower brass plate. Before it struck the plate the switch was thrown so as to create the electric field in the space between the plates. The droplet, if properly charged by the frictional process involved in blowing the spray, would then begin to rise against gravity, because of the pull of the field on its charge. Just before it could strike the upper plate, the field would be thrown off by opening the switch, and the droplet would then begin to fall again at exactly its former rate. Its successive times of fall under gravity and of subsequent rise under the action of the field were then taken. The table gives a typical set of readings, the first column headed g giving the successive numbers of seconds required for the droplet to fall, with no field on, the distance between two fiducial marks in the eyepiece which corresponded to an actual distance of fall of exactly ·5222cm. The second column headed f, gives successive numbers of seconds required for the droplet to rise under the action of the field upon its charge. Between the second and third trips up, the charge on the droplet was changed by passing *underneath* it a beam of X-rays from the X-ray bulb I, and it is sufficient, for the present, to know that this procedure does change the charge, leaving to a later time the discussion of why it changes it. Similarly, a change in charge was brought about between the third and fourth trips up, the fourth and fifth, the sixth and seventh, the ninth and tenth, and the eleventh and twelfth.

Proof of Atomicity.—Now, the striking result which appears at once from a glance at column f is that only a few definite *times of rise* seem to be possible, and these recur continually, thus indicating that *only certain definite charges can be placed upon the drop.* These charges are proportional to the speeds imparted by the field, and, since the action of the field is first to neutralize the downward speed, imparted by gravity, and then to impart an upward speed in addition, the total speed imparted by the field is actually obtained by adding v_1, the downward speed due

to gravity, and v_2, the upward speed in the field. The results of such addition are shown in the middle portion of the table under the heading (v_1+v_2). The difference between the first two of these, corresponding to the two times of rise 34·7sec. and 85·0sec., respectively, is ·05347—·04456=·00891, which therefore represents, in terms of a speed, the charge *caught from the air* between the fourth and fifth trips up. When the whole succession of

TABLE

g	f
13·6 sec.	
13·8 "	
13·4 "	
13·4 "	12·5 sec.
13·6 "	12·4 "
13·6 "	21·8 "
13·7 "	34·8 "
13·5 "	84·5 "
13·5 "	85·5 "
13·8 "	34·6 "
13·7 "	34·8 "
13·8 "	16·0 "
13·6 "	34·8 "
13·5 "	34·6 "
13·4 "	21·9 "
13·8 "	
13·4 "	

$$\frac{v_1}{v_2}=\frac{mg}{Fe-mg}$$

$$e=\frac{mg}{FV}(v_1+v_2)$$

Volts = 5051

Distance = 0·5222cm.

Mean = 13·595 sec.

$$v_1=\frac{\cdot 5222}{13\cdot 595}=0\cdot 03845\text{cm. per sec.}$$

	v_2	v_1	(v_1+v_2)
·5222/85·0 =	·006144 +	·03845 =	·04456
·5222/34·70 =	·015050 +	·03845 =	·05347
·5222/21·85 =	·023900 +	·03845 =	·06232
·5222/16·00 =	·032640 +	·03856 =	·07105
·5222/12·45 =	·041960 +	·03845 =	·08038

·05347 — ·04456 = ·00891

5) ·04456	6) ·05347	7) ·06232	8) ·07106	9) ·08038
·008912	·008911	·008903	·008883	·008931

observed speeds imparted by the field is divided through by the integers 5, 6, 7, 8, 9, respectively (*see* lower part of table), there results in each case a number which is ·00891 within the very small limits of observational error. This shows conclusively, first, that the charge captured from the air when the time of rise changed from 34·8sec. to 84·5sec. was itself the *elementary unit of charge*, and, second, that the droplet carried successively 5, 6, 7, 8 and 9 of these units. In other words, the charges which the droplet is able to carry do show very definitely, unitary relationships, and the number of units (*electrons*) on the drop at any time can be counted by the foregoing process with quite the same certainty with which we can count our fingers or toes.

Since the foregoing sort of tests have been extended to thousands of droplets made of many different substances, some of which are insulators like oil, some semi-conductors like glycerine, some excellent conductors like mercury, and always with results precisely like those just presented, there is clearly no escape from the conclusion that *all electrical charges are built up out of a definite number of discrete elements or particles all exactly alike.* Indeed, anyone who has seen the foregoing experiment, and hundreds, perhaps thousands, have now done so, has proved for himself the existence of the electron with just as much certainty as if he had seen it as a visible object.

Electrons as Constituents of Atoms.—The experiment shows also that, since the X-rays were passed beneath the drop and were not incident upon it, the changes in charge must necessarily have been due to charges *knocked out of the atoms* of nitrogen and oxygen, by the passage of the rays, and caught by the drop, or thrown into it by the electric field. Since these charges were found to be electrons the experiment furnishes definite proof that ordinary *atoms have electrons as constituents.*

The electrons thus knocked out of atoms by X-rays or by ultraviolet light are found by slight variations of this same experiment to be always negative in sign. One such variation was as follows:—When the suspended droplet was of mercury and the exciting narrow beam was of ultra-violet light instead of X-rays the droplet did not change its charge when the beam passed underneath it (ultra-violet light has not a sufficiently short wave-length to detach electrons from the molecules of nitrogen or oxygen) but only when the light shone directly on the droplet itself; and then the sudden changes in its motions were always such as to show that it was invariably a negative, never a positive, electron that was detached from the mercury atoms of the drop by the incidence of ultra-violet light. These and slightly different experiments with X-rays show that it is only the negative, never the positive, electronic constituents of atoms that can be detached by external agencies such as molecular bombardment, incident aether waves, or temperature. As a matter of fact we now know that all the positive electrons in an atom are concentrated in its very minute nucleus.

Further in the course of the oil-drop experiment it was found possible to change the charge on the droplet, and to obtain an oil or a mercury drop altogether electrically neutral, which therefore falls under gravity with exactly the same speed when the electrical field is on as when it is off—a very important fact from which it follows that the negative constituents of the mercury, or other atoms, have as partners in the drop exactly as many unit positive charges as they have negative charges. In other words, we have here evidence that all atoms of which we have any knowledge have in them a certain definite number of negative electrons and exactly the *same number of positive electrons,* else they could not be obtained in the neutral condition. (This number can now be counted with certainty by a number of methods, the simplest being the method of Moseley.)

The discovery of the unitary or electronic structure of electricity means, of course, that all electrical phenomena must henceforth be interpreted in terms of the positions and movements of positive and negative electrons.

Absolute Value of the Electron.—The measurement of the absolute value of the electron was made by means of the oil-drop method, and involved a very large number of precise measurements of the foregoing sort upon a very large number of oil-droplets of widely varying sizes, floating, or falling, in many different sorts of gases, at many different pressures varying from one and a half millimetres of mercury up to 760 millimetres. By such a series of measurements the results were made independent of the gas pressures, and of the individual properties both of the droplets and of the media in which they floated. The details of these measurements will be here omitted, and only the final result stated; viz., that all the different series of measurements on different drop-substances and in different media always pointed infallibly, as shown by the convergence point of fig. 2, to the value $e^{2/3}=61\cdot 085\times 10^{-8}$, which corresponds to the absolute value of the electron $e=4\cdot 774\times 10^{-10}$ absolute electrostatic units, or $1{,}592\times 10^{-20}$ electromagnetic units. This is correct to about one part in a thousand.

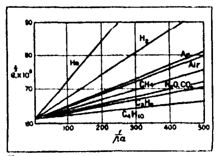

FIG. 2.—ABSOLUTE VALUE OF THE ELECTRON

From various experiments this has been established as a constant, $e = 4.774 \times 10^{-10}$ absolute electrostatic units

The electron is one of the most important of all physical constants; for the absolute magnitudes of practically all molecular and atomic quantities are determined as soon as it is accurately known, but they are indeterminable without it. Thus, for example, the so-called Faraday constant, the amount of electricity required to deposit from a solution one gramme molecule of a univalent substance, like hydrogen or silver, is found to be 9649·4 coulombs, or absolute electro-magnetic units; but this is obviously equal to Ne where N is the number of molecules in a gramme-molecule, and e is the value of the electron in electromagnetic units. Hence, as soon as e had been accurately determined N could be at once computed with precisely the same degree of precision obtained in the measurement of e. N is thus found to be $6\cdot 062\times 10^{23}$. This number of molecules in a gramme-molecule is usually called the Avogadro number. From it we determine at once the number of molecules in a cubic centimetre

of any gas, or, indeed, the exact number of molecules in a given weight of any substance whatever of known molecular weight, so that our knowledge of practically all absolute atomic and molecular magnitudes comes from the evaluation of *e*. The same is true to a somewhat lesser extent of atomic dimensions and of radiation constants. Thus, *e* takes its place as a constant of outstanding practical and theoretical importance. All electrical currents are caused by the slow travel of a well-nigh infinite number of these electrons along the wire which carries the current. All light or other short wave-length radiations are caused by changes in positions of electrons within atoms. All atoms are built up out of definite numbers of positive and negative electrons. All chemical forces are due to the attractions of positive for negative electrons. All elastic forces are due to the attractions and repulsions of electrons. In a word, *matter itself is electrical in origin.*

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ELECTROPHONE, a musical instrument making use of electric bells and giving a brilliant metallic sound, invented by the Dutch composer Daniel Ruyneman, who has employed it in some of his compositions.

ELECTROPHORUS, an instrument invented by Alessandro Volta in 1775, by which mechanical work is transformed into electrostatic charge by the aid of a small initial charge of electricity. In one form it consists of a disk of non-conducting material, such as pitch or resin, placed between two metal sheets, one being provided with an insulating handle. For the pitch or resin may be substituted a sheet of glass, ebonite, indiarubber or any other good dielectric placed upon a metallic sheet, called the sole plate. The method of use of the electrophorus is described in the article ELECTRICITY.

ELECTRO-PLATING, the art of depositing metals by the electric current. In the article ELECTROLYSIS it is shown how the passage of an electric current through a solution containing metallic ions (electrically charged atoms of a metal) involves the deposition of the metal on the cathode (the negative electrode). Under certain conditions, however, the metal is deposited in a non-adherent and pulverulent form. The main factors which influence the nature of the deposit are the following: chemical composition and temperature of the electrolyte, current density, concentration and circulation of the electrolyte, and the nature of the metal receiving the deposit (Watts, *Metal Indust.*, 1913). As the durability of the electro-deposited coat on plated wares of all kinds is of the utmost importance, the greatest care must be taken to ensure its complete adhesion. This can only be effected if the surface of the metal on which the deposit is to be made is chemically clean. If the surface is coated with rust or oxide, a preliminary cleaning is given by a sandblast or wire brushes, if the size of the object allows. Grease is removed by dipping into a hot alkaline solution. The last traces of oxide are dissolved and a bright metallic surface produced by means of a "pickling" solution, which is generally acid and varies with the metal treated. A cleaning treatment, which can generally be employed very advantageously, is to join the article as cathode in a suitable electrolyte, when the gas evolution removes much of the scale or grease mechanically.

General Methods.—The vats for depositing are generally wooden, lead-lined vessels, but may be enamelled iron, slate or particularly for small sizes, glazed earthenware. Large objects are suspended in the tanks by hooks or wires, the position of support being occasionally displaced so as to avoid wire-marks. Small objects are often heaped together in perforated trays or ladles, the cathode connecting-rod being buried in the middle. These require constant displacement since the objects are in contact at many points, and the top ones shield those below from the depositing action of the current. Processes have been devised in which the objects to be plated are suspended in revolving drums between the anodes, the rotation of the drum causing a constant renewal of surfaces, and at the same time imparting a burnishing action. As a galvanic deposit must be regular, tenacious, and usually capable of a high polish, its crystalline structure should be fine and as even as possible. With some metals, like nickel and iron, such deposits can be obtained from simple salt solutions. With others, like silver and lead, coarsely crystalline deposits are produced from such solutions, whilst finely grained deposits may generally be obtained by using electrolytes in which the metal is mainly present in the form of a complex ion. Solutions which would deposit their metal on the metal to be coated by simple displacement on immersion should not generally be used, as the resulting deposit is usually non-adherent. For this reason the acid copper bath is not used for iron or zinc objects, but is replaced by one containing copper cyanide or oxide dissolved in potassium cyanide. The formation of the complex ions reduces to a very high degree the concentration of the free metal ions, and, in accordance with the Nernst relation (*see* ELECTROLYSIS), the potential required for deposition is considerably raised; and the separation of the metal by simple displacement is precluded and is only brought about by secondary chemical interaction with some more electro-positive element, such as sodium or potassium, the ions of which are present in much larger numbers and are first separated.

Processes to Secure Regular Deposition.—It is found that an adherent, smooth, fine grained deposit is more readily obtained from concentrated solutions. Consequently, the current density should be kept low, in general about 0·02 amp. per sq.cm. (or 20 amp. per sq.ft.), because otherwise the concentration of the electrolyte is too rapidly decreased in the neighbourhood of the cathode. A high temperature and stirring also helps to prevent a decrease in concentration near the cathode. When possible the electrolyte should, as a general rule, be kept slightly acid, to prevent precipitation of basic salts or hydroxides at the cathode. The character of the deposit is frequently improved by the addition of a small quantity of an organic colloid to the electrolyte.

Hydrogen overvoltage is an important factor in the electrolytic deposition of metals. Although the separation potentials of zinc and cadmium from their solutions are higher than that of hydrogen, these metals can be deposited electrolytically before the hydrogen from a solution containing hydrogen ions; whilst iron, which has a lower separation potential than either metal, cannot. This is because the liberation of hydrogen is prevented by the high hydrogen overvoltage of zinc and cadmium, while iron has a very low hydrogen overvoltage.

A consideration of much practical importance in electro-plating is the so-called *throwing power* of the electrolyte. With an object of irregular shape there is a tendency for a thicker layer to be deposited on parts of it which project towards the anodes, whereas in hollows and indentations very little metal may be deposited. With some solutions, however, under suitable conditions, this unevenness of the layer on different parts of the surface at different distances from the anode is very small; such a solution is said to possess good throwing power. The factors which determine this important property have recently been elucidated by Arndt and Clemens (*Chem. Zeit.*, 1922) and by Haring and Blum (*Trans. Amer. Electrochem. Soc.*, 1923).

In some instances a screening or vignetting of the surface of the cathode is employed to increase the regularity of the deposit, or specially shaped anodes are employed in order that the distance between the electrodes may be fairly uniform. Supplementary anodes are sometimes used in difficult cases of this kind. With large metallic external surfaces use is sometimes made of a brush which is constantly wetted with the electrolyte while the hairs or bristles are connected with a wire anode and is painted slowly over the surface of the metal to be coated, which is connected to the negative pole of current supply.

Under these conditions electrolysis of the solution in the brush takes place. Iron ships' plates have been coated with copper in sections (to prevent adhesion of barnacles) by building up a temporary trough against the side of the ship, making the thor-

oughly cleansed plate act both as cathode and as one side of the trough. Decorative plating-work in several colours (*e.g.*, "parcel-gilding") is effected by painting a portion of an object with a stopping out (*i.e.*, a non-conducting) varnish, such as a copal varnish, so that this portion is not coated. The varnish is then removed, a different design stopped out, and another metal deposited. By varying this process, designs in metals of different colours may readily be obtained.

Special Methods.—Reference must be made to the text-books (*see* ELECTRO-CHEMISTRY) for a fuller account of varied solutions and methods used for electro-plating with different metals.

For the deposition of zinc, Sherard Cowper-Coles devised a process in which a lead anode is used, and powdered zinc is suspended in the solution to maintain the proportion of zinc in the electrolyte, and so to guard against the gradual acidification of the bath. It was formerly considered essential for the satisfactory deposition of zinc to avoid the presence of any considerable amount of acid. In a process developed by Tainton and Pring, however, it has been established that the deposition of zinc either for plating or for recovery from solutions of ores can be efficiently conducted in solutions containing as much as 20–25% free sulphuric acid. This is effected by the use of current densities as high as 100–500 amp. per sq.ft. and the presence of small amounts of a suitable colloid.

Cobalt is deposited by a method analogous to that used for nickel. Platinum, palladium and tin are occasionally deposited for special purposes. In the deposition of gold the colour of the deposit is influenced by the presence of impurities in the solution; when copper is present, some is deposited with the gold imparting to it a reddish colour, whilst a little silver gives it a greenish shade. Thus so-called coloured-gold deposits may be produced by the judicious introduction of suitable impurities. Even pure gold, it may be noted, is darker or lighter in colour according as a stronger or a weaker current is used. The electro-deposition of brass—mainly on iron ware, such as bedstead tubes—is now very widely practised, the bath employed being a mixture of copper, zinc and potassium cyanides, the proportions of which vary according to the character of the brass required, and to the mode of treatment. The colour depends in part upon the proportion of copper and zinc, and in part upon the current density, weaker currents tending to produce a redder or yellower metal. Other alloys may be produced, such as bronze or German silver, by selecting solutions (usually cyanides) from which the current is able to deposit the constituent metals simultaneously.

Electrolysis has in a few instances been applied to processes of manufacture. For example, Wilde produced copper printing surfaces for calico printing-rollers and similar articles by immersing rotating iron cylinders as cathodes in a copper bath. Elmore, Dumoulin, Cowper-Coles and others have prepared copper cylinders and plates by depositing copper on rotating mandrels with special arrangements. Cowper-Coles was also successful in producing true parabolic reflectors for projectors by depositing copper on glass surfaces.

The most noteworthy recent developments in electro-plating are in the deposition of iron and chromium and the use of electroplating for restoring worn components.

Iron Plating.—Processes of iron plating have been applied mainly at Grenoble and in the United States (*Trans. Amer. Electrochem. Soc.*, 1924) for the direct formation of articles such as boiler tubes of soft iron which on account of its purity has special properties.

In the process of Boucher in operation at Grenoble, which is used for producing iron tubes, an electrolyte is employed consisting of ferrous sulphate or ferrous chloride solution. The electrolyte is, during use, circulated over iron turnings and air is also blown in or iron oxide added. In this way the hydrogen ion concentration is kept low, and the dissociated air tends to depolarize the discharge of these ions. The current density is 10–11 amp./dm^2 and the temperature about 80° C. The small hydrogen content of the metal is eventually removed by annealing at 900° C. The product contains 99·97% iron. About 4 kw. of current are required for one kilo of iron deposited.

Chromium Plating.—Chromium plating has been largely developed very recently for special purposes where surfaces are required which possess the highest possible resistance to abrasion. Chromium deposits can be produced which are considerably harder than the hardest steel. The main application has so far been in the surface coating of plates used in intaglio printing which are subjected to severe abrasion during use. Formerly these plates were made of case-hardened steel or nickel-plated. A procedure now adopted is to deposit a thin layer of chromium on the nickel surface of the finished printing plate (*Chem. and Met. Eng.*, 1925). The thickness of the deposit need not exceed 0·0002 in. (0·005 mm.) in order to yield a greatly increased service. It is found that as a result of the poor throwing power in chromium plating, the lines are made deeper and the impressions are better than from the original plates. A smooth bright deposit is essential as subsequent polishing is impracticable. Further, after the chromium plate has been worn almost through it can be "stripped" and a new surface deposited, without any loss of definition. The electrolyte employed is usually a solution of chromic acid with a small amount of chromic sulphate and chromium carbonate. The chromium carbonate neutralizes any excess acid and maintains the correct degree of acidity or hydrogen ion concentration which is essential for the deposition. The current density employed is 100 to 200 amp. per sq. foot (11 to 22 amp. per sq.dm.), voltage, 7·9, and temperature of bath 40°–50° C.

Repair of Worn Components by Electro-deposition.—An important application of electro-deposition which has been made in recent years is to the restoration of worn parts such as the bearings of machines, wheel axles and the linings of guns and howitzers (J. P. McLare, *Trans. Faraday Soc.*, 1924–25). Copper was applied at the outset for this purpose on account of ease of deposition, but it is not sufficiently hard for a rubbing or rolling bearing surface, and even when used merely as a "packing," its liability to extrude under pressure renders it unsuitable for use. Methods of depositing iron have subsequently been developed. Formerly it was only possible to obtain this in coherent layers of a maximum thickness of about 0·003 in. and a procedure was adopted which employed alternate thin layers of copper and iron. It was found that one of the main causes of the inability to obtain thick deposits of iron was the lack of adequate preparatory cleaning of the metal surface. Eventually the adoption of an anodic system of cleaning in an acid bath, following a prolonged immersion of the articles in a boiling caustic soda solution, has enabled the development of a process whereby deposits of iron or nickel of any desired thickness may be applied.

The initial cleaning of the metal surface to be coated is effected by connecting as cathode and suspending in a hot electrolyte containing 1 lb. of commercial caustic soda, ½ lb. of washing soda, and 1 oz. of sodium cyanide per gallon of water. A current density of about 100 amp. per sq.ft. of cathode surface is applied and electrolysis continued for a period of from 3 to 10 minutes. The parts to be protected from deposition are then insulated by coating with a suitable wax composition and the metal is given a further anodic cleaning treatment for a short period in a cold alkaline cleaning bath. The object is then rinsed in clear cold water and transferred to an acid cleaning bath containing 2¼ lb. of sulphuric acid in 1 gal. of water, and by connecting as anode is subjected to an electrolytic current of at least 200 amp. per sq. foot. On applying the current a black film forms on the metal immediately and very little gas is formed; in about 30 sec. or so, however, the film is observed to break away and a free evolution of oxygen occurs. The gassing is allowed to continue for about 20 sec. when the surface of the article is seen to have a clear grey matte appearance. The acid is then washed off as rapidly as possible and the article transferred to the depositing tank. In some instances, as with the harder steels, the black film does not break away completely. In this event, the current is reversed for about a minute, making the article the cathode; an evolution of hydrogen then takes place which assists in disintegrating the clinging film, and on again reversing the current the cleaning is completed. The metal, after rinsing with water, is then transferred rapidly to the electro-deposition bath. The electrolyte

formerly considered essential consisted of a dilute solution of neutral ferrous ammonium sulphate. With this bath, a current density not exceeding 5 amp. per sq.ft., agitation of the solution, and a mechanical means of removing clinging hydrogen bubbles from the deposit to prevent pitting were essential. It has subsequently been found possible to employ concentrated solutions, containing from 3 to 3½ lb. of ferrous ammonium sulphate per gallon, and a current density of 18 to 20 amp. per sq.ft. without the necessity for continuous agitation of the electrolyte. The concentrated solution should be neutral or only very slightly acid to obtain deposits of reasonable hardness. The anodes consist preferably of very soft Swedish iron wire, wound in the form of a cylinder on flat grids. The temperature should be maintained at about 18° C.

Thick deposits of nickel are obtained from an electrolyte containing 2 lb. nickel sulphate, 3¼ oz. nickel chloride, and 4¾ oz. boric acid per gallon of water. A current density of 20 amp. per sq.ft. of cathode surface can be employed at normal room temperatures, giving a rate of deposition of approximately 0·001 in. of thickness per hour. As with iron, good deposits free from pitting can be obtained without the necessity for agitation when a sufficiently large bulk of liquid can be accommodated around the work.

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(J. N. P.)

ELECTROSCOPE, an instrument, as its name indicates, for detecting electrification. (*See* ELECTRICITY: *Faraday's Works on Electrostatics* and INSTRUMENTS, ELECTRICAL: *Electrostatic.*)

ELECTROSTATICS, the study of phenomena associated with stationary electricity. (*See* ELECTRICITY: *Electrostatics.*)

ELECTROTHERAPY, a general term for the use of electricity in the alleviation and cure of disease. Many claims have been made for it in the past which could not be justified, or at best were psychological. Of recent years its sphere has been better defined and at present four different types of electricity are employed in medicine:—

(1) The constant, continuous, or galvanic current.
(2) The interrupted currents of low frequency (the interrupted galvanic current, the alternating and sinusoidal currents, the faradic current).
(3) The interrupted currents of high frequency (high frequency currents and diathermy).
(4) The high voltage unidirectional currents derived from the static machine.

The Constant Current.—It is now generally accepted that the chief curative action of the constant current is due to the reflex action resulting from the stimulation of the cutaneous and subcutaneous nerves immediately beneath the area over which the pads conveying the current are applied. By this reflex stimulation an increased blood supply, with its valuable consecutive effects, is obtained. This stimulation is very similar in nature to what has been termed "counter-irritation," with the great advantages that the amount of stimulation is capable of exact regulation, that it takes place within the epidermis, thus acting directly on the nerve endings, and that it can be continued daily for a long period, improving the condition of the skin rather than destroying it, as the constant painting on of an irritant would do. The extent of this stimulation is dependent on the strength and duration of the current employed and the nature of the solutions with which the conducting pads are moistened.

When a positive pole of zinc or copper, or when salts of these metals in solution are employed, a caustic and destructive compound such as the chlorides or oxychlorides of zinc or copper is formed in the submucous or subcutaneous area by the combination of the negatively charged atoms of zinc (zinc ions), proceeding from the positive pole to the tissues, with the positively charged chlorine atoms (chlorine ions) proceeding from the tissues toward the positive pole. In the process of combination the atoms get rid of their electrical charges, the process is therefore rather one of de-ionisation. This method is very valuable for the thorough and safe destruction of the diseased membranes of cavities, such as the unhealthy mucous membrane of the uterus or the lining of septic cavities.

Similarly, by the employment of less destructive solutions, a reflex stimulation of the tissues can be brought about. The amount of stimulation depends on (1) the nature of the solution; (2) the strength and duration of the current. In general the best results are obtained by a solution causing the minimum of irritation and the application of the maximum current which can be readily tolerated by the patient for at least 40 minutes.

This form of treatment is indicated when increased local nutrition or the re-absorption of fibrotic thickening is desired: such as in the local treatment of chronic rheumatics, neuritis, sprains, and many other conditions. It is especially valuable in the treatment of tic douloureux, for which the employment of strong currents of from 40 to 80 milliamperes is necessary.

Interrupted Currents of Low Frequency.—The therapeutic effects obtainable from the employment of the interrupted currents of low frequency have been greatly increased by the methods recently introduced by Prof. Lapicque, Prof. Leduc, and Dr. Morton Smart. In the method of Lapicque, by the interposition in parallel of condensers with capacities varying from 2 to 30 microfarads, an interrupted current of such progressive onset and decline is obtained that it will excite contractions in paralysed muscles without exciting corresponding or over-powering contractions in the neighbouring healthy muscles due to the physiological fact that the contraction excited in a paralysed muscle is less dependent on a sharp make and break than with a healthy muscle.

In the treatment of infantile paralysis objection has been raised to the electrical excitation of the paralysed muscles on account of the over-excitation of the opposing healthy muscles which accompanies such stimulation. By the method of Lapicque this objection is entirely overcome. The defined and isolated contraction elicited by this method has a valuable re-educative effect in cases of recovering motor-nerve lesions. Lapicque's technique is especially useful in the treatment of facial palsy.

The Leduc current consists in the interruption at a frequency of about 100 per sec. of the galvanic current at the very low intensity of from two to four milliamperes. Leduc claims that it is possible by employing these minute currents interrupted at such frequency to induce successively local anaesthesia and, if applied through the brain, general anaesthesia, electric sleep, coma, and eventually death. Applied locally, avoiding the region of the brain, this treatment is perfectly safe and has proved valuable in the treatment of certain forms of neuritis and especially in that otherwise intractable condition, causalgia.

The advantages of the instrument and technique elaborated by Dr. Morton Smart for the application of faradism to muscles deficient in excitability and tone, which have very greatly enhanced the therapeutic value of the faradic current, are that the pain of the treatment is abolished or reduced to a minimum, the vigour and amplitude of the contractions are increased; and, above all, when employing this method, the operator can at once appreciate when the muscles are becoming fatigued and so can at once discontinue further stimulation before any of the bad effects, which were liable to occur when employing the older methods, can take place.

High Frequency Currents and Diathermy.—Although the researches of D'Arsonval which led to his discovery of the high frequency currents and diathermy were commenced in 1888 and concluded in 1890, diathermy (the most valuable result of his research) only began to be employed in Great Britain in 1911 or 1912. D'Arsonval, when experimenting with alternating currents in 1888, noticed that, with a constant strength of current, the more rapidly the interruptions occurred the more vigorous were the resulting muscular contractions.

When, however, a frequency of from 2,500 to 5,000 excitations a second was reached, a decrease in the vigour of the contractions occurred and progressively decreased with the increased frequency of excitation. At this time, the instruments at D'Arsonval's disposal did not permit a further increase of frequency, but in 1890, by employing the wireless apparatus of Hertz, he obtained what he rather exaggeratingly termed "billions of oscillations a second."

With these frequencies he found that he was able to pass a current of two or three amperes through the human body without producing any muscular contraction or other sensation than that of heat. He thus obtained the clinical high frequency currents. Diathermic currents were subsequently evolved from the high frequency currents by such modifications in the instruments as permitted currents of lower voltage, higher amperage, and higher frequency to be obtained.

The main therapeutic effect of diathermy is the generation of heat deeply in the tissues by the friction from the oscillation of the electrically charged atoms. Any organ of the body, any limb or part of the body, or the whole body to any extent required, can be heated by this current. Before the advent of diathermy we were able to heat only the superficies or the accessible cavities of the body; even under such limitations the application of heat formed one of the oldest and most useful therapeutic measures. Moreover, the heat obtainable from diathermy admits of exact and easily regulated adjustment to a degree never before obtainable.

The consecutive effects of heat applied in this manner are an increased blood supply, relaxation of tension and spasm with consequent relief of pain, increased local drainage, increased local nutrition. The heat thus generated is an expression of the mechanical or dynamic force exercised by the oscillations of the ions within the tissues and this primary action (the so-called "ionic massage") appears to be of value in aiding the dispersal of recent effusions. Some of the main indications for the application of diathermy are the relief of pain and spasm, the treatment of rheumatism, neuritis, sciatica, asthma, and pneumonia.

Diathermy in Surgery.—Apart from its medical application, diathermy is of considerable value in surgical practice for the destruction of superficial morbid growths, such as rodent ulcers, warts, naevi, etc. When applied for this purpose, in place of the two electrodes of large size employed in medical diathermy, one large (the indifferent electrode) and one small metal point (the active electrode) are substituted. In this way the heat, which is distributed and is only appreciated as a slight warmth over the large pad, is concentrated at the small metal point and almost immediately coagulates and destroys the tissue with which the point is brought in contact. Very satisfactory results have been obtained from the treatment of haemorrhoids in this manner.

The point of a metal wire can be employed as the active electrode and by inserting this wire through, *e.g.*, a cystoscope (an instrument for viewing the interior of the bladder) small growths can be readily destroyed and serious surgical operations avoided.

High Voltage Unidirectional Currents.—The therapeutic effects obtainable from the static machine were exhaustively worked out towards the end of the 19th century, notably by Drs. W. J. Morton and Benham Snow of New York. Recent research has enabled the therapeutic action of the currents derived from these instruments to be rationally explained on a physiological basis and the claims formerly put forward for this form of treatment have been fully justified. Under their influence the regularity and frequency of the pulse are increased, the blood pressure is raised, and skin action is promoted. The nervous system is quieted, sleep is better, and the patient often becomes drowsy during the application. (W. T.)

ELECTROTYPING, the production of copies of types, wood-cuts, medals and other objects by means of the electro-deposition of a metal upon a mould. A negative cast of the object to be copied is generally prepared in the first place, and is made from gutta-percha, plaster of paris, or wax. After being coated with a thin layer of graphite to serve as conductor the negative cast is connected to copper leads and is immersed in an electroplating bath as cathode. Forms of fusible metal may also be used, or electro-deposition may be effected on mandrels of special shapes and later stripped off.

Electrotypes may consist of copper, nickel or iron, the first metal being most usually employed. Copper electrotypes which are subjected to much wear are often "faced," however, with a thin coating of nickel, iron or chromium. In producing the relatively thick deposits of copper required in electrotyping an acid copper sulphate bath is used, similar to that employed in refining. The electrolyte contains 200 grams $CuSO_4,5H_2O$ and 30 grams H_2SO_4 per litre, and is usually kept somewhat above room temperature. The anodes are sheets of electrolytic copper. The current density is about 2 amp./dm.^{2} and the bath voltage about one volt. For more rapid working the temperature is raised and the electrolyte stirred by vigorously blowing in air. In this way current densities of 5–8 amp./dm.^{2} can be employed at the cost of a considerably increased bath voltage. When the copper positive is sufficiently thick and rigid, the whole is taken from the bath, the negative cast detached, and the electrolyte backed with some low melting lead alloy to provide the necessary strength.

Other applications of electrotyping are in the Elmore process, by which seamless copper tubes are produced. The density, regularity and evenness of the deposit are increased by continuously rotating the cathode and by causing pieces of agate, pressed on the cathode surface by springs, to travel continuously from one end of the cathode to the other and back again. To detach the tubes subsequently from their cores, they are gently heated, and worked loose by pressure. Their great tensile strength allows them to be easily drawn; consequently a few standard sizes only are directly produced in the bath. Tubes up to 5 ft. in diameter and 16 ft. in length have been produced. In other processes, such as that devised by Cowper-Coles, a very rapid rotation of the cathode enables high current densities to be used and improves the smoothness of the deposit. The similar production of iron tubes is described under ELECTROPLATING. An ingenious process has been described (*Chem. and Met. Eng.*, 1914), for the production of narrow, flat copper tubing through which small supporting tubes pass transversely at regular intervals: the copper is deposited on a perforated lead band which passes continuously through the solution, and the lead is subsequently melted out. Finally, Thain (*Trans. Faraday Soc.* 1921), has described an interesting electrotyping operation in which copper water jackets are built up around the cylinders of aero-engines. The metal is deposited on a fusible metal form which is afterwards melted out. A preliminary coating is put on from a cyanide solution, the main deposit being produced in the acid copper sulphate bath. (*See* also ELECTROPLATING, PRINTING.)

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ELECTRUM, ELECTRON, an alloy of gold and silver in use among the ancients, described by Pliny as containing one part of silver to four of gold. The term is also applied in mineralogy to native argentiferous gold containing from 20 to 50% of silver. In both cases the name is derived from the pale yellow colour of electrum resembling that of amber (Gr. ἤλεκτρον).

ELEGIT, in English law, a judicial writ of execution, given by the statute of Westminster II. (1285), and so called from the words of the writ, that the plaintiff has chosen (*elegit*) this mode of satisfaction. Previously to the statute of Westminster II. a judgment creditor could only have the profits of lands of a debtor in satisfaction of his judgment, but not the possession of the lands themselves. But this statute provided that henceforth it should be *in the election* of the party having recovered judgment to have a writ of *fieri facias* (*q.v.*) unto the sheriff on lands and goods or else all the chattels of the debtor and the one-half of his lands until the judgment be satisfied. Since the Bankruptcy Act, 1883, the writ of *elegit* has extended to lands and hereditaments only. (*See* EXECUTION.)

ELEGY, a short poem of lamentation or regret, called forth by the decease of a beloved or revered person, or by a general sense of the pathos of mortality. The Greek word ἐλεγεία is of doubtful signification; it is usually interpreted as meaning a mournful or funeral song. But there seems to be no proof that this idea of regret for death entered into the original meaning of ἐλεγεία. The earliest Greek elegies which have come down to us are not funereal, although it is possible that the primitive ἐλεγεία may have been a set of words liturgically used, with music, at a burial. When the elegy appears in surviving Greek literature, we find it dedicated, not to death, but to war and love. Callinus of

Ephesus, who flourished in the 7th century B.C., is the earliest elegist of whom we possess fragments. A little later Tyrtaeus was composing his famous elegies in Sparta. Both of these writers were, so far as we know, exclusively warlike and patriotic. On the other hand, the passion of love inspires Mimnermus. In the work of Theognis of Megara we can observe the characteristics of Greek elegy best. Here the Dorian spirit of chivalry reaches its highest expression, and war is combined with manly love. It is curious to notice that antiquity styled the funeral dirges of Theocritus, Bion, and Moschus—which are to us the types of elegy—not elegies at all, but idylls.

Gallus, whose works are unhappily lost, composed erotic elegies, which were the earliest elegies in Latin. The *Cynthia* of Propertius, however, with its rich and unexampled employment of that alternation of hexameter and pentameter which had now come to be known as the elegiac measure, seems to have settled the type of Latin elegy. Tibullus is always named in conjunction with Propertius, who was his contemporary, although in their style they were strongly contrasted. Finally, Ovid wrote elegies of great variety in subject, but all in the same form.

From the beginning of the 16th century "elegy" was used in English, as it has been ever since, to describe a funeral song or lament. The *Daphnaida* of Spenser (1591) is an elegy in the strict modern sense. Dr. Johnson's definition, "*Elegy*, a short poem without points or turns," is singularly inept and careless. By that time (1755) English literature had produced many great elegies, of which the *Lycidas* of Milton is by far the most illustrious. Since the 18th century the most famous examples of elegy in English literature have been the *Adonais* of Shelley (on Keats) and the *Thyrsis* of Matthew Arnold (on Clough). The most celebrated elegy in English is that written by Gray in a country churchyard. This, however, belongs to a class apart, as it is not addressed to the memory of any particular person. James Hammond (1716–42) enjoyed a certain success with his *Love Elegies* in which he endeavoured to introduce the erotic elegy as it was written by Ovid and Tibullus. This experiment took no hold of English literature but was welcomed in France in the amatory works of Parny (1753–1814), in those of Chênedollé (1769–1833), and of Millevoye (1782–1816). Lamartine must be included among the elegists, and his famous "Le Lac" is as eminent an elegy in French as Gray's "Country Churchyard" is in English. The elegy has flourished in Portugal, partly because it was cultivated with great success by Camoens. In Italian, Chiabrera and Filicaia are named among the leading national elegists. In German literature, the notion of elegy as a poem of lamentation does not exist. The famous Roman elegies of Goethe imitate in form and theme those of Ovid; they are not even plaintive in character.

ELEGIAC VERSE has commonly been adopted by German poets for their elegies, but by English poets never. Coleridge defines this kind of verse, which consists of a distich of which the first line is a hexameter and the second a pentameter, in the following illustration:

> In the hexameter rises the fountain's silvery column,
> In the pentameter aye falling in melody back.

The word "elegy," in English, is one which is frequently used very incorrectly; it should be remembered that it must be mournful, meditative, and short without being ejaculatory. Thus Tennyson's *In Memoriam* is excluded by its length; it may at best be treated as a collection of elegies. Wordsworth's *Lucy* is a dirge; this is too brief a burst of emotion to be styled an elegy.

ELEMENTARY EDUCATION. While elementary schools of a kind were founded before and after the Reformation (*see* SCHOOLS), the first connected movement towards providing such instruction on a large scale was that inaugurated in 1699 by the Society for Promoting Christian Knowledge, which by 1729 had led to the foundation of 1,658 charity schools with some 54,000 children. A somewhat similar impetus was provided by the Sunday School movement under Robert Raikes towards the end of the century. But the beginnings of a really national system may be said to date from the commencement of the 19th century, when Lancaster, and later Bell, established respectively undenominational and Church of England schools.

First State-aided Schools.—The first State grant was made in 1832. In 1843 State aid was given to training colleges. The pupil teacher system was established in 1846. Payment by result, and so examinations (*q.v.*) were introduced in 1862. In 1870 the first education act was framed and school boards established, to supplement but not to supplant existing church schools with schools in which religious teaching was to be undenominational.

Development of Free Education.—Elementary education was made free in 1891, and in 1898 payment by result was abolished, while during the last 20 years of the century higher-grade schools had been developed. In 1902–03 school boards were superseded as the local authorities by the county councils, who were made responsible under the act for all elementary schools in their area. Various unsuccessful attempts were made to upset the new system, as far as the church schools were concerned, in 1907–08, while during the same period medical inspection and after-care committees were instituted, and increasing stress was laid on physical training and school hygiene; the pedagogical side of the board's work had been emphasized in the *Suggestions for Teachers* (1905) and central schools established in place of the old higher-grade in 1906. Further milestones on the road of progress were the provisions for the preliminary education of the future teachers in secondary schools and the establishment of public training colleges, either locally or in the universities. Other landmarks are the Education Act of 1918, which codified and extended the schools' activities, and in particular raised the leaving age to 14, and the introduction of the Burnham scale of salaries in 1920. (C. BR.)

20TH CENTURY DEVELOPMENTS

The policy of the Board of Education as originally set out in the prefatory memorandum to the *Suggestions for Teachers*, first published in 1905, and reaffirmed in subsequent issues of the pamphlet (Ed. 2,638) indicated very clearly the ideal that animated English administrators, especially since the beginning of the 20th century.

The only uniformity of practice that the Board of Education desire to see in the teaching of public elementary schools is that each teacher shall think for himself, and work out for himself, such methods of teaching as may use his powers to the best advantage and be suited to the particular needs and conditions of the school. Uniformity in details of practice (except in the mere routine of school management) is not desirable, even if it were attainable. But freedom implies a corresponding responsibility in its use.

The administration and inspection of public elementary education upon lines as broad as these have combined with other influences to produce the variety which characterizes English and Welsh elementary schools. Other influences besides those directly exercised by the Board of Education may also be set down here.

Influence of Psychological Science.—The study of psychology has exercised a powerful and widespread influence upon elementary school teaching. For example, the emphasis placed by W. MacDougall (*Social Psychology*, 1908) and his school upon the importance of "interest" in education has been almost universally reflected in school methods and schemes of work and has been largely although not entirely responsible for many attempts—often singularly original and successful—to co-ordinate the life of the child in school with his life at home and for the adoption of "imaginative methods," *e.g.*, free drawing, dramatization, modelling, etc.

Again, teachers everywhere have taken great interest in both the theory and practice of intelligence tests (*q.v.*). The realization that the traditional methods of teaching in elementary schools often fail to develop latent ability, has led to original experiment on these lines and to a critical scrutiny of traditional examinations.

Physical Training.—The criticism of medical authorities (closely associated with the development of the school medical service) has checked any tendencies to regard education as an exclusively intellectual process. The modern elementary school has an equal regard for the physical as for the mental development of its pupils, and, quite apart from the specifically remedial

action of the school medical officers, now does much to improve the physique of its children. (*See* PHYSICAL TRAINING.) Considerable time and attention are devoted to suitable games (largely musical in character) in the infants' schools; and organized games, such as cricket, football, swimming, netball and folk dancing are practically universal in the senior schools. Progress has also been made in the provision of schools for the blind, deaf, etc. (*See* BLIND, TRAINING OF; DEAF AND DUMB, EDUCATION OF.)

Individual Methods.—The influence of Mme. Montessori's theories (*see* MONTESSORI SYSTEM) has been very marked in directing criticism against the traditional classroom methods of teaching and so leading on to a particularly fruitful experimentation in individual methods of instruction, which has been remarkably general and often remarkably successful in the infants' schools. The great majority of English infants' schools employ "individual methods" to a substantial extent, although seldom to the entire exclusion of the more traditional classroom methods. Somewhat similar methods—such as those adopted under variations of the "Dalton plan"—have been largely applied to the case of older pupils, the broad aim being to train the children to use books and to work individually with self-reliance and effect.

Teachers' Courses.—The "teachers' courses" have become more and more important in the development of elementary school teaching. The popularity of "refresher courses" for teachers already fully qualified increased steadily after the World War, and these courses are now attended by thousands of teachers annually. (*See* SUMMER SCHOOLS.) The courses may be held during the school holidays or the school terms; they may take the shape of continuous fortnights of study or of weekly demonstrations and lectures; they may be conducted by a local education authority, the Board of Education or private enterprise; they may deal with the theory or practice of education, or aim merely at deepening the teachers' knowledge of a particular subject. But whatever their system they have exerted a very beneficial influence upon elementary school teachers.

Special Developments.—Provision for the advanced education of children capable of profiting by it has been made. The brighter children are drafted away in increasing numbers from the elementary schools at the age of 11–12 to continue, by means of scholarships and free places, their education in the secondary schools. There has been an increase in many areas of "central schools," "central classes," "higher tops" and distinctively vocational schools, which also draw their pupils from contributory elementary schools, generally on a selective basis. Thus more and more the children remaining in the elementary schools beyond the age of 12 are those that are left after the cream has been drawn off, and the elementary school is left to solve the problem of a suitable method of education for children not of the first ability. The solution of this problem is dealt with in the paragraph below on the education of the adolescent.

Relations with Parents.—The elementary school as a whole since 1910 has very definitely resisted any tendency to become an educational machine for the instilling of mere information into children. Not many things are so significant as the widespread popularity of the "Education Week"—a week set apart by a local authority in order to explain and exhibit its system of education to the public. (*See* SCHOOL AND THE HOME.)

Infants' Schools.—As regards the infants' school, the special aim here is, not only to impart a rudimentary educational grounding, but to develop interest and the natural activities, special weight being laid upon oral responsiveness. The lively, eager, interested child, although with the powers of concentration proper to his age, is increasingly regarded as the typical product of the good infant school.

Senior Schools.—In the senior schools the general aim is to train the child in habits of independent work and self-reliance and to cultivate in him an interest and ability in intelligent work, which will stand him in good stead long after leaving school. In particular, the position of arithmetic as the weightiest subject in the elementary school curriculum has been severely shaken, if not definitely occupied by English, which has made great advance. The old multiplicity of subjects has defined itself into two groups—the English group, including reading, spelling, compositions, the study of elementary literature, geography and history; and the mathematical-scientific group, including arithmetic, elementary mathematics and general science. This process of definition, with its accompanying simplification of the whole and co-ordination of parts, has done a great deal to liberalize both the content and method of teaching.

Handwork.—Handwork has established itself firmly as a teaching method; as a subject in the shape of laundry, cookery and housewifery for girls, and wood, metal and varied work for boys, its value is increasingly allowed, especially for the kind of children likely to remain in the elementary schools until their school-life finishes. (*See* SCHOOL AND ITS CURRICULUM.)

Education of the Adolescent.—The most important event in the development of English public education was undoubtedly the issue of the *Report on the Education of the Adolescent* (1926), by the consultative committee of the Board of Education. This report, rich in educational material and suggestions of all sorts, can only be summarized here. Its chief recommendations are as follows:—

(1) That primary education should be regarded as an initial stage, definitely ending in ordinary cases at the age of 11. At this point all normal children should go forward to some form of post-primary education, which preferably should be provided in premises other than those used for primary purposes.

(2) That the post-primary stage of education should include not only secondary schools, but other types of post-primary school giving a wide variety of curriculum in accordance with the interests and abilities of the children. The schools which provide post-primary education should include, besides secondary schools, the following types:—(*a*) Selective central schools, (*b*) non-selective schools, (*c*) senior classes specially organized for the purpose in primary schools, (*d*) technical and "trade" schools.

(3) That school attendance up to the age of 15 should be made obligatory by legislation at the beginning of the school year 1932.

The committee suggested that the secondary schools should in future be known as "grammar schools" and the post-primary schools (*a*, *b*, *c*) be named "modern schools"; that the education in the modern schools be planned to cover a three years', and, when possible, a four years' course, and that it should definitely be a more "realistic" and "practical" type than that obtaining in the grammar schools, while being at the same time no less humane.

The president of the Board of Education (Lord Eustace Percy) intimated that he did not consider the moment opportune for introducing legislation for extending the age of compulsory school attendance. The other recommendations of the committee, however, impressed themselves deeply upon the administration of the board and of the local education authorities. In their circular 1,350 of Jan. 1925 the board had already recognized the age of 11 as the dividing line between "junior" and "senior" education, and had stressed the need of making provision for the advanced instruction of children over the age of 11 by giving opportunities for suitable classification and organization. The need for these opportunities and for the provision of forms of post-primary instruction alternative to the secondary school was implicitly recognized in the Education Act of 1918, but the effect of the committee's report was to throw into stronger relief the problem of the provision of post-primary education and to impress its importance upon public opinion.

Definite separation of primary and post-primary education could not of course be carried out by a stroke of the pen, when the vast majority of English schools had been structurally planned in accordance with a traditional organization of an infant department for children up to about seven and senior departments for boys and girls from seven to 14; when the number of central schools or suitably organized senior schools was inadequate, and the problem was further complicated by "dual control." But the shifting or decline of population had, in many districts, set free a good deal of elementary school accommodation, and whenever such an opportunity occurred, it was seized by the more active local education authorities for a comprehensive reorgan-

ization of the local schools on the lines of the report. The general drop in the number of births led to much more being found feasible in this direction than at first appeared. The lines of a further advance are outlined in the Board's Circular 1,397 of May 18, 1928. The circular laid down as the main task of the local education authorities during the years 1930–33 the solution of the closely related problems of the reorganization of the schools on the lines recommended by the Report on the Education of the Adolescent, the elimination of large classes, and the replacement, reconstruction and repair of all defective school premises. An official pamphlet entitled "The New Prospect in Education" gives more detailed suggestions on the grading and instruction of pupils above the age of 11. It will remain for experience to show which are the best of the many paths that are being tried as a means of advance through this difficult and most important territory. (*See* also EDUCATION: *England* and *Bibliography.* For elementary education in other European countries, *see* EDUCATION: *Growth of National Systems,* under the sections dealing with the separate countries. (K. M. A.)

UNITED STATES

Throughout the colonial period of American history and during the national period up to the middle of the 19th century the lowest unit of the American educational system was called the district school or sometimes the common school. The district school was not graded and was open to pupils until they reached their majority. It was supported in part by fees levied on the pupils, in part by subscription and in part by taxation. Following the reforms of Horace Mann in Massachusetts and of Henry Barnard in Connecticut and Rhode Island, that is from about 1850 on, the lower school was graded. Attendance was restricted to pupils of from 6 to 14 years. In general, throughout the northern States, the elementary school included eight grades. In a few centres in New England nine grades were included. Since the rise of the public school system in the southern States, subsequent to the Civil War, a seven grade school has been common in such States as Virginia, Texas, Louisiana, Georgia and Alabama.

Since about 1910 a strong tendency has manifested itself throughout the United States to reduce the number of grades in the elementary school to six. The higher grades which formerly were included in the elementary schools, especially the seventh and eighth, have very generally been absorbed into the so-called junior high school. This change is directly traceable to the fact that instruction has so far improved and the number of days during which pupils attend school each year has been so increased that it is now possible to cover in six grades the instructional materials which formerly required a full period of eight years.

Since the middle of the 19th century there has been a great increase in the average schooling of Americans. It is estimated that in 1840 the school attendance of the average citizen was limited to 208 days. In 1870 the number of days of attendance increased to 582, in 1890 to 770. In 1928 the average attendance of Americans was somewhat more than 1,200 days. These changes are due in part to the enactment of compulsory attendance laws in force in all the States. In larger measure, however, the changes are traceable to a growing desire on the part of parents that their children be better prepared for life in the modern world where advanced forms of knowledge are requisite to any high degree of success.

The graded elementary school is everywhere free. The annual expenditure for all public schools has increased from $1.64 per head of the total population in 1870 to $17.30 in 1926; *i.e.,* from $15.55 per pupil in average attendance in 1870 to $102.05 in 1926. The curriculum of the district and elementary school at first consisted almost exclusively of the so-called three R's, reading, writing and arithmetic. Since 1865 there has been a rapid expansion of the curriculum. History, geography, physiology, nature study, drawing, manual training, home economics and a number of other less common subjects have appeared in the programmes of more progressive schools, until the merging of the upper grades into the high school through the organization of the junior high school.

The expansion of the elementary curriculum has been accompanied by a demand for increased training of teachers. In the period of the district school the teacher was elected by the town meeting or was chosen by the lay officer elected as a trustee of the district. His or her training was often meagre and never included special professional preparation. With the rise of State boards of education in 1837 the practice of certificating teachers through the central State educational authorities has become common. All States restrict the local district officers in their choice of teachers to persons thus certificated. The States have also organized normal training schools (*q.v.*), or teachers colleges as many of them have designated themselves, where teachers may receive a professional training. The first State normal school was established in Massachusetts in 1839. In 1926 there were 400 such institutions with a total enrolment of 294,064. The more progressive elementary schools require teachers to have completed a high school education and to have taken in addition at least two years of training in a normal school. The less progressive schools, especially the one-room schools in rural districts, are often unable to employ normal trained teachers. It is estimated that from 25% to 40% of the rural teachers of the United States are without even a high school education.

The school buildings in which elementary schools are now housed are vastly more commodious and hygienic than were the buildings which housed the district school. These improvements are in part due to the fact that the rise of urban communities has made it possible to concentrate pupils in such numbers in a single building that the building can be provided with facilities which were out of the question in small schools. It is true, however, that even in the rural districts there has been a vast improvement in the construction and equipment of buildings. The Bureau of Education supplies figures which indicate the improvement since 1870. At that date the total value of school property was $130,383,008. In 1900, when the population of the United States was approximately twice the population of 1870, the value of school property had increased to $550,069,217. In 1926, when the population was about three times that of 1870, the value of school property was $4,676,603,539.

Attendance in elementary schools is made compulsory in all States. The first modern compulsory attendance law was passed in 1852 by the Commonwealth of Massachusetts. The last States to enact such laws were Georgia in 1916 and Mississippi in 1918. The earliest laws were at first inadequately enforced. It was not until the '80s that enforcement was vigorously carried on and then only in the older New England States, especially in Connecticut. Since 1900 there has been a movement to increase the age up to which pupils are required to attend school. Idaho requires attendance to 18 years of age, and 15 of the older States require attendance to 16. Compulsory attendance legislation is very commonly coupled with legal restrictions of employment of children. For some years the tendency has been to extend the period of education downward. The kindergarten was introduced into certain public school systems, notably in St. Louis, as early as 1873. Since then it has spread slowly until it enrolls (1927) 673,231 pupils, or between one-fifth and one-sixth as many as are enrolled in the first grade. A number of centres of investigation have laid great emphasis on the importance of the pre-school years in the formation of character, especially on the determination of emotional trends. As a result a number of pre-school training classes have been established in which controlled training of very young children is undertaken.

In the form of their organization and control American elementary schools are in sharp contrast with European schools of like level. In America the elementary schools are attended by pupils of all social ranks and they lead directly into the high school. Any pupil who completes the work of the elementary school may pass into the upper school. The administrative control of schools in the United States is largely in the hands of local authorities. The State exercises certain general powers, but these powers are, for the most part, such as to leave the local authorities much latitude of choice. For example, as stated, State departments grant teaching certificates, but the local authorities choose

the teachers for the schools from among the total list of possible candidates. There is in the United States no federal control of education, while in Europe every nation has a minister of education with large powers. The result of local control is that great variations appear, first, in the support provided for schools by different communities, second, in the quality of instruction, and third, in the breadth of the curriculum.

The total enrolment of pupils in all public schools in the United States in 1926 was 24,741,468. Of this number 20,039,051 were in elementary schools. The percentage of pupils enrolled in public schools as compared with the total population from 5 to 17 years of age was in 1926, 82·3%. The total number of school officers in public schools, including supervisory officers and teachers, was 831,078, of which number 644,631 were teachers in elementary schools. The total expenditure for public education in 1926 was $2,026,308,190, of which amount somewhat more than half, or $1,100,316,674, was for supervisory and instructional salaries.

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ELEMENTS, in theoretical astronomy, the six numerical quantities used for the computation of the position of a planet. Two depend on the geometrical properties of the orbit, *i.e.,* its semi-major axis and its eccentricity. Two define the position of the plane of the orbit; one of these is the angle between the *line of nodes,* and some fixed line, the other being the inclination of the plane of the orbit to the fundamental plane. The fifth is the position of the pericentre; and the sixth, the position of the planet in the orbit at a given moment. A seventh is the time of the revolution of the body in its orbit, called its period; but the seven elements are so related that any six only have to be known in order that the seventh may be deduced. (*See* also ORBIT.) For a definition of a chemical element *see* ELEMENTS, CHEMICAL. *See* also TRANSMUTATION OF ELEMENTS. For Euclid's *Elements see* EUCLID.

ELEMENTS, CHEMICAL, are entities which have hitherto resisted analysis and which are therefore regarded as simple substances. In ancient and mediaeval philosophy, the elements were the four simple substances, earth, air, fire and water, of which all material bodies were supposed to be compounded. In pre-scientific chemistry, the elements were variously enumerated, the usual number being five or six, such as spirit, salt, sulphur, water and earth, or water, oil, air, salt and earth. The modern use of the word dates from the time of Robert Boyle (1661), who described elements as primitive and simple, or perfectly unmixed bodies, which are not made of any other bodies or of one another. From this time onwards the term element was reserved for material substances, and by the end of the 18th century the question of which are true elements had been largely settled. Early chemistry was chiefly concerned with the preparation and description of chemical substances, and no criteria were available to decide whether substances were elements or compounds. About the middle of the 18th century, however, chemistry became definitely a quantitative science based on weighing, and the criteria became available. As the weight of a compound is the sum of the weights of its elements, an element is necessarily lighter than any of its compounds. An element is therefore a chemical substance which, by being changed into other chemical substances, invariably increases in weight. By means of this rule and the experimental chemical evidence relative thereto, A. L. Lavoisier in 1789 was able to compile the first scientific list of elements.

According to the knowledge of his time he regarded the alkalis as elements, although he remarked that they were rather similar to certain oxides, and therefore might possibly contain oxygen; the truth of this was proved at a later date by Humphry Davy. But the inconsistency of the reformer may be observed with the French scientist. He included "heat and light" in his list of elements, although he knew that neither of them had weight and that neither filled his definition of an element.

However an element be defined there is always one anomaly, in that there can exist more than one chemical substance containing one and the same kind of atom. On electrolyzing water, the component hydrogen atoms are set free at one electrical pole and the component oxygen atoms at the other pole. The oxygen atoms, however, do not appear as such, but combine with one another in two different ways to form two different chemical substances, both of which are gases containing nothing but oxygen atoms. These substances are ordinary oxygen gas, composed of two atoms per molecule, and ozone, composed of three atoms per molecule. There are thus three different things which are all strictly within the definition of the element, viz., single oxygen atoms, diatomic oxygen molecules, and triatomic oxygen molecules. This anomaly in nomenclature arises from the fact that the element oxygen was identified long before the possibility was considered that elements consisted of atoms capable of various combinations to yield different chemical substances. Usually, however, no confusion arises, because in the discussion of chemical elements the atom is understood, while in the discussion of elementary substances the polyatomic molecules are implied.

When an element can exist in more than one modification, it is said to exhibit allotropy (*q.v.*), the different forms or chemical substances being termed allotropes or allotropic modifications of the element. The conception of elements is further complicated by the fact that radioactive chemical substances are known which are absolutely identical in all chemical and physical properties save those of radioactive origin and disintegration. To these substances F. Soddy in 1911 gave the name isotopes (*see* RADIOACTIVITY). In the same year Sir J. J. Thomson made the important discovery that the element neon (atomic weight 20·2) is a mixture of two atoms differing only in atomic weight, the lighter isotope having the atomic weight 20 and the heavier 22. Since then F. W. Aston, using a modification of the same method of positive-ray analysis, has shown that about half of the known elements are mixtures of atoms having whole-number atomic weights (*see* ISOTOPES).

The elements may be divided into two classes, metals and non-metals. Though the line of demarcation is not sharp, it is usual to assign to the non-metals the eleven gaseous elements, hydrogen, nitrogen, oxygen, fluorine, chlorine, helium, neon, argon, krypton, xenon and radon; the liquid element, bromine; and the nine solid elements, boron, carbon, silicon, phosphorus, arsenic, sulphur, selenium, tellurium and iodine. All the remaining elements are metals, and with the exception of mercury, which is liquid, are solids.

The number of elements is limited. Reference to the periodic classification (*q.v.*) shows that only 92 elements up to the heaviest, uranium, can possibly exist. Of these, 90 are now known, though three of them, masurium (43), illinium (61) and rhenium (75), are only known with certainty from distinctive lines in their X-ray spectra, their atomic weights having not yet been ascertained. The two missing elements are a halogen (85) and an alkali metal (87). These numbers, which relate to the order in the classification, and to the numbers of electrons in the atoms, are known as atomic numbers (*q.v.*). Elements are thus characterized not only by distinctive physical and chemical properties but by numbers indicating that they differ in structure by one electron in successive atoms in the periodic classification.

Only about 30 elements occur in nature in the free state on the earth (*see* Table II.), though it is probable that in the sun and the hotter stars all elements are present in the uncombined condition. The commonest of these earth elements, namely, oxygen, comprises free and in combination about half the weight of the earth's crust, while the rarest, radon, probably amounts to less than a million millionth of the earth's atmosphere. Table I. gives the average composition of terrestrial material half a mile deep, including the earth's crust, oceans and atmosphere.

TABLE I.

Element	Parts per 1,000	Atoms per 1,000	Element	Parts per 1,000	Atoms per 1,000
Oxygen	500	538	Carbon	1·9	2·9
Silicon	257	159	Phosphorus	1·1	..
Aluminium	73	47	Sulphur	1·1	..
Iron	42	13	Barium	0·9	..
Calcium	32	14	Manganese	0·8	..
Sodium	24	17	Strontium	0·3	..
Potassium	23	10	Nitrogen	0·2	..
Magnesium	22	16	Fluorine	0·2	..
Hydrogen	9·5	163	Bromine	0·1	..
Titanium	4·3	1·6	Remaining		
Chlorine	2·1	1·1	elements	4·5	19·4

From this table it is evident that the four light elements, oxygen, hydrogen, silicon and aluminium, comprise together about 90% of the earth's crust both by weight and by proportion of atoms, and that a dozen light elements together account for 98% of terrestrial matter.

The general properties of the elements, even of those very close in atomic weight, are extremely diverse. Carbon, for example, has a boiling point about 3,700° C, while the next heavier element, nitrogen, has a boiling point nearly 4,000° lower at −195° C, only 78° C above the absolute zero temperature of −273° C. The melting and boiling points of an element are in some cases quite close together, and in others very far apart. The boiling point of helium, for example, is only about 2° above its melting point, −271° C, the lowest temperature that has ever been attained by artificial means, whereas tungsten melts about 3,000° C and boils about 6,000° C, the highest melting and boiling points known for any element. Table II. gives the melting and boiling points, where known, for all the elements.

TABLE II.

Element	Melting point, °C	Boiling point, °C	Element	Melting point, °C	Boiling point, °C
*Helium	−271	−268·7	Radium	700	..
*Hydrogen	−258·8	−252·8	Calcium	800	1,200
*Neon	−253(?)	−245·9	Strontium	809(?)	950
Fluorine	−223	−187	Lanthanum	810	..
*Oxygen	−218·4	−182·9	*Arsenic	817	..
*Nitrogen	−210·5	−195·7	Neodymium	840	..
*Argon	−189·6	−186·1	Barium	850	..
*Krypton	−169	−151·7	Germanium	958	..
*Xenon	−140	−109	*Silver	960·5	1,955
Chlorine	−102	− 33·7	*Gold	1,063	2,530
*Radon	− 71	− 62	*Copper	1,083	2,310
*Mercury	− 38·9	356·7	Manganese	1,260	1,900
Bromine	− 7·3	58·7	Beryllium	1,290	1,900
Caesium	28·3	670	Samarium	1,350	..
Gallium	30·2	1,700	Silicon	1,434	..
Rubidium	38·5	696	*Nickel	1,452	2,340
Phosphorus	44·1	279·3	*Cobalt	1,480	2,415
Potassium	62·5	762·2	*Iron	1,530	2,450
Sodium	97·5	882·9	Zirconium	1,530	..
*Sulphur	112·8	444·7	Chromium	1,540	2,200
Iodine	114	184·4	*Palladium	1,550	3,600
Indium	155	1,450	*Carbon	..	3,700
Lithium	186	1,400	Vanadium	1,720	..
Selenium	217	690	*Platinum	1,755	4,050
Tin	231·9	2,270	Titanium	1,795	..
*Bismuth	268	1,420	Uranium	1,850	..
Thallium	301	1,700	*Ruthenium	1,900	4,150
*Cadmium	321	765·9	*Rhodium	1,907	4,000
Lead	326·9	1,525	Niobium	1,950	..
*Zinc	419·4	905·7	Boron	2,200	..
*Tellurium	450	1,400	Molybdenum	2,500	..
Cerium	623	..	*Iridium	2,550	4,400
*Antimony	630	1,440	*Osmium	2,600	4,450
Magnesium	649	1,120	Tantalum	2,910	5,500
Aluminium	658·7	1,800	Tungsten	3,000	6,000

*Elements marked thus are known to occur in the free state on the earth.

The outstanding chemical constants of the elements are their atomic weight, atomic number and valency. Atomic weights, referred to the unit of one-sixteenth of that of oxygen (taken as 16), range from 1·008 in the case of the lightest element, hydrogen, to 238·17 for the heaviest element, uranium (*see* ATOMIC WEIGHTS). Atomic weights have not yet been determined for masurium (43), illinium (61), rhenium (75), polonium (84), actinium (89) and protoactinium (91). The atomic numbers 43, 61 and 75 are known from X-ray spectra, and 84, 89 and 91 are inferred from the radioactive disintegration series. The atomic weight, 222, of the radioactive noble gas, radon (86), is not completely certain, though, by analogy with the other noble gases, it is assumed to be double the known density.

The elements may be classified into two species by the valency criterion, first, those that have no valency (the six noble gases typified by helium), and second, all the elements that possess valency (the remaining 86 elements). The valency of an element is always an integer, as follows from the law of simple multiple proportions by weight, and, as indicated by modern theory, is the number of its electrons that are effective in chemical combination. The highest known valency is eight, exemplified by the octafluoride of osmium and the tetroxides of ruthenium and osmium. It is also known from the radioactive disintegration series that the noble gas, radon, has eight electrons that are potential valency factors. According to valency, the elements fall into eight families, the eight groups of the periodic classification with valency from one to eight. For the majority of the elements, valency is not a fixed number, but varies for any one element within certain limits. This variation occurs in two different ways, some elements exhibiting variation always of two units from the maximum to a minimum, whereas others exhibit variation by a single unit. Reference to the periodic classification (*q.v.*) shows that this variation is characteristic of certain types of elements, the elements of the typical classification exhibiting variation by two units of valency, whereas the remaining 48 elements (known as transition elements) exhibit variation by one unit. All the transition elements are metals, and, with the exceptions of zinc, cadmium and mercury, have boiling points above 1,900° C. The transition elements, moreover, are the only known elements which give rise to coloured salts in their highest condition of valency, and most of them form coloured salts at every condition of valency. The valency variation of two units for the elements of the typical classification is interpreted as indicating that each atom contains one pair or two pairs of valency electrons, and that the electrons forming a pair are equally firmly bound to the atom. The valency variation of one unit for the transition elements indicates that this system of electron pairs does not exist except where the minimum valency is two. With the exceptions of copper, silver and gold, every transition element has a minimum valency of two, and thus possesses a single pair of electrons that are equally and least firmly bound to the atom. To these two types of valency electronic structure are to be ascribed not only the general and characteristic chemical properties of the elements, but also the specialized chemical properties, which differentiate the typical from the transition series of elements. For transmutation of elements *see* article under that title.

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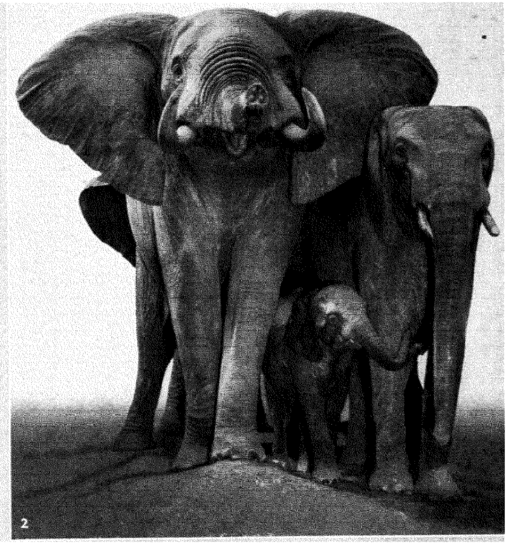
ELEMENTS, CONSCIOUS, the simplest, independently observable constituents of conscious experience. In the late 19th and early 20th centuries the conviction was widespread among psychologists that all conscious phenomena could be reduced to combinations of a limited number of simple observable constituents, termed "conscious elements." There was little agreement, however, as to the nature of these constituents. W. Wundt believed them to be of two main types,—sensations and feelings. E. B. Titchener, one of the most influential of Wundt's pupils, distinguished a third main type,—images. Chr. von Ehrenfels and other members of the school of *Gestaltqualität* insisted that consciousness involved a further class of elements, namely, form-qualities (*Gestaltqualitäten*). Yet another view was advocated by the school of "imageless thought," whose members claimed to find in consciousness certain impalpable elements which they termed knowledges (*Bewusstheiten*).

Since 1912 the attitude of psychologists toward conscious ele-

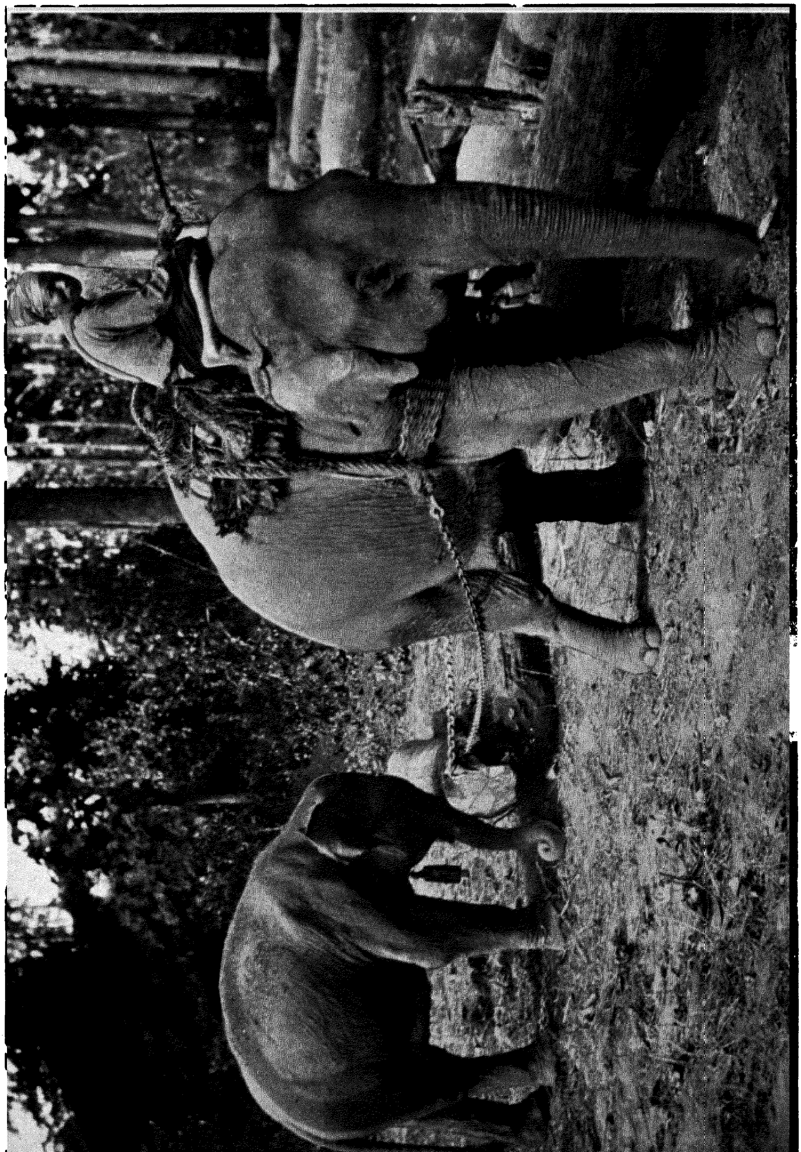


BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

AFRICAN ELEPHANT GROUP

Front and side views of a group of elephants shot for the American Museum of Natural History, on the African expedition in 1909 under Carl Akeley (1864–1926). The group was mounted by Akeley according to the sculptural method of taxidermy originated by him. It will form the central group in the Akeley African hall in the museum

The arrangement of the group shows the bull scenting danger—feeling for scent with his trunk, ears fully extended to catch the slightest sound. The attitude of the cow indicates that she has seen the intruder and has "frozen,"—ears back, trunk pendent, prepared for either attack or retreat. The calf, conscious of the alarm, is snuggling up to its mother *for protection.* The young bull, of which only an ear and a tusk are visible, has started forward to swing around and face the danger. The big bull elephant in the front of the group, and the smaller bull behind, were shot by Carl Akeley. The cow was shot by Theodore Roosevelt and the baby by Kermit Roosevelt on the Uasin Gishu plateau, where the Roosevelt and Akeley expeditions met



PHOTOGRAPH, COWLING FROM EWING GALLOWAY

ASIATIC ELEPHANTS AS DRAUGHT ANIMALS

Elephants which have been captured and trained for use in the logging industry in the teakwood forests of Upper Burma

ments has undergone a radical change. The works of M. Wertheimer, C. Rahn, K. Koffka and W. Koehler have shown that conscious elements such as sensations and feelings are inferential entities, not observable ones; and furthermore, that explanatory systems, which, like those of Wundt and Titchener, involve syntheses of such inferential entities, are at variance with a large number of experimental findings. There has resulted a marked tendency either to give up the concept of conscious elements entirely, or to interpret it as referring not to constituents of conscious events but to their aspects or attributes. In the latter case, conscious elements are considered not as explanatory or generative entities, but as the raw data of observation, whose variety is presumably as great as is the number of distinct predications which can be made about conscious events.

See W. Wundt, *Outlines of Psychology* (2nd ed.); M. Bentley, *American Journal of Psychology* (vol. xiii., 1902); E. B. Titchener, *Lectures on the Experimental Psychology of the Thought-Processes* (1909); C. Rahn, *Psychological Monographs* (No. 67, 1913); K. Koffka, *Psychological Bulletin* (vol. xix., 1923); W. Koehler, *Psychologies of 1925* (1926). (J. G. B.-C.)

ELEMI, an oleo-resin (Manilla elemi) obtained in the Philippine Islands, probably from *Canarium commune* (nat. ord. Burseraceae), which when fresh and of good quality is a pale yellow granular substance of honey-like consistency, but which gradually hardens with age. It is soluble in alcohol and ether, and has a spicy taste with a smell like fennel. In the 17th and 18th centuries the term usually denoted an oleo-resin (American or Brazilian elemi) obtained from trees of the genus *Icica* in Brazil, and still earlier it meant oriental or African elemi, derived from *Boswellia Frereana*, which flourishes in the neighbourhood of Cape Gardafui. The word, like the older term *animi*, appears to have been derived from *enaemon* (Gr. ἔναιμον), the name of a styptic medicine said by Pliny to contain tears exuded by the olive tree of Arabia.

ELEPHANT is the name applied to the two existing species of the Proboscidea and their immediate allies. The existing elephants inhabit respectively the forest-lands of India, Burma, the Malay peninsula, Cochin China, Ceylon, Sumatra and the continent of Africa south of the Sahara.

The Asiatic elephants are distinguished by the following characteristics. They possess complex teeth, the third molar having about 24 plates. There are 5 nails on the forefoot and 4 (occasionally 5) on the hind one. There is a depression crossing the dorsal surface of the neck, and the ears are of moderate size. The trunk is smooth, not possessing the transverse ridges and grooves of the African form and at the end is a single finger-like process. The Asiatic elephants although referred to the single species *Elephas maximus*, differ a good deal amongst themselves; for instance, the Ceylon animals are generally tuskless and the elephant of Sumatra, with its slighter build and longer trunk, is equally distinct.

The Asiatic elephant lives in small herds moving about in forests in the neighbourhood of water. It has a dislike of bright sunlight and hence during the hot season keeps to the denser parts of the forest. It drinks by sucking up water into the cavity of the trunk and then discharging it directly into the mouth. Its food consists chiefly of grass, leaves, the young shoots of trees, bamboo and fruits.

The height of the male Indian elephant when full grown is usually between 8 and 10 ft. but may reach as much as 11 ft.; the calf when born has a height of about 3 feet. The adult Indian elephant is usually very sparsely provided with hair, there is the well-known tuft on the end of the tail and occasionally small patches on the forehead. The new-born elephant, on the other hand, may be covered with a continuous coat of short, grey fur. This coat is soon shed but is replaced in part by coarser and darker hair which may be comparatively abundant in individuals about 5 years old. The period of gestation is not accurately known but is about 18 months and the animal lives to about 45–60 years. One calf is usually produced at birth, but twins are known.

The African elephant (*Elephas* [*Loxodon*] *Africanus*) differs from that of Asia in its body form, the highest point lying in the middle of the back and there being no depression across the dorsal surface of the neck. Also there are transverse ridges and grooves on the trunk which possesses 2 finger-like processes at the end. The molar teeth are shallower and coarser than those of the Indian elephant, and possess only about 8 ridges in the second molars. On the worn surface the plates have a lozenge-shaped section instead of having nearly parallel sides. The ear of the African elephant is always very large, although it varies in this respect as it does in shape in different geographical races. The African elephant, although it is a woodland form, is much less averse from exposure to full sunlight than is the Indian form; it also lives in herds varying from a few to a large number of individuals. The African elephants have been separated out into about a dozen different races distinguished from one another chiefly by the form and size of the ears, but also in some cases by differences in the shape of the skull. In the Congo there is found a dwarf-race of the African elephant[1], perhaps only about half the normal height.

The Asiatic elephant has long been captured and domesticated and is used as a transport animal in India, Burma and Siam. As the animal does not breed readily in captivity, most of the tame elephants have been caught, the following method being employed. A herd is driven through a funnel-shaped palisade into a small enclosure, individuals are then cut out from the herd by tame elephants and soon learn to obey their *mahout*, even when old animals. The only other commercial use of the elephant is as a source of ivory, a trade which is rapidly leading to the extermination of the African species. The tusks of the Indian elephant may reach a length of nearly 9 ft. and a weight of 100 lb., whilst the African elephant tusks may be 10 ft. in length, with a weight of 220 pounds. The female Indian elephant usually has small tusks, if any at all, but in the African species the female tusks are always large, as they are extensively used by the animal in feeding. African elephants are not now tamed, although they are actually as tractable as the Indian form, and were tamed and used in warfare by the Carthaginians and Romans.

Fossil elephants very similar in structure to those now living existed during Pleistocene times throughout Europe, Africa, Asia and North America. They belong to several species, of which the best known is the mammoth (*q.v.*). Amongst the others the most interesting are the dwarf forms whose remains are found in cave deposits in the islands of the Mediterranean, Cyprus, Malta and Crete. The smallest of these is a Cretan form, which in the adult stood about 3 ft. high. The whole group appear to be local varieties of *Elephas antiquus*, a straight-tusked elephant found essentially over the whole of Europe, India and Africa; it includes also gigantic individuals such as the one now mounted in the British Museum which was found in Kent, and has a height of about 14 feet, probably the greatest height to which any elephant has attained. (*See* also MASTODON.)

(D. M. S. W.)

ELEPHANTA, a small island between Bombay and the mainland of India, situated about 6 m. from Bombay (native *Gharapuri*). It is nearly 5 m. in circumference, and the few inhabitants it contains are employed in the cultivation of rice, and in rearing sheep and poultry for the Bombay market. The island, till within recent times, was almost entirely overgrown with wood; it contains several springs of good water. There are also important quarries of building stone. But it owes its chief celebrity to the famous Temple Caves, standing on a plateau and approached by a long flight of steps. The entrance is nearly 60 ft. wide and 18 high, supported by pillars cut out of the rock; the sides are sculptured into numerous compartments, containing representations of the Hindu deities, but many of the figures have been defaced. In the centre of the excavations is a remarkable *Trimurti* or bust, thought to be a triform representation of Siva. The heads are from 4 to 5 ft. in length, and are well cut. The head-dresses are curiously ornamented; and one of the figures holds in its hand a cobra, while on the cap are, amongst other symbols, a human skull and an infant. On each side of the Trimurti is a pilaster,

[1]The height of a large bull African elephant may reach eleven ft. and the weight 6–8 tons.

the front of which is filled up by a human figure leaning on a dwarf, both much defaced. There is a large hollowed compartment covered with figures, the largest of which is 16 ft. high, representing the double figure of Siva and Parvati, named Viraj, half male and half female. On the right is Brahma, four-faced, on a lotus—one of the very few representations of this god which now exist in India; and on the left is Vishnu. On the other side of the Trimurti is another compartment with various figures of Siva and Parvati, the most remarkable of which is Siva in his vindictive character, eight-handed, with a collet of skulls round his neck. On the right of the entrance to the cave is a square apartment, supported by eight colossal figures, containing a gigantic symbol of Mahadeva or Siva cut out of the rock. In a ravine connected with the great cave are two other caves, also containing sculptures, much defaced, and in another hill is a fourth cave. This interesting retreat of Hindu religious art is said to have been dedicated to Siva, but it contains numerous representations of other Hindu deities. It forms a wonderful monument of antiquity, and must have been a work of incredible labour. The cave is thought to have been excavated about the 10th century of the Christian era, if not earlier. The island is much frequented by the British residents of Bombay and few visitors to the city leave without making a trip to Elephanta.

ELEPHANT-HEAD (*Pedicularis groenlandica*), a North American plant of the figwort family (Scrophulariaceae), native to wet soil from Greenland to Alaska and southward on mountains to New Mexico and California. It is a smooth, erect perennial, about a foot high, bearing pinnately divided leaves and a dense cluster (spike), 2 in. to 6 in. long, of crimson flowers, irregular in shape, with the upper lip produced into a long beak, at first bent downward but soon curving forward and upward, the whole strikingly suggestive of an elephant's head. The plant, which blooms in midsummer, is an interesting floral feature of alpine meadows in the national parks of the western United States and Canada. A closely related species, *P. attollens*, of high mountains in California, with white or pinkish flowers marked with purple, but lacking the long beak, is known as elephant-snouts.

ELEPHANTIASIS, ĕl-ĕf-ănt-ī′ăs-ĭs (*Barbadoes leg; Boucnemia*), a disease dependent on lymphatic obstruction and characterized by hypertrophy of the skin and subcutaneous tissue. Two forms are known: (1) elephantiasis arabum, due to filariasis (*q.v.*); (2) the non-filarial form due to lymphatic obstruction from any other cause, as erysipelas, the deposit of tuberculous or cancerous material in the lymphatic glands, phlegmasia dolens (white leg), long-continued eczema, etc. The enlargement is limited to a particular part of the body, generally one of the lower limbs, rarely both, or the scrotum, one of the labia, or the mammary gland; far more rarely the face. An attack is usually ushered in by fever (elephantoid fever), the part attacked becoming rapidly swollen and the skin tense and red as in erysipelas. The subcutaneous tissues become firm, infiltrated, and hard, pitting only on considerable pressure. The skin is roughened with a network of dilated lymphatics and bullae may form, discharging a chyle-like fluid when broken (lymphorrhoea). In a later stage still the skin may be coarse and wart-like, and there is a great tendency for varicose ulcers to form. At the end of a variable time enlargement ceases to take place and the disease becomes quiescent, but recrudescences occur at irregular intervals, always ushered in by elephantoid fever. At the end of some years the attacks of fever cease and the affected part remains permanently swollen. The only difference in the history of the two forms of the disease lies in the fact that the non-filarial form progresses steadily, until either the underlying condition is cured or death occurs. The elephantiasis due to filaria is due to lodgment of the parasites in the lymphatics and lymph spaces.

Treatment is unsatisfactory. Occasionally the dilated lymph trunks can be found and an operation performed to implant them in some vein (lymphangeioplasty). And in some few other cases artificial lymphatics have been made by introducing sterilized silk thread in the subcutaneous tissues of the affected part and prolonging it into the normal tissues. This operation has been applied to the elephantoid arms dependent on a late stage of cancerous breast. Elevation of the limb and elastic pressure should always be tried, but often amputation has to be resorted to in the end. The disease is totally different from the so-called elephantiasis graecorum or true leprosy, for which *see* Leprosy.

ELEPHANT MOUND. A prehistoric earthwork in the Upper Mississippi and Lakes region—where effigy earthworks are common. It is near Wyalusing, Grant county, Wisconsin, and received its name from its massive form and a conjectured prolongation of the nose, supposed to be a part of the original mound when first brought to notice in 1872. The immediate situation is a long rectangular depression, the level of which is only a few feet above the Mississippi at high water. The highest point of the mound (4 ft.) was the hip of the effigy, the length was 140 ft., and the width across the body and to the lower end of the hind leg, 72 feet. When surveyed in 1884 no indication of an elephant-like proboscis was found, and it has long been believed that the effigy was intended to represent a bear.

ELEPHANT'S-FOOT, the popular name for the plant *Testudinaria Elephantipes,* a native of the Cape of Good Hope. It takes its name from the large tuberous stem, which grows very slowly but may reach a size of more than 3yd. in circumference with a height of nearly 3ft. above ground. It is rich in starch, whence the name Hottentot bread, and is covered outside with thick, hard, corky plates. It develops slender, leafy, climbing shoots which die down each season. It belongs to the monocotyledonous family Dioscoreaceae (*q.v.*), which includes the yam and the black bryony, *Tamus communis,* the latter found in Britain.

ELETS, a town in the Orel province of the Russian S.F.S.R., situated on the Sosna R., a tributary of the Don, in lat. 52° 37′ N., long. 38° 10′ E. Its population, 42,492 in 1926, has increased rapidly owing to its favourable situation as a junction for five railway lines. It has an electric generating plant, and its industrial undertakings include iron founding, lime-burning, leather preparation and tobacco works. It is an important grain and cattle centre: the first grain elevator in Russia was erected here in 1887. The cathedral and two monasteries contain historic relics. Elets is first mentioned in 1147, when it was a fort of Ryazan. The Turkish Polovtsi or Kumans attacked it in the 12th century, and the Mongols destroyed it during their first invasion (1239) and again in 1305. The Tatars plundered it in 1415 and 1450; and it seems to have been completely abandoned in the latter half of the 15th century. Its development dates from the second half of the 17th century, when it became a centre for trade with south Russia.

ELEUSIS, an ancient city of Greece about 14 m. W. of Athens, on a rocky ridge close to the shore of the bay of the same name opposite the island of Salamis. Its fame is due to its Mysteries (*see* Mystery). Tradition carries back its origin to the highest antiquity. In earlier history it seems to have been independent of Athens. Of its small territory the plain of Thria was fertile, though swept by blighting winds. To the west was the Rharian Plain, where Demeter is said to have sown the first seeds of corn; and the field called Orgas, planted with trees consecrated to Demeter and Persephone. The sacred buildings were destroyed by Alaric in A.D. 396. The present village (Lefsina or Lepsina, officially 'Ελευσίς) is Albanian.

The Site.—The Greek Archaeological Society has laid bare since 1882 the whole of the sacred precinct, traced its extensions at various periods and revealed successive stages in the structure of the Telesterion, or Hall of Initiation.

In front of the main entrance is a paved area, with the temple of Artemis Propylaea of Roman date; on each side of the Great Propylaea stood a Roman triumphal arch. Just below the steps of the Propylaea, on the left, a curb surrounding an early well marks almost certainly the καλλίχορον φρέαρ mentioned by Pausanias. The Great Propylaea is of Roman imperial date, set in a wall of 6th-century work, repaired in later times, which encloses an outer court, of irregular shape. The Small Propylaea, not set exactly opposite to the Great Propylaea, was built by Appius Claudius Pulcher, the contemporary of Cicero. It is in a later wall which, like two earlier ones of the 6th and 5th centuries,

bounded the inner precinct. Thence a paved road of Roman date leads to one of the doors of the Telesterion. Above the Small Propylaea, partly set beneath the overhanging rock, is the precinct of Pluto; it has a curious natural cleft approached by rock-cut steps. Here was found the famous head, now in Athens, usually called Eubouleus. Farther on a rock-cut platform approached by broad steps probably served for spectators. Beyond this, on higher ground, close to the side of the Telesterion, stood a small temple, unidentified.

The Telesterion (Hall of Initiation) was a large covered building, about 170 ft. square, surrounded on all sides by steps partly cut in the solid rock, which served as seats for the mystae, while the sacred rites took place on the floor. There were two doors on each side of the hall, except the north-west, where it is cut out of the solid rock, and a rock terrace at a higher level adjoins it. The roof was carried by rows of columns, more than once renewed.

The architectural history of the hall has been traced with the help of various foundations. The earliest building was small, rectangular, of polygonal masonry, quarried on the spot. This was succeeded by a square hall, almost of the same plan as the later Telesterion, but about a quarter of the size; its eastern corner coincides with that of the later building, and it had a portico in front and internal columns. This has been assigned to the time of Peisistratus; was destroyed by the Persians and partly rebuilt soon after; only to be replaced by the much larger Periclean hall designed by Ictinus, with projecting foundations for a portico or for angle buttresses, to resist the thrust of the roof. This hall is faced with a portico which was designed by the architect Philo (*c.* 300 B.C.); the marble pavement is a most conspicuous feature.

The Telesterion took up the greater part of the sacred precinct, and the massive walls and fortress towers of the time of Pericles are quite close to it; later the precinct was extended to the south, and at its end was erected a building, probably the Bouleuterion, rebuilt in Roman times. The precinct was full of altars, dedications and inscriptions. Its subterranean passages are nothing but cisterns or watercourses.

The excavations of Eleusis, and the antiquities found in them, have been published from time to time by the Greek Archaeological Society. *See* also D. Philios, *Éleusis, ses mystères, ses ruines, et son musée.* Inscriptions in *Bulletin de correspondance hellénique.*

ELEUTHERIUS, pope from *c.* 175 to 189. Allusions to him are found in the letters of the martyrs of Lyons, cited by Eusebius, and in other documents of the time. The *Liber Pontificalis,* at the beginning of the 6th century, says that he had relations with a British king, Lucius, who was desirous of being converted to Christianity. This tradition—Roman, not British—is an enigma to critics, and, apparently, has no historical foundation.

ELEUTHEROPOLIS, an ancient city of Palestine, 25 m. from Jerusalem, on the road to Gaza, mod. Beit Jibrin (Gabriel); pop. 1,000.

History.—Marēshah was the name of the settlement in Old Testament times, now Khirbet Mar'ash, about 1 m. S.W. of Beit Jibrin beside Tell Sandahanna (St. John), on which are the ruins of an early church of that name. Marēshah was fortified by Rehoboam, sacked by Judas Maccabeus (163 B.C.), and taken by John Hyrcanus (110 B.C.). Pompey restored it to independence (63 B.C.), and in 40 B.C. it was completely destroyed by the Parthians. The Romans rebuilt it as a fortress on the modern site with the name Baitogabra. Septimius Severus showed it favour and gave it the name Eleutheropolis ("free city") (A.D. 200). It boasted an era of its own, with the year 199 as zero year. In the course of the 9th century the old name reappeared as Beit Jibrin. On this site, the name of which they corrupted to Gibelin, the crusaders built a castle (1134), which fell into the hands of Saladin (1187), was retaken by Richard Lionheart (1191), and destroyed by Beibars (1264). During the World War the Turkish troops, who had entrenched themselves in the caves in its neighbourhood, were surprised and dislodged by Australian cavalry, Nov. 11, 1917.

Archaeology.—The hills in the neighbourhood of Tell Sandahanna are honeycombed with caves, some of great dimensions, which have been cut out of the soft rock. They are thought to be of early date. They seem to have been used in different ages for a variety of purposes—dwellings, tombs (one with about 2,000 columbaria), chapels, cisterns, etc. Some of the caves were decorated in the Roman period with paintings, which are now carefully protected. More recently (1922) at Tell Sandahanna, the site of a Roman villa of the 2nd century A.D., on which had been superposed a church, has been excavated. In one of its chapels there has been discovered a most wonderful mosaic, the finest example of its kind yet found in Palestine.

See H. Thiersch and J. P. Peters, *Painted Tombs in the Necropolis of Marissa* (Mareshah, 1905); F. M. Abel, "Découvertes récentes à Beit-Djebrīn," *Revue Biblique* (1924).

ELEUTHEROPOULOS, ABROTELES (1873-), German philosopher of Greek descent, was born on May 24, 1873, in Constantinople. He studied at Leipzig, and since 1896 has been *a privatdozent* at Zürich. He desired to put philosophy on a scientific basis and investigated its relation to sociology and economics. Besides his chief work, *Wirtschaft und Philosophie* (1898; 3rd ed., 1915), he has written *Einführung in eine wissenschaftliche Philosophie* (1900); *Sociologie* (1904; 2nd ed., 1908); *Rechtsphilosophie, Sociologie und Politik* (1908); *Seelenleben* (1911) and *Philosophie, allgemeine Weltanschauung* (1911).

ELEUTS. The western Mongols, certain of whom are called Kalmucks by their neighbours, although this term has been very loosely used, were called Urat by the Manchus, U-lat by the Chinese, and in western languages, through the Russian this term became Eleut. Some of them, notably the Torgots (Torgod) have migrated as far west as the Volga, whence they returned, and to-day their descendants are settled in the Ili district. Their culture and relationships are discussed in MONGOLIA: *Ethnology,* of which group they form an important part.

ELEVATOR, GRAIN: *see* GRANARIES.

ELEVATORS are designed to transfer people or materials from one level to another in a vertical direction with safety. Complete installations comprise the elevator machine with its motive power and controller, platform and enclosure in a hatchway operating on guides and with the necessary connecting cables, sheaves and other accessories. There are many types of elevators in use, operated by hand, steam, belt, hydraulic or electric power. Those installed recently (1928) have been almost exclusively of the electric type. There is a wide variation in their construction, depending upon the motive power, type of building served and the character of service to be performed.

The modern elevator dates from a platform hoist made by Henry Waterman in New York, in 1850, this being a very crude affair, operating between two floors. At about the same time George H. Fox and Company of Boston were building the same type of elevator and sending it to other parts of the country. In 1852 Elisha Graves Otis began the manufacture of elevators at Yonkers, N.Y., and in 1854 invented the first safety device to prevent the falling of the car platform in case the ropes should break.

Early Types.—The first passenger elevator was installed by Otis in 1857 in New York. The distinction of being the first passenger elevator has been claimed for an elevator installed by Otis Tufts, of Boston, in New York, which was known as the "vertical railway," but this was not installed until 1859. This "vertical railway" had as its principal feature an immense vertical screw, by means of which the car platform was raised and lowered. It was not, however, successful and only two of them were installed. The oscillating cylinder steam engine and the stationary cylinder steam engine which replaced it, were both invented by the Otis organization and remained in use until superseded by the hydraulic type. In 1878, Charles R. Otis invented the safety governor. The first passenger elevator in an office building was of the steam-driven type and was installed in New York in 1869. About this time steam driven belt machines were standard for factory elevators.

Hydraulic Elevators.—Early in the '70s, hydraulic machines were introduced and had many advantages over the steam machines, principally that of increased speed. This development of the hydraulic elevator began with the direct acting plunger

elevator which, however, was soon superseded for all except low rises, by the vertical hydraulic elevator, invented by Cyrus W. Baldwin. This type of elevator was rapidly developed for increased rises of elevators and improved forms of control. The early machines were operated by a hand rope in the car, but as speeds increased so that this was impossible, there was invented the differential valve and the pilot valve, operated by a lever device in the car. In meeting demands for higher buildings and consequently greater speeds, water pressures were rapidly increased which, together with further developments in the controlling system of the car, soon made available car speeds of 600 ft. per minute, which at that time was considered marvellous.

Electric Elevators.—In 1887 William Baxter, Jr., designed and installed an electric elevator in Baltimore, which was not successful. In 1889 the first successful electric elevator installation was made by Otis Brothers and Company in New York. This elevator remained in service about 35 years. The early electric elevators were of the drum type in which the hoisting cables were wound on the drum which was driven from an electric motor through a worm and gear reduction. These early machines were controlled by hand rope which, however, soon gave way to a lever device somewhat similar to that used with hydraulic elevators. In a few years this was superseded by what was known as the "magnet control," by means of which the car was stopped and started from a switch in the car itself, which operated electro-magnets on a control board.

Shortly after the development of car switch control for electric elevators, there was placed on the market the automatic push button type of control. This type was intended primarily for private residences and apartments and was operated by means of buttons in the car corresponding to the floors served and by buttons at the entrances on each floor. No operator was required and the passenger operated the car by pressing the buttons. This type was limited to slow speeds on account of the difficulty in making level landings under all conditions of loading, and they could only be used where the service was light as only one passenger at a time could be served. Combination door locks and switches were provided to prevent the opening of the hatchway doors until the car was stopped at the landing and to prevent the operation of the elevator if any of the hatchway doors were open.

It was only a few years after its invention that the electric elevator began to take the place of the hydraulic elevator in all except the highest buildings. This was due to its higher efficiency, its easier handling and because much less space was required for machinery. The early electric machines were all of the direct current type and it was not until April 1898, that the Otis organization installed the first alternating current electric elevator, which was mechanically controlled, as electro-magnets were not yet adapted for that character of current.

In 1899 the plunger type of elevator was developed for high rise, high speeds. The claim of safety put forth was that the elevator could not fall. There were, however, many inherent disadvantages and this type of elevator for high rises had a very brief period of popularity. The electric elevator of the worm geared type, as then developed, had two disadvantages which prevented its ready adoption for the then highest type of building. Elevator travel was limited because the hoisting ropes were wound on the drum, the face of which necessarily projected in the hatchway, and the face of the drum was limited by the space available in the width of the hatch. The result was that the vertical hydraulic elevators continued in use for high speed service.

1:1 Gearless Traction Elevator.—In 1904 the Otis Elevator Company installed in Chicago, the first gearless traction electric elevator apparatus, which was of the direct drive type, known as the 1:1 elevator. This elevator machine consisted of a slow speed motor with the driving sheave mounted directly on the armature shaft and with an electric brake on the same shaft. The hoisting ropes attached to the car ran directly to the driving sheave on the machine and around that and a secondary sheave, and directly to the counterweight. This direct drive, without any intermediate gear reduction, and with the slow speed motor, permitted car speeds of 550 to 600 feet. This type of machine was placed over the hatchway and so saved a great deal of valuable space in the basement. They developed very high efficiency and were easily operated at high speed. This machine was perfected rapidly and within a few years had come into general use for all high speed service.

Where it is desired to use a gearless traction machine for very heavy duties at slower speeds, it is possible to utilize the gearless machine with rope gearing of 2:1 by means of sheaves on the top of the counterweight and on the steel frame of the elevator car. By 1916 an improvement on the worm gear drum type machine was made which consisted of the use of a driving sheave instead of a drum and which became known as the single wrap traction geared elevator. This improvement provided the geared type of elevator with greater safety, as it gave it the inherent advantage of the traction type of drive in that if the car or counterweight should bottom in the hatchway the other member would not be drawn into the overhead work, as had happened with the drum type machine.

MODERN IMPROVEMENTS

Micro-drive or Self-levelling Elevator.—With this type, the elevator platform is automatically levelled exactly with the floor landing at each stop, irrespective of the operator. This eliminates "inching" at the floors, with consequent saving of time. It also saves power consumption and wear on the machinery.

Automatic Operation.—In 1924 an important advance was made in elevator operation by the invention of the Otis automatic signal control. The entire operation is automatic and controlled by the pressing of buttons in the car by an attendant, or on the floors of the building by the waiting passengers. Upon being given the signal to start, the attendant releases the doors, which close automatically. The elevator then starts automatically and runs to the first floor for which a button has been pressed, where the car stops automatically and the doors open automatically. After the passenger has alighted the attendant releases the doors and the cycle of operation is repeated at each floor for which a button has been pressed. In the meantime waiting passengers press buttons at the floors, indicating the direction in which they wish to travel. Each call is automatically registered on the first elevator travelling in the proper direction, which then automatically stops at that floor, without even the foreknowledge of the attendant. This type of control is supplied with micro-drive, which enables these elevators to be operated at speeds up to 900 or 1,000 ft. per minute, and as much higher as may be required by buildings of the future. These high speeds are made possible by the automatic levelling, as cars travelling at such speed could not be satisfactorily handled by manual operation of an operator, with car switch control.

A form of control which has become very popular in the United States in recent years and which is known by various names such as unit multi-voltage, variable voltage, etc., was patented many years ago by Ward Leonard and has been used extensively outside of the elevator industry wherever considerable variation of speed and smooth retardation and acceleration were desired. In the elevator industry it consists of an individual generator driven by direct or alternating motor-supplying current to the elevator motor. A further development of the automatic signal control is the collective automatic control and the department store control. The collective automatic control is an outgrowth of the ordinary automatic push button elevator used for private residences and small apartment houses as previously described. With the collective type of control, combined with micro-drive, speeds of 450 ft. per minute may be attained with perfect stopping, and the control is so arranged that the elevator will stop at each floor for which a button has been pressed in the direction in which the car is travelling. These improvements make it possible to use this type of elevator without an operator in larger apartments and small hotels.

The department store type of control is designed for buildings of that character, or other service where stops are usually made at each floor in both directions. With this system there are no floor buttons required, nor is the attendant required to press any buttons in the car. Upon the releasing of the doors at the first floor, which close automatically, the car then starts automatically and runs to the next floor, where it stops automatically and the doors are

opened automatically, this cycle being repeated at each floor. It is possible, however, by the movement of a switch in the car to have the elevator travel past any floors without stopping. There are variations of both collective control and department store control to suit individual requirements of certain buildings.

A form of automatic operation for freight elevators in large groups is known as the operatorless control, used with a number of elevators in one or more banks. With this system there is one central operator for each group who receives by telephone all calls from any floor where an elevator is required. He has before him an indicator board which shows him the position of all elevators at all times and whether they are in use or not. By means of buttons on his desk, which automatically control all of the elevators, he then dispatches the nearest available elevator to the floor where it is needed. This effects a great saving in time and eliminates the possibility of waiting for an elevator that is in use.

Safety Devices.—The first essential of an elevator installation is the inclusion of all necessary safety devices to accomplish this purpose and prevent accident or injury. The early builders, with very crude machines, did not require any devices other than that of one over the platform to prevent its falling in case the ropes should break. As the machines developed in character, capacities and speed, various other devices were put into operation to take care of increased hazards until at the present time the electric elevator of the reputable manufacturers has a number of safety devices which cover practically every condition which might occur.

In addition to the safety device under the car connected with the automatic speed governor, there is also, on high speed installations, a switch on the governor which cuts off current to the motor and applies the brake if the car should attain excessive speed. Automatic stopping and final limit switches are provided to slow down and stop the car at the terminal landings in case the operator should fail to throw the car switch, or in case an automatically controlled machine should run beyond its normal stopping point. Buffers are provided in the pit to bring the car to a gradual stop if other safety devices should fail. On high speed installations, these long stroke oil buffers are so arranged that if the car lands upon them they are gradually compressed and checked by oil circulating through graduated openings. Featured in the traction type of plant, in which, where neither the car nor the counter-weight can be pulled into the overhead work if the other should be checked in its descent, buffers mean that another possibility of accident is eliminated.

All automatic types of elevators used without a regular operator have the interlocking door locks and contacts as heretofore described. In many American cities the regulations now require that all passenger elevators shall have a gate or door on the platform, with a switch so connected that the car cannot be operated while this gate is open. This prevents any possibility of passengers in the car coming in contact with the side of the hatchway while the elevator is running.

Signals.—The early annunciator in the car to notify the operator of calls has given place on the high speed elevators to flash light signal systems of several types. When service is not continuous the flash light annunciator is used; this being automatically reset when the call is answered. In continuous service, as in office buildings where the elevators are kept running continuously, the signal system on car switch controlled elevators is such that the pressing of a button by a waiting passenger on any floor signals the first car in the desired direction by flashing a light when the car is approximately two floors away, thus notifying the operator of the call. This light is extinguished when the car passes the floor. There is also provided with this system an "up" and "down" signal lantern in front of each elevator at each floor to notify the passenger as to which elevator will service his call. On signal control elevators the pressing of a button on any floor registers the call on the elevator controllers. Signal lanterns are provided on each floor.

Influence of Elevators on Buildings.—Before the advent of the elevator it was not feasible to construct buildings more than a few storeys in height. The early elevators permitted of a few additional storeys. As the speed and reliability of elevators increased this improvement was reflected in the taller buildings which sprang up in the larger cities. With the coming of the steel skeleton building structure builders saw the possibilities of increased returns from their property, especially in the more congested districts where land values are high, and turned to the elevator as the means of making it possible to rent such buildings advantageously.

The development and application of gearless electric elevators which removed the height limitation of building as far as the elevator is concerned, was immediately reflected in the 41 storey Singer building in New York. Since 1924, coincident with the development of the still higher speeds of the signal control elevator, there has been a tremendous increase in the number of high buildings erected in the larger cities throughout the United States. The present maximum car speed of 900 ft. per minute has already been exceeded in estimates for still higher speeds in buildings which might require it. It would thus appear that no matter to what extent the builders may aspire in the height of their buildings, elevator manufacturers will be able to meet their requirements.

In office buildings the character of elevator service is frequently the most important feature in the success of the building. Elevators in a building are divided into those for local service, approximately from the 1st to the 10th floor; then express elevators serving the 10th to 20th floors; another group making no stops to the 20th, and serving from there to the 30th and so on. In this way the offices on the upper floors become practically as easy of access as those on the lower floors and are frequently more desirable on account of the better light and ventilation and freedom from street dust and noise. (J. H. Van A.)

ELF, a diminutive supernatural being of Teutonic mythology, usually mischievous, causing diseases and evil dreams, stealing children and substituting changelings; differs from the Romanic, less sinister fairy. (O.E. *aelf; cf.* Ger. *Alp*, nightmare.) The prehistoric flint implements, in England known as "elf-bolts" or "elf-arrows," were looked on as the weapons of the elves, with which they injured cattle. A tangle in the hair was called an "elf-lock."

ELGAR, SIR EDWARD (1857–), English composer, was born at Worcester on June 2, 1857. His father was organist of the Roman Catholic church of St. George in that city, and had connections with the Glee Club and the Three Choirs Festival. He was also a violinist, and both he and his son played in the Festival orchestra. The boy also played the organ and occasionally the bassoon, and sometimes led the Glee Club band. He had no regular musical education. In 1879 he became bandmaster at the county lunatic asylum; in 1882 he was engaged as conductor of the Worcester amateur orchestral society; and in 1885 he succeeded his father as organist at St. George's. In 1889 he married Caroline Alice, daughter of Maj.-Gen. Sir Henry Gee Roberts and in the same year he moved to London; but finding no encouragement there he retired to Malvern in 1891, and in 1894 settled in Hereford. From 1905 to 1908 he was professor of music at Birmingham university.

To the public generally Elgar's name was little known until the production of his oratorio, *The Dream of Gerontius.* This work, first performed at the Birmingham Festival in 1900 under Richter, did not at first receive the recognition which it merited. Portions of it, such as the death scene and the "Angel" music, made an instant impression, but the whole was felt to be disappointing. A section of the audience objected to its "Catholicism," though to others, who appreciated the spiritual affinity existing between the music and Newman's poem, this was the element that was most precious. It was not until the performance of the oratorio at the Lower Rhine Festival at Düsseldorf on May 19, 1902, under Julius Buths, when it elicited from Richard Strauss a generous tribute which attracted universal attention, that its position was assured. Elgar's next great work was *The Apostles,* forming the first part of a trilogy, which was produced at the Birmingham Festival of 1903 and performed at the Lower Rhine Festival in Cologne in 1904. Its reception in both cases was disappointing. Made of sterner stuff than *Gerontius,* it was not calculated to appeal to those who had taken that work to their

hearts. The harshness of some of the progressions was displeasing to English festival audiences who had been brought up on Mendelssohn and Spohr, but subsequent performances brought a revulsion in its favour. Elgar's growing popularity led to the organization, in March 1904, of an Elgar festival of three days at Covent Garden, London, at which *Gerontius, The Apostles* and the concert overture, *In the South,* were performed. The last is one of the composer's finest works, remarkable for the broad lines of its melody and its warm colouring, and interesting as a foretaste of the great symphonic writing that was to come. In 1906 *The Kingdom* (op. 51) (part II. of the trilogy), was produced at the Birmingham Festival.

The appearance of the first symphony (in A flat, op. 55), first played in Manchester on Dec. 3, 1908, marked the opening of a new phase. Where the massive choral works had failed to convince and impose, the symphony now succeeded. Its breadth, its beauty and its sincerity left no doubt, from the first time of hearing, of its importance. Its reception abroad was almost as enthusiastic, and in the result it was hardly going too far to say that English music had been raised to a higher position in the estimation of Europe than any which it had occupied since the death of Purcell. After the symphony came the violin concerto (op. 61), the second symphony (op. 63) and the symphonic study for orchestra, *Falstaff* (op. 68). The concerto was first played by Kreisler at a Philharmonic concert in London in 1910 and, like the first symphony, attained immediate popularity.

The World War inspired Elgar to write some patriotic pieces, one of which, *Carillon* (op. 75), written to a poem by Émile Cammaerts, had innumerable performances. These works were followed by *Polonia*, a symphonic prelude, and *Le Drapeau Belge* (op. 79). After the war Elgar turned his attention to chamber music, producing in a single year (1919) the violin and piano sonata (op. 82); the string quintet (op. 83); the piano quintet (op. 84) and the violoncello concerto, all works of the finest quality. Since the death of his wife in 1920, he has produced little beyond two brilliant transcriptions for orchestra of a fugue by Bach and an overture by Handel, but it is believed that there are other works still to come.

Many of Elgar's earlier compositions were revived when his fame became established and have become permanent favourites with the British public. Among these are the *Pomp and Circumstance* marches (op. 39), the first of which contains as its *trio* the stirring melody now sung to the words of "Land of Hope and Glory"; the song-cycle, *Sea-Pictures,* first sung at Norwich by Dame Clara Butt in 1899; the "Enigma" *Variations for orchestra on an original theme;* the overture *Cockaigne* and the two orchestral suites *The Wand of Youth,* written on material dating from the composer's childhood. Among these, the Variations stand easily first and have indeed long since taken their place, alike at home and abroad, among the most important of all Elgar's instrumental works; the *Sea-Pictures,* though on a lower level, rank none the less among the best of Elgar's songs, while *Cockaigne* has also proved very popular, not least on the continent, where it is regarded as a typical picture in tones of London's busy life. Still earlier works include the popular *Salut d'amour* for violin and piano; *Sursum corda* for brass, strings and organ; a concert overture *Froissart; Spanish Serenade* for chorus and orch.; *The Black Knight,* cantata; *The Light of Life,* oratorio; and *Scenes from the Saga of King Olaf* for soli, choir and orch.

Elgar received his knighthood in 1902, at the time of King Edward VII.'s coronation, for which he wrote the official Ode. In 1900 he received the degree of Mus. D. from Cambridge university, and in 1905 from Oxford and from Yale. The Order of Merit was conferred on him in 1911, while he succeeded Sir Walter Parratt as Master of the King's Musicke in 1924.

For further information concerning the composer, *see* an excellent and comprehensive article in *Grove's Dictionary* (3rd ed.); R. J. Buckley, *Sir Edward Elgar* (1904); Ernest Newman, *Elgar* (1906); J. F. Porte, *Sir Edward Elgar* (1921).

ELGIN, a royal and municipal burgh, and county town of Moray, Scotland, situated on the Lossie, 5 m. S. of Lossiemouth its port, on the Moray Firth, and 37 m. N.E. of Inverness, with stations on the L.N.E.R. and L.M.S.R. Pop. (1921) 7,776. It was created a royal burgh by Alexander I., and received its charter from Alexander II. in 1234. Edward I. stayed at the castle in 1296 and 1303, and to blot out the memory of his visit the building was destroyed immediately after national independence had been reasserted. The hill on which it stood was renamed the Ladyhill. In 1452 half of the town was burnt by the earl of Huntly. Montrose plundered it twice in 1645. In 1746 Prince Charles Edward spent a few days in Thunderton House. For 50 years after this date the place remained a sleepy cathedral city, but with the approach of the 19th century much that was picturesque disappeared, though its prosperity increased. The cathedral of Moray was founded in 1224, when the church of the Holy Trinity was converted to this use. It was partially burned in 1270 and almost destroyed in 1390 by Alexander Stewart, the Wolf of Badenoch, natural son of Robert II. In 1402 Alexander, lord of the Isles, set fire to the town, but spared the cathedral for a consideration, in memory of which mercy the Little Cross (so named to distinguish it from the Muckle or Market Cross, restored in 1888) was erected. After these outrages it was practically rebuilt on a scale that made it the finest church in the north. Its design was that of a Jerusalem cross, with two flanking towers at the east end, two at the west end, and one in the centre, at the intersection of the roofs of the nave and transepts. The central steeple fell in 1506, but was rebuilt, the new tower with its spire reaching a height of 198 ft. By 1538 the building was complete in every part. Though the Reformation left it unscathed, it suffered wanton violence from time to time. The central tower again collapsed in 1711, after which the building was allowed to go to ruin. Its stones were carted away, and the churchyard, overgrown with weeds, became a dumping-ground for rubbish. It lay thus neglected until 1824, when John Shanks, a "drouthy" cobbler, was appointed keeper, and conceived the notion of restoring the place to order. When he died in 1841 he had cleared away all the rubbish, disclosed the original plan, and collected a quantity of fragments. A tablet, let into the wall, contains an epitaph by Lord Cockburn, recording Shank's services to the cathedral which was later entrusted to the custody of H.M. Office of Works. The chapter-house, to the north-east of the main structure, suffered least of all the buildings, and contains a 'Prentice pillar, of which a story is told similar to that of the ornate column in Roslin chapel. General Andrew Anderson (1746–1822) endowed the Elgin Institution (commonly known as the Anderson Institution) for the education of youth and the support of old age. Within the cathedral precincts stood the bishop's palace (now in ruins), the houses of the dean and archdeacon (now North and South colleges), and the manses of the canons. Other ecclesiastical buildings were the monasteries of Blackfriars (1230) and Greyfriars (1410) and the preceptory of Maisondieu (1240). They also fell into decay, but the third marquess of Bute restored the Greyfriars' chapel in part. Gray's hospital, at the west end of High Street, was endowed by Dr. Alexander Gray (1751–1808). There is a museum of antiquities and natural history and a Victoria school of science and art. In 1903 G. A. Cooper presented his native town with a public park laid out for sports and skating. Grant Lodge, an old mansion of the Grant family, occupying the south-west corner of the park, was converted into the public library, museum and art gallery. From the top of Ladyhill the view commands the links of the Lossie and the surrounding country, and a recreation ground is laid out on Lossie Green.

The industries include distilling, nursery gardening, tanning, and there are saw and flour mills, iron-foundries and manufactures of woollens, and stone quarrying. There are weekly corn and cattle markets. The town has a council with provost and bailies.

Two miles and a half south by west of Elgin stands the church of Birnie, with the exception of the church at Mortlach in Banffshire probably the oldest place of public worship in Scotland still in use. Its date is not later than 1150 and, with its predecessor, it was the cathedral of Moray during the rule of the first four bishops; the fourth bishop, Simon de Toeny, an Englishman, was buried in its precincts in 1184. In the church is preserved an old Celtic altar-bell of hammered iron, known as the "Ronnell bell."

Six miles south-west of Elgin, in a secluded valley, lies Pluscarden Priory, a Cistercian house founded by Alexander II. in 1230. The ruins consist of tower, choir, chapter-house, refectory and other apartments. The *Liber Pluscardensis,* a valuable authority on early Scottish history down to the death of James I., was compiled in the priory by Maurice Buchanan in 1461.

ELGIN, a city of Kane county, Ill., U.S.A., on the Fox river, 36m. N.W. of Chicago. It is on Federal highway 20, and is served by the Chicago and North Western, the Chicago, Aurora and Elgin, and the Chicago, Milwaukee, St. Paul and Pacific railways. The population was 33,384 in 1927, when a special census was taken under the supervision of the census bureau. Elgin is in a fine dairying region, and has a large trade in butter, cheese and agricultural produce. Water power is abundant, and there are important manufactures (notably watches and watch-cases, condensed milk, butter tubs and meat products), with an aggregate output in 1925 valued at $30,064,803. The Elgin National Watch company employs over 4,000 persons. Three juvenile weeklies with a combined circulation of 750,000, a popular monthly for Sunday-school teachers, and the books and periodicals of the Brethren (Dunkers) are published in Elgin. It is the seat of the Northern State hospital for the insane. The assessed valuation of property in 1926 was $14,450,473. Elgin was settled in 1835, and chartered as a city in 1854.

ELGIN AND KINCARDINE, EARLS OF. Thomas Bruce, 7th earl of Elgin (1766–1841), British diplomatist and art collector, was born on July 20, 1766, and in 1771 succeeded his brother in the Scottish peerage as the 7th earl of Elgin (cr. 1633), and 11th of Kincardine (cr. 1647). In 1792 he was appointed envoy at Brussels, and in 1795 envoy extraordinary at Berlin; and from 1799 to 1802 he was envoy extraordinary at the Porte. During his stay at Constantinople he formed the purpose of removing from Athens the celebrated sculptures now known as the Elgin Marbles. His action was censured by some as vandalism, and doubts were also expressed as to the artistic value of many of the marbles; but he vindicated himself in a pamphlet published in 1810, and entitled *Memorandum on the Subject of the Earl of Elgin's Pursuits in Greece.* In 1816 the collection was purchased by the nation for £36,000, and placed in the British Museum, the outlay incurred by Lord Elgin having been more than £50,000. Lord Elgin was a Scottish representative peer for 50 years. He died at Paris on Nov. 14, 1841.

James Bruce, 8th earl of Elgin (1811–1863), British statesman, eldest son of the 7th earl by his second marriage, was born in 1811, and succeeded to the peerage as 8th earl of Elgin and 12th of Kincardine in 1841. He began his official career in 1842 at the age of 30, as governor of Jamaica, where he improved the condition of the negroes and conciliated the planters by working through them. In 1846 Lord Grey appointed him governor-general of Canada. Son-in-law of the popular earl of Durham, he was well received by the colonists, and he set himself deliberately to carry out the Durham policy. His assent to the local measure for indemnifying those who had suffered in the troubles of 1837 led the mob of Montreal to pelt his carriage for the rewarding of rebels for rebellion, as Mr. Gladstone described it. But long before his eight years' term of service expired he was the most popular man in Canada. His relations with the United States, his hearty support of the self-government and defence of the colony, and his settlement of the free-trade and fishery questions, led to his being raised in 1849 to the British peerage as Baron Elgin.

Soon after his return to England in 1854, Lord Palmerston offered him a seat in the cabinet, which he declined. But when, in 1856 the seizure of the "Arrow" by Commissioner Yeh plunged England into war with China, he went as special envoy with the expedition. On reaching Point de Galle he was met by a force summoned from Bombay to Calcutta by the news of the sepoy mutiny at Meerut on May 11. Urgent letters from Lord Canning reached him at Singapore, the next port, on June 3. H.M.S. "Shannon" was at once sent to Calcutta with the troops destined for China, and Elgin himself followed it, when gloomier letters from India reached him. The position in China was not seriously affected by the want of the troops. Elgin sent in his ultimatum to Commissioner Yeh at Canton on the same day, Dec. 12, that he learned of the relief of Lucknow, and soon afterwards he sent Yeh a prisoner to Calcutta. By July 1858, after months of Chinese deception, he was able to leave the Gulf of Pechili with the emperor's assent to the Treaty of Tientsin. He then visited Japan, and obtained less considerable concessions from its government in the Treaty of Yeddo. That visit proved the beginning of British influence in Japan. Unfortunately, the Chinese difficulty was not yet at an end. After tedious disputes with the tariff commissioners as to the opium duty, and a visit to the upper waters of the Yang-tzse, Elgin had reached England in May 1859. But when his brother and the allied forces attempted to proceed to Peking with the ratified treaty, they were fired on from the Taku forts at the mouth of the Peiho. Lord Russell again sent out Elgin as ambassador extraordinary to demand an apology for the attack, the execution of the treaty, and an indemnity for the military and naval expenditure. Sir Robert Napier (afterwards Lord Napier of Magdala) and Sir Hope Grant, with the French, routed the Tatar troops and sacked the Summer Palace, and by Oct. 24, 1860, a convention was made which was "entirely satisfactory to Her Majesty's Government."

Elgin had not been a month at home when Lord Palmerston selected him to be viceroy and governor-general of India. As the first viceroy directly appointed by the Crown, and as subject to the secretary of State for India, Elgin at once gave up all Lord Canning had fought for, in the co-ordinate independence, or rather the stimulating responsibility, of the governor-general, which had prevailed from the days of Clive and Warren Hastings. On the other hand, he loyally carried out the wise and equitable policy of his predecessor towards the Indian feudatories. He did his best to check the aggression of the Dutch in Sumatra, which was contrary to treaty, and he supported Dost Mohammed in Kabul until he entered the then neutral and disputed area of Herat.

Elgin then assembled a camp of exercise at Lahore, and marched a force to the Peshawar border to punish those branches of the Yusufzai tribe who had violated the engagements of 1858. In the midst of this "little war" he died at the hill station of Dharmsala on Nov. 20, 1863.

For his whole career see *Letters and Journals of James, Eighth Earl of Elgin,* ed. Walrond, but corrected by his brother-in-law, Dean Stanley; for the China missions *see* Laurance Oliphant, *Narrative of the Earl of Elgin's Mission to China and Japan;* for the brief Indian administration *see* the *Friend of India* for 1862–63.

Victor Alexander Bruce, 9th earl of Elgin (1849–1917), British statesman, was born on May 16, 1849, the son of the 8th earl. A Liberal in politics, he became first commissioner of works (1886), and subsequently viceroy of India (1894–99). His administration in India was chiefly notable for the frontier risings of 1897–98. The Afridis broke out into a fanatical revolt and through hesitation on the part of the Government were allowed to seize the Khyber pass, necessitating the Tirah expedition. After his return to England he was nominated chairman of the royal commission to investigate the conduct of the South African War; and on the formation of Sir Henry Campbell-Bannerman's ministry in Dec. 1905, he became secretary of State for the colonies. He retired in 1908, and died in 1917.

His son, Edward James Bruce (1881–), who succeeded him as 10th earl, was made chairman of the Carnegie United Kingdom Trust, and in 1925 was lord high commissioner to the Church of Scotland.

ELGINSHIRE: *see* Moray.

ELGON, also known as Masawa, an extinct volcano in British East Africa, cut by 1° N. and 34½° E., forming a vast isolated mass over 40 m. in diameter. The outer slopes are in great measure precipitous on the north, west and south, but fall more gradually to the east. The southern cliffs are remarkable for extensive caves, which have the appearance of water-worn caves on a coast line and have for ages served as habitations for the natives. The higher parts slope gradually upwards to the rim of an old crater, lying somewhat north of the centre of the mass, and measuring some 8 m. in diameter. The highest point of the rim is

about 14,100 ft. above the sea. Steep spurs separated by narrow ravines run out from the mountain, affording the most picturesque scenery. The ravines are traversed by a number of streams, which flow north-west and west to the Nile (through Lake Choga), south and south-east to Victoria Nyanza, and north-east to Lake Rudolf by the Turkwell, the head-stream of which rises within the crater, breaking through a deep cleft in its rim. To the north-west of the mountain a grassy plain, swampy in the rains, falls towards the chain of lakes ending in Choga; towards the north-east the country becomes more arid, while towards the south it is well wooded. The outer slopes are clothed in their upper regions with dense forest formed in part of bamboos, especially towards the south and west, in which directions the rainfall is greater than elsewhere. The lower slopes are exceptionally fertile on the west, and produce bananas in abundance. On the north-west and north the region between 6,000 and 7,000 ft. possesses a delightful climate, and is well watered by streams of ice-cold water. The district of Save on the north is a halting-place for Arab and Swahili caravans going north. On the west the slopes are densely inhabited by small Bantu-Negro tribes, who style their country Masawa (whence the alternative name for the mountain); but on the south and north there are tribes which seem akin to the Gallas. Of these, the best known are the Elgonyi, from whom the name Elgon has been derived. They formerly lived almost entirely in the caves, but many of them have descended to villages at the foot of the mountain. Elgon was first visited in 1883 by Joseph Thomson, who brought to light the cave-dwellings on the southern face. It was crossed from north to south, and its crater reached, in 1890 by F. J. Jackson and Ernest Gedge, while the first journey round it was made by C. W. Hobley in 1896. (E. HEA.)

EL GRECO: *see* THEOTOCOPULI.

ELI, a member of the ancient priesthood founded in Egypt (1 Sam. ii. 27), priest of the temple of Shiloh, the sanctuary of the ark, and also "judge" over Israel. In the history preserved to us he appears in the weakness of extreme old age, unable to control the petulance and rapacity of his sons. While the central authority was thus weakened, the Philistines advanced against Israel, and gained a complete victory in the great battle of Ebenezer, where the ark was taken, and Hophni and Phinehas slain. On hearing the news Eli fell from his seat and died. After these events the sanctuary of Shiloh appears to have been destroyed (*cf.* Jer. vii. 12, xxvi. 6, 9), and the house of Eli settles at Nob (1 Sam. xxi. 1, xxii. 11 *sqq.*, cp. xiv. 3). In the fall of his house later writers saw the fulfilment of the prophecies of judgment uttered in the days of Eli against his corrupt house (1 Sam. ii. 27 *sqq.*, iii. 11 *sqq.*). (*See* further, SAMUEL, BOOKS OF.)

ELIAS, of Çortona (*c.* 1180–1253), disciple of St. Francis of Assisi, was born of the working class, near Assisi. In 1217 he was the head of the Franciscan mission to the Holy Land, and in 1219 St. Francis made him first provincial minister of Syria. When St. Francis was recalled from the East in 1220 he brought Elias with him. Elias played a leading part in the early history of the Franciscans; Francis made him his vicar general in 1221; he was the practical acting superior of the order till Francis' death in 1226, and the actual superior till the general chapter of 1227. In 1232 he was elected minister general, but at the chapter of 1239 he was deposed. During these years he erected the basilica and monastery at Assisi. After his deposition Elias joined the party of Frederick II. and so incurred excommunication. Frederick sent him as ambassador to Constantinople. A small number of friars adhered to him and for these he built a church and monastery at Cortona. On his death-bed he made his submission to the pope. (*See* FRANCIS OF ASSISI, SAINT.)

See E. Lempp, *Frère Elie de Cortone* (1901), who points out the conflict between the *Speculum perfectionis* and the *First Life*, by Thomas of Celano, as to the relations between Elias and Francis. *See* also P. Sabatier, *Examen de la vie de Frère Elie du Speculum Vitae* (1904).

ELIAS LEVITA (1469–1549), Jewish grammarian, was born at Neustadt on the Aisch, Bavaria. He preferred to call himself "Ashkenazi," the German, and bore also the nickname of "Bachur," the youth or student, which latter he gave as a title to his Hebrew grammar. Before the end of the 15th century he went to Italy, living first at Padua, then (1509) at Venice, going in 1513 to Rome, where he found a patron in the learned general of the Augustinian Order, the future cardinal Egidio di Viterbo, whom he helped in his study of the Kabbalah. The storming of Rome by the Constable de Bourbon in 1527 compelled Elias to go to Venice, where he became corrector in the printing-house of Daniel Bomberg. In 1541 and 1542 he lived at Isny, S. Württemberg, where he published several of his writings in the printing-house of the learned pastor Paul Fagius. The last years of his life he spent at Venice. Levita furthered the study of Hebrew in Christian circles by his activity as a teacher and by his writings, his works on Hebrew grammar (*Bachur*, a text-book, 1518; *Harkaba*, an annotated dictionary of irregular word-forms; a Table of Paradigms; *Pirke Elijahu*, a description—partly metrical—of phonetics, and other chapters of the grammar, 1520; his earliest work, a Commentary on Moses Kimḥi's Hebrew Grammar, 1508) being clear and methodical. Amongst his other writings is the first dictionary of the Targumim (*Meturgeman*, 1541) and the first attempt at a lexicon in which much of the treasure of late Hebrew language was explained (*Tishbi*, explanation of 712 new Hebrew vocables, as a supplement to the dictionaries of David Kimḥi and Nathan b. Yeḥiel, 1542). Scientifically most valuable, and of original importance, are the works of Levita on the *Massora;* his Concordance to the Massora (*Sefer Zikhronot* completed in the second revision 1536), and *Massoreth Hamasoreth* (1538; Eng. tr. by Chr. D. Ginsburg, London, 1867). Of his other writings may be mentioned his commentary on Kimḥi's Grammar and Dictionary (in the Bomberg editions 1545, 1546), his German translation of the Psalms (1545) and the *Baba-Buch* (more properly *Buovobuch*, a German recension of the Italian novel *Historia di Buovo d'Antona*, 1508).

See Y. Levi, *Elia Levita und seine Leistungen als Grammatiker* (Breslau, 1888); W. Bacher, "E. Levita's wissenschaftliche Leistungen" in *Z. d. D. M. G.* xliii. (1889), p. 206–272.

ELIE, police burgh, parish and watering-place, Fifeshire, Scotland, on the Firth of Forth. Pop. (1921), 1,507, including the hamlets of Liberty and Williamsburgh. It is 10 m. S. of St. Andrews, but 20 m. distant by the L.N.E.R., which follows the coast. Though it retains some old houses, and the parish church dates from 1639, Elie is mostly modern and is a popular resort, with fine golf and bathing. The royal burgh of Earlsferry (pop. 745) is continuous with Elie, and in its parish. Its charter, granted by Malcolm Canmore, having been burned, was renewed by James VI. The place derived its name from its use by the earls of Fife as a ferry to the opposite shore of Haddington, 8 m. distant. Macduff's cave near Kincraig Point is believed traditionally to have been that in which the thane took refuge from Macbeth.

ÉLIE DE BEAUMONT, JEAN BAPTISTE ARMAND LOUIS LÉONCE (1798–1874), French geologist, was born at Canon, Calvados, on Sept. 25, 1798. In 1835 he was appointed professor of geology at the École des Mines, in succession to Brochant de Villiers, whose assistant he had been in the duties of the chair since 1827. He held the office of engineer-in-chief of mines in France from 1833 until 1847, when he was appointed inspector-general; and in 1861 he became vice-president of the Conseil-Général des Mines and a grand officer of the Legion of Honour. He was a member of the Academy of Berlin, of the Academy of Sciences of France and of the Royal Society of London, a senator of France from 1852, and, from 1853, perpetual secretary of the Academy of Sciences. Élie de Beaumont's theory of the origin of mountain ranges was propounded in a paper read to the Academy of Sciences in 1829, and afterwards elaborated in his *Notice sur le système des montagnes* (3 vols., 1852). According to his view, all mountain ranges parallel to the same great circle of the earth are of strictly contemporaneous origin, and between the great circles a relation of symmetry exists in the form of a pentagonal *réseau* (*see* criticism by W. Hopkins in *Quart. Journ. Geol. Soc.*, 1853). Probably the best service Élie de Beaumont rendered to science was in the preparation with Dufrénoy (*q.v.*) of the great geological map of France. After his superannuation at the École des Mines he continued to super-

intend the issue of the detailed maps almost until his death at Canon on Sept. 21, 1874. His academic lectures for 1843–44 were published in 2 vols., 1845–49, under the title *Leçons de géologie pratique.*

A list of his works was published in the *Ann. des Mines,* vol. vii. 1875, p. 259.

ELIJAH, a prophet of Tishbeh in Gilead, contemporary with Ahab king of Israel (*c.* 876–853 B.C.), and the hero of the following stories preserved in the Books of Kings: (*a*) *1 Kings xvii., xviii.*—Of the marvellous acts of Elijah, and of his triumph over the prophets of Baal: how he brought a three years' drought upon Israel, and, during the famine caused by the drought, was himself miraculously fed, first by ravens, and, later, by a widow of Zarephath, whose food he miraculously multiplied and whose son he raised from the dead; how he defied the king of Israel, challenged the prophets of Baal to a religious contest, and, having defeated them by the aid of Yahweh his God, slew them with his own hand; finally, how he brought the drought to an end. (*b*) *1 Kings xix.*—Of the despondency of Elijah: how he fled from the wrath of Jezebel to Beersheba, was there visited by an angel, miraculously fed, and commanded to go to Horeb the mount of God; how he came thither and waited in a cave; how Yahweh made himself known in a "still small voice," and in answer to Elijah's complaints against his people commissioned him to anoint Hazael, Jehu, and Elisha as agents of (their?) destruction; how Elijah called (or, as Gunkel believes, magically compelled) Elisha to follow him. (*c*) *1 Kings xxi.*—Of his denunciation of Ahab: how Ahab and Jezebel encompassed the death and obtained the vineyard of Naboth of Israel, and how, in the very flush of Ahab's guilty satisfaction, Elijah suddenly appeared proclaiming the wrath of Yahweh against the thing which Ahab had done and foretelling that Ahab's blood should be shed in the very place where he had shed the blood of Naboth. (*d*) *2 Kings i.*—Of Elijah's hostility to foreign gods, and of the deference demanded by him: how Ahaziah, king of Israel, sent messengers to the temple of the god of Ekron to enquire whether he would recover from the effects of a fall; how Elijah turned back the messengers with the message that the king would die; how the king twice sent companies of soldiers to arrest Elijah, and how they were destroyed by fire from heaven; how, when a third company approached him with complete deference, Elijah went with them to the king, told the king that he would die, and how the king accordingly died. (*e*) *2 Kings ii.,* 1–18.—Of the passing of Elijah: how, divinely prompted, he went from Gilgal to Bethel, from Bethel to Jericho; how Elisha refused to leave him, though at each stage of his journey "sons of the prophets" warned him that Elijah was to be taken away, and Elijah himself exhorted him to stay behind; how, with a blow of his folded mantle, Elijah divided the waters of Jordan; how, beyond Jordan, Elijah asked Elisha to choose one last favour, and, when Elisha requested that he might inherit a first-born's portion of Elijah's power, replied that this gift could only be given if he actually saw his master taken away; how Elisha saw chariots and horses of fire and Elijah snatched by a whirlwind to heaven, took up Elijah's mantle, passed over Jordan dryshod by its magic power; was received by the sons of the prophets at Jericho as Elijah's true successor; and how the sons of the prophets sought in vain for three days for Elijah.

Some details of these stories are corroborated by evidence from other sources (the occurrence of a drought at this time, *cf.* Menander, *ap.* Josephus *Antiq.* viii., 13.2; the name of Ahab's wife and her difference with Elijah, *cf.* 1 Kings xvi. 31; 2 Kings ix. 36; the toleration of Baal worship by the house of Omri, 2 Kings x.; the murder of Naboth, 2 Kings ix., 26); some are inconsistent with other evidence (*e.g.,* Jezebel did not murder all the prophets of Yahweh, *cf.* 1 Kings xxii., 6; 2 Kings ii., 3, etc.; if Ahab had abandoned the worship of Yahweh he would not have called his sons "Ahaziah" and "Jehoram"; according to 2 Kings x., 19, *seq.* the massacre of the prophets of Baal was made not by Elijah but by Jehu); some have many parallels in secular folk-lore (*e.g.,* the ministering ravens, the unfailing cruse, the magic mantle, the mysterious appearances and disappearances); some stories are remarkably like those told of other Biblical heroes (*e.g.,* Moses and Elisha, *cf.* Exod. xiv., 21 *seq.* xxxiii., 22, Deut. xxxiv., 5 *seq.,* Josh. iii., 16, 2 Kings iv.). In short, the Elijah stories are not genuine biography but folk-tales, some of which were told of other heroes also. Behind the folk-tales stands a historical person, who evidently made a deep impression upon the minds of his contemporaries, but he is shrouded in mist, and we can no longer see him clearly. That he was a religious enthusiast who lived in Ahab's time, and was violently opposed to royal oppression and to the toleration of foreign cults in Israel, even when such toleration was a political necessity, is as much of his story as can now be recovered. Was he a monotheist? What were his theological beliefs? How far did he use political means to gain his ends? Is the story of his visit to Horeb an idealization of some attempt he made to stir up the Arabian tribes to war against Israel? To such questions no answer can be given.

"In solitary grandeur did this prophet tower conspicuously over his time; legend, and not history, could alone preserve the memory of his figure. There remains a vague impression that with him the development of Israel's conception of Jehovah entered upon a new stadium, rather than any data from which it can be ascertained wherein the contrast of the new with the old lay" (Wellhausen, *Hist. of Israel.* E. T., p. 462).

References to the original stories, and to later legends, about Elijah occur in 2 Chron. xxi., 12 *seq.,* Mal. iv., 5 *seq.,* Ecclus, xlviii., 1–12; Matt. xi. 14, xvi. 14, Luke ix. 8, John i. 21, Rev. xi. 6. For further information *see,* besides the commentaries on the Books of Kings, the article "Elijah" in *Encyc. Bibl.,* Gunkel, *Elias, Yahwe, und Baal,* (Tübingen, 1906), and *Camb. Anc. Hist.* vol. iii., pp. 364–72.

(F. S. M.)

ELIJAH WILNA or **ELIJAH BEN SOLOMON,** best known as the Gaon Elijah of Wilna (1720–1797), a noted Talmudist who hovered between the new and the old schools of thought. Orthodox in practice and feeling, his critical treatment of the rabbinic literature prepared the way for later scientific investigations. He was one of the first to distinguish the various strata in rabbinic records; to him was due the revival of interest in the older Midrash (*q.v.*) and in the Palestinian Talmud (*q.v.*). As an ascetic, he opposed the emotional mysticism known as the new Hassidism.

See S. Schechter, *Studies in Judaism* (1896). For his voluminous writings see *Jewish Encyclopedia,* v. 134.

ELIOT, SIR CHARLES NORTON EDGCUMBE (1864–), British diplomatist and writer, was educated at Cheltenham and Balliol college, Oxford, and became a fellow of Trinity college. He entered the diplomatic service in 1886 and acted as chargé d'affaires in Morocco in 1892–93, in Bulgaria, 1895 and in Serbia, 1897. In Jan. 1901 he was appointed high commissioner of the British East Africa Protectorate, but resigned in Jan. 1904, being opposed to the grant of a concession to the East Africa Syndicate, which he held to be detrimental to genuine colonization. For some years he abandoned the diplomatic service, but in Aug. 1918 he was named high commissioner in Siberia, and in Nov. 1919 became ambassador to Japan, being thereupon sworn of the Privy Council. He was created G.C.M.G. in 1923, and in 1926, the year of his retirement, was appointed a member of the Japanese Imperial Academy, being the first foreigner to receive this honour.

Eliot's works include: *Turkey in Europe* (1900); *Letters from the Far East* (1907); *Hinduism and Buddhism* (1921). He wrote also *The East Africa Protectorate* (1905), and *A Finnish Grammar* (1890).

ELIOT, CHARLES WILLIAM (1834–1926), American educator and publicist, the son of Samuel Atkins Eliot (1798–1862), who was mayor of Boston, representative in Congress and in 1842–53 treasurer of Harvard college, was born in Boston on March 20, 1834. He graduated in 1853 at Harvard, where he was successively tutor in mathematics (1854–58) and assistant professor of mathematics and chemistry (1858–63). He studied chemistry and foreign educational methods in Europe (1863–65); was professor of analytical chemistry in the newly established Massachusetts Institute of Technology (1865–69), although absent 14 months in Europe in 1867–68; and in 1869 was elected president of Harvard university, a choice remarkable at once because of his

youth and because of his being a layman and scientist. This position he held until 1909, from which year until his death, 17 years later, at the age of 92, he was president emeritus. With Johns Hopkins university, Harvard, in the early years of Eliot's presidency, led in organization and increased efficiency of graduate work. The elective system, which has spread far, although not originated by President Eliot was thoroughly established by him, and is only one of many innovations which he successfully championed. The raising of entrance requirements, which led to a corresponding raising of the standards of secondary schools, and the introduction of an element of choice in these entrance requirements, which allowed a limited election of studies to secondary pupils, became national tendencies primarily through President Eliot's potent influence. As chairman of a national committee of ten (1890) on secondary school studies, he urged the abandonment of brief disconnected "information" courses, the correlation of subjects taught, the equal rank in college requirements of subjects in which equal time, consecutiveness and concentration were demanded, and a more thorough study of English composition; and to a large degree he secured national sanction for these reforms and their working out by experts into a practicable and applicable system. He laboured to unify the entire educational system, minimize prescription, do away with monotony and introduce freedom and enthusiasm; and he emphasized the need of special training for special work. He contended that secondary schools maintained by public funds should largely shape their courses for the benefit of students whose education goes no further than high schools, and should not be mere training schools for the universities.

President Eliot was long a leader in the movement for the introduction of business methods in government work, and in Dec. 1908 was elected president of the National Civil Service Reform League. He was offered the post of ambassador to England by President Taft in 1909, but preferred to serve his country in a private capacity at home. The same position was tendered him in 1913 by President Wilson and again declined. By writing and speaking he continued to take an active part in all the important public questions of the day. His theories as to needed changes toward the concrete and practical in education had great influence upon American schools. He aided vocational education by his continued insistence upon the training of the senses of sight, hearing and touch, as being the sources of the best part of knowledge. In 1914 he was elected president of the American Association for the Advancement of Science. In his educational writings he maintained that the traditional systems had dealt too exclusively with language and literature. In 1916, however, he was awarded a gold medal by the American Academy of Arts and Letters for his services to literature in his educational work. In the field of religion he was an authoritative spokesman for the Unitarian faith. In his books *The Religion of the Future* (1909) and *Twentieth Century Christianity* (1914) he emphasized freedom in place of authority; he held that the teaching of Jesus had been "the undying root of all the best in human history since He lived," and that He would be the supreme teacher in the religion of the future, the outcome of which would be the brotherhood of man. President Eliot gave much attention to labour problems and declared that "profit-sharing, combined with co-operative management, in which the employees take active and reasonable part, with co-operative care of health, education and happiness of employees, and with full knowledge by employees of the employers' account, is the only road to industrial peace." He condemned the closed shop, limited output by labour and uniform hours and wages. The settling of industrial strife he considered the next important thing after the establishment of a league of nations. He was a strong supporter of President Wilson's administration; he favoured prohibition as a war measure, and later as an amendment to the Constitution. He wrote in favour of military training after the Swiss method, but maintained that, after a league of nations was formed, no country should be allowed to have an army "whose officers have entered for life the profession of soldier." In 1920 he was an active worker for the Democratic party because he regarded the immediate adoption of the Covenant of the League of Nations as a moral obligation. He died at Northeast Harbor, Me., on Aug. 22, 1926.

The "unique place in American public life" occupied by President Eliot has been well described by William Allan Neilson, president of Smith college: "For 40 years the head of a great university, he exercised on all classes of his countrymen an influence far beyond that of the usual academic dignitary. During the latter part of his presidency, and still more after he became emeritus, he was looked up to by hundreds of thousands of his fellow-citizens as a guide not merely in educational matters, but in all the great questions that have agitated the public mind, political, industrial, social and moral. Other leaders of opinion have come and gone, and some for a time have been more conspicuous; but it is impossible to name a figure who so continuously dominated our intellectual horizon for so long a period."

President Eliot's writings include *A Compendious Manual of Qualitative Chemical Analysis* with F. H. Storer (1869), many times reissued and revised; *The Happy Life* (1896); *American Contributions to Civilization, and Other Essays and Addresses* (1897); *Educational Reform, Essays and Addresses 1869–1897* (1898); *Charles Eliot, Landscape Architect* (1902), a biography of one of his sons; *More Money for the Public Schools* (1903); *Four American Leaders* (1906), chapters on Franklin, Washington, Channing and Emerson; *University Administration* (1908); *The Durable Satisfactions of Life* (1910); *The Conflict Between Individualism and Collectivism in a Democracy* (1910); *The Road Toward Peace* (1915); and *A Late Harvest* (1924). His annual reports as president of Harvard were notable contributions to the literature of education, and he delivered numerous public addresses, many of which have been reprinted.

See "President Eliot's Administration," by various writers, a summary of his work at Harvard in 1869–94, in the *Harvard Graduates' Magazine*, vol. ii., pp. 449–504 (1894); E. H. Cotton, *The Life of Charles W. Eliot* (1926); and *Charles W. Eliot, the Man and His Beliefs*, edited, with a biographical study, by W. A. Neilson (1926).

ELIOT, GEORGE, the pen-name of the famous English writer, *née* Mary Ann (or Marian) Evans (1819–1880), afterwards Mrs. J. W. Cross, born at Arbury farm, Chilvers Coton, Warwickshire, on Nov. 22, 1819. Her father, Robert Evans, was the agent of Francis Newdigate, and the first 21 years of her life were spent on the Arbury estate. She received an ordinary education till the age of 17, when her mother's death and the marriage of her elder sister called her home in the character of housekeeper. She was thus able to work without pedantic interruptions at German, Italian and music, and to follow her own excellent taste in reading. Marian Evans was subdued all through her youth by a severe religious training which, while it pinched her mind and crushed her spirit, attracted her idealism by the very hardness of its counsels. But when her father moved to Coventry in 1841 she made new friends, Mr. and Mrs. Charles Bray and Charles Hennell. Bray had written works on the *Education of the Feelings*, the *Philosophy of Necessity*, and the like. Hennell had published in 1838 *An Enquiry Concerning the Origin of Christianity*. Miss Evans, then 22, absorbed immediately these unexpected and, at that time, daring habits of thought, and narrowly avoided a breach with her father, a churchman of the old school. George Eliot was never orthodox again; she remained throughout life a rationalist. But she had learnt the evangelical point of view; she knew—none better—the strength of religious motives; vulgar doubts of this fact were as distasteful to her as they were to Huxley. Her books abound in tributes to Christian virtue, and one of her own favourite characters was Dinah Morris in *Adam Bede*.

She began, in 1844, the translation of Strauss's *Leben Jesu*. On the death of her father in 1849 she went abroad for some time. In 1851 she accepted the assistant-editorship of the *Westminster Review*. For a while she had lodgings at the offices of the *Review* in the Strand, London. She wrote several notable papers, and became acquainted with Herbert Spencer, Carlyle, Harriet Martineau, Francis Newman, George Henry Lewes and others. Her friendship with Lewes led to a closer relationship which she regarded as a marriage. Among the many criticisms passed upon this step (Lewes had a wife living at the time), no one has denied her courage or her tact in a difficult position. The union was a singularly happy one. Lewes was devoted to her, appreciated her

genius and did his best to shield her from every kind of rough contact with the world. In later days he perhaps went too far in this direction, for she was never allowed to see adverse criticism which might have wounded her sensitive nature. She was over-sensitive, liable to fits of depression and at no time robust in health. A woman of wide culture and masculine understanding, she yet had an excessively feminine temperament. The lovers made a delightful tour in Germany which Marian Evans thoroughly enjoyed. Lewes was preparing his *Life of Goethe,* and they saw many important people in Berlin and Weimar. This journey made the definite break with her former life, and undoubtedly gave her fresh inspiration. On their return to England, Lewes and she established joint housekeeping. They moved frequently, but always maintained a circle of friends. Many descriptions exist of George Eliot's receptions; they became in course of time serious affairs, with Lewes as master of ceremonies. Admission was very highly prized and, in later days, not too easy. The house specially associated with the Leweses was 21 North Bank, Regent's Park, which they took in 1863.

But at this time fame had not been achieved. Marian Evans was occupied with translations—Feuerbach's *Essence of Christianity* (1854); Spinoza's *Ethics* (never published)—and with articles for the *Westminster Review* and the *Saturday Review.* Presently she confided to Lewes that she was seeking relaxation in writing fiction. The story was "The Sad Fortunes of the Reverend Amos Barton," the first of the *Scenes from Clerical Life* (2 vols., 1858); it appeared in *Blackwood's Magazine* as the work of "George Eliot," and Marian Evans strictly hid her identity for many years. *Scenes from Clerical Life* won the praise of Dickens, but triumphant success only came with *Adam Bede* (1859), followed in 1860 by *The Mill on the Floss,* and in 1861 by *Silas Marner.* Neither of these met with the great immediate success of *Adam Bede.* This group of novels remains for most readers George Eliot's most valuable contribution to English literature and to English social history. She was writing of the Warwickshire countryside, of the impressions gathered in her early life when distractions were few and her mind and vision still unimpeded by the theories and the philosophy of the *Westminster Review* circles. In the earlier and better half of *The Mill on the Floss* she drew, with little disguise, on her own life and her relations with her brother Isaac, and in Adam Bede and Caleb Garth there is something of her father. In the opinion of many good judges the first of the series, *Scenes from Clerical Life,* is George Eliot's most enduring work. Leslie Stephen (*Dict. Nat. Biog. s.v.* Cross) wrote: "In some respects, the *Scenes from Clerical Life* were never surpassed by their author. Their unforced power, their pathos, and the sympathetic appreciation of the old-fashioned life by a large intellect give them a singular charm."

George Eliot was now famous. Smith and Elder offered her £10,000 for the copyright of her next book; she accepted £7,000 for its appearance in the *Cornhill Magazine.* The book was *Romola* (1862–63), and with it begins her second period. She spent a month in Florence (May–June 1861) seeking material, and before she began to write in the autumn she had amassed an imposing pile of notes and memoranda on the history of Florence and the times of Savonarola. The book has perhaps been unduly disparaged; the truth is that all her later work, with the possible exception of *Middlemarch,* suffers, for modern readers, by comparison with the powerful and deeply felt earlier stories, when she was driven to write by an overpowering need for self expression. By her contemporaries they were eagerly looked for in a great age of the novel. The works following *Romola* are *Felix Holt* (1866), a political novel; *The Spanish Gypsy* (1868), a drama in blank verse, written under strong positivist influence; *The Legend of Jubal and other Poems* (1874); *Middlemarch* (1872), a long novel, which is a masterly psychological analysis of middle class life; *Daniel Deronda* (1876), a strong intellectual plea against anti-Jewish prejudice; and *The Impressions of Theophrastus Such,* a collection of essays (1879). This great body of work between 1866 and 1879, was the accomplishment of a powerful intellect and shows an extraordinarily acute perception of human nature.

George Eliot wrote for a serious public. She herself demanded too strenuously from the very beginning an aim, more or less altruistic, from every individual; and as she advanced in life this claim became the more imperative, till at last it overpowered her art, and transformed a great delineator of humanity into an eloquent observer with far too many personal prejudices. Joy was lost in the consuming desire for strict accuracy; her genius became more and more speculative, less and less emotional. The highly-trained brain suppressed the impulsive heart. Little of her verse, beyond the famous lines "O, might I join the choir invisible," passed into current thought; her best work was done in prose.

Throughout these years she was sustained and stimulated by the companionship of Lewes. At the end of 1876 they settled at Witley, near Godalming, and on Nov. 28, 1878, Lewes died. George Eliot wrote no more. She saw hardly anyone, and devoted herself to preparing Lewes's unfinished work for press. In her widowhood—it was a real widowhood—she was helped in her affairs by a friend of long standing, J. W. Cross, and married him, at St. George's, Hanover square, on May 6, 1880. Early in December they took a house in London, No. 4, Cheyne Walk. There she died on Dec. 22, 1880.

See the *Life of George Eliot,* edit. by J. W. Cross (3 vols., 1885–87); Sir Leslie Stephen, *George Eliot,* in the "English Men of Letters" series (1902); Oscar Browning, "Great Writers" series (1890), with a bibliography by J. P. Anderson; Mathilde Blind, "Eminent Women" series, a later edition of which also contains a bibliography (Boston, Mass., 1904); A. W. Ward in *Camb. Hist.,* vol. xiii. (1916); Elizabeth Haldane, *George Eliot and her Times* (1927); and Arthur Paterson, *George Eliot's Family Life and Letters* (1928).

ELIOT, SIR JOHN (1592–1632), English statesman, was born at Port Eliot, Cornwall, and educated at Exeter college, Oxford. He then studied law, and spent some years in travel on the continent before he entered parliament as M.P. for St. Germans in 1614. In 1618 he was knighted, and next year through the patronage of Buckingham he obtained the appointment of vice-admiral of Devon, with large powers for the defence and control of the commerce of the county. In 1623 he succeeded by a clever but dangerous manoeuvre in entrapping the famous pirate John Nutt, who had for years infested the southern coast, inflicting immense damage upon English commerce. The pirate, having a powerful protector at court in Sir George Calvert, the secretary of State, was pardoned; while the vice-admiral was flung into the Marshalsea, and detained there nearly four months.

A few weeks after his release Eliot was elected member of parliament for Newport (Feb. 1624). On the 27th he delivered his first speech, in which he at once revealed his great powers as an orator, demanding boldly that the liberties and privileges of parliament, repudiated by James I. in the former parliament, should be secured. In the first parliament of Charles I., in 1625, he urged the enforcement of the laws against the Roman Catholics. Meanwhile he had continued the friend and supporter of Buckingham, but the bad faith with which both he and the king continued to treat the parliament, alienated Eliot completely from the administration. Distrust of his former friend developed into a conviction of his criminal ambition and treason to his country. Returned in 1626 as member for St. Germans, Eliot found himself the leader of the House. He immediately demanded an inquiry into the disaster at Cadiz. On March 27 he made an open and daring attack upon Buckingham and his evil administration. He was not intimidated by the king's threatening intervention on the 29th, and persuaded the House to defer the actual grant of the subsidies and to present a remonstrance to the king, declaring its right to examine the conduct of ministers. On May 8, he was one of the managers who carried Buckingham's impeachment to the Lords, and on the 10th he delivered the charges against him, comparing him in the course of his speech to Sejanus. Next day Eliot was sent to the Tower. On the Commons declining to proceed with business as long as Eliot and Sir Dudley Digges (who had been imprisoned with him) were in confinement, they were released, and parliament was dissolved on June 15. Eliot was dismissed from his office of vice-admiral of Devon, and in 1627 he was again imprisoned for refusing to pay a forced loan, but liberated shortly before the assembling of the parliament of 1628,

to which he was returned as member for Cornwall. He joined in the resistance now organized to arbitrary taxation, was foremost in the promotion of the Petition of Right, continued his outspoken censure of Buckingham, and after the latter's assassination in August, led the attack in the session of 1629 on the ritualists and Arminians.

PROSECUTOR OF BUCKINGHAM

In February the question of the right of the king to levy tonnage and poundage came up for discussion; and on the king ordering an adjournment of parliament, the speaker, Sir John Finch, was held down in the chair while Eliot's resolutions against illegal taxation and innovations in religion were read to the House by Holles (*q.v.*). In consequence, Eliot, with eight other members, was imprisoned on March 4, in the Tower. He refused to answer in his examination, relying on his privilege of parliament, and on Oct. 29 was removed to the Marshalsea. On Jan. 26, he appeared at the bar of the king's bench, with Holles and Valentine, to answer a charge of conspiracy to resist the king's order, and, refusing to acknowledge the jurisdiction of the court, he was fined £2,000 and ordered to be imprisoned during the king's pleasure and till he had made submission. This he steadfastly refused. Eliot's confinement in the Tower was exceptionally severe. Charles hated him as the prosecutor and bitter enemy of Buckingham; "an outlawed man," he described him, "desperate in mind and fortune."

In prison Eliot wrote several works, his *Negotium posterorum*, an account of the parliament in 1625; *The Monarchie of Man*, a political treatise; *De jure majestatis, a Political Treatise of Government;* and *An Apology for Socrates*, his own defence. In Oct. 1632 ill-health drove him to petition Charles for permission to go into the country, but leave could only be obtained at the price of submission and was finally refused. He died on Nov. 27, 1632. When his son requested permission to move the body to Port Eliot, Charles returned the curt refusal: "Let Sir John Eliot be buried in the church of that parish where he died." The manner of Eliot's death had more effect, probably, than any other single incident in embittering and precipitating the dispute between king and parliament; and the sacrifice of a man actuated originally by no antagonistic feeling against the monarchy or the church, is the surest condemnation of the king's policy and administration.

Eliot married Rhadagund, daughter of Richard Gedie of Trebursye in Cornwall, by whom he had five sons, from the youngest of whom Granville John Eliot, the present earl of St. Germans, is descended, and four daughters.

The *Life of Sir J. Eliot*, by J. Forster (1864), is supplemented and corrected by Gardiner's *History of England*, vols. v.–vii., and the article in the *Dict. of Nat. Biog.*, by the same author. Eliot's writings, together with his Letter-Book, have been edited by Dr. Grosart.

ELIOT, JOHN (1604–1690), American colonial clergyman, known as the "Apostle to the Indians," was born probably at Widford, Hertfordshire, England, where he was baptized on Aug. 5, 1604. He was the son of Bennett Eliot, a middle-class farmer, and graduated at Jesus college, Cambridge, in 1622. He probably entered the ministry of the Established Church, but there is nothing definitely known of him until 1629–30, when he became an usher at the school of the Rev. Thomas Hooker, at Little Baddow, near Chelmsford. Apparently influenced by him to become a Puritan, he emigrated to America in the autumn of 1631, where he settled first at Boston, assisting for a time at the First Church. In Nov. 1632 he became "teacher" to the church at Roxbury, with which his connection lasted until his death. There he married Hannah Mulford, who had been betrothed to him in England, and who became his constant helper.

Inspired with the idea of converting the Indians, his first step was to perfect himself in their dialects, and with the aid of a young Indian he translated the Ten Commandments and the Lord's Prayer; in 1646 he first preached to them in their own tongue at Nonantun (Newton). The conversion of a number of Indians caused the Massachusetts general court to set aside land for their residence and in July 1649 Parliament incorporated the "Society for the Propagation of the Gospel in New England," which henceforth supported and directed the work inaugurated by Eliot. In 1651 the Christian Indian town founded by Eliot was removed from Nonantun to Natick, where Eliot continued to preach throughout his life. A second town under his direction was established at Ponkapog (Stoughton) in 1654, in which he had the assistance of Daniel Gookin (*c.* 1612–87). His success was duplicated in Martha's Vineyard and Nantucket by the Mayhews, and by 1674 the unofficial census of the "praying Indians" numbered 4,000. King Philip's war (1675–76) was a staggering blow to all missionary enterprise; and although few of the converted Indians proved disloyal, it was some years before adequate support could again be enlisted. Yet at Eliot's death, which occurred at Roxbury on May 21, 1690, the missions were at the height of their prosperity.

Of wide influence and lasting value was Eliot's work as a translator of the Bible and various religious works into the Massachusetts dialect of the Algonkin language. The *Catechism*, published in 1653 at Cambridge, Mass., was the first book to be printed in the Indian tongue. The New Testament was issued in 1661, and the Old Testament two years later. With the assistance of his sons he completed his well known *Indian Grammar Begun* (1666). *The Indian Primer* and a translation of the *Larger Catechism* followed in 1669. In 1671 Eliot printed in English *Indian Dialogues*, followed in 1672 by *Logick Primer*, both of which were intended for the instruction of the Indians in English. A curious treatise on government entitled *The Christian Commonwealth* was published in 1659. His *Harmony of the Gospels* (1678) was a life of Jesus Christ.

See Williston Walker's *Ten New England Leaders* (1901); the "Life of John Eliot," by Convers Francis, in *Sparks' American Biography* (vol. v., 1836); another by N. Adams (1847); and a sketch in Cotton Mather's *Magnalia* (London, 1702). *See* the chapter on "The Indian Tongue and its Literature," by J. H. Trumbull, in vol. i. of the *Memorial History of Boston* (1882). *See* also the *Cambridge History of American Literature* vol. i., pp. 390–393 (1917).

ELIS or **ELEIA,** an ancient district of southern Greece, bounded on the N. by Achaea, E. by Arcadia, S. by Messenia, and W. by the Ionian Sea. The local form of the name was Valis, or Valeia, and its meaning, in all probability, "the lowland." In its physical constitution Elis is continuous with Achaea and Arcadia; its mountains are offshoots of the Arcadian highlands, and its principal rivers are fed by Arcadian springs. From Erymanthus in the north, Skollis (now known as Mavri and Santameri in different parts of its length) stretches toward the west, and Pholoe along the eastern frontier; in the south a prolongation of Mt. Lycaeon bore in ancient times the names of Minthe and Lapithus, which have given place respectively to Alvena and to Kaiapha and Smerna. These mountains are well clothed with vegetation, and present a pleasing contrast to the picturesque wildness of the parent ranges. Towards the west they sink into what was one of the richest tracts in Peloponnesus. Except at the rocky promontories of Chelonatas (now Chlemutzi) and Ichthys (now Katakolo), the coast lies low, with stretches of sand in the north and lagoons and marshes towards the south. During the summer when they communicate with the sea, these lagoons yield a rich harvest of fish but the inhabitants are then almost driven from the coast by the mosquitoes. The district for administrative purposes forms part of the nome of Elis and Achaea (*see* GREECE).

Elis was divided into three districts—Hollow or Lowland Elis, Pisatis, the territory of Pisa, and Triphylia, the "country of the three tribes." (1) *Hollow Elis*, the largest and most northern of the three, was watered by the Peneus and its tributary the Ladon, whose united stream forms the modern Gastouni. It included not only the champaign country originally designated by its name, but also the mountainous region of Acrorea, occupied by the offshoots of Erymanthus. Besides the capital city of Elis, it contained Cyllene, an Arcadian settlement on the sea-coast, whose inhabitants worshipped Hermes under the phallic symbol; Pylus, at the junction of the Peneus and the Ladon, which, like so many other places of the same name, claimed to be the city of Nestor, and the fortified frontier town of Lasion, the ruins of which are

still visible at Kuti, near the village of Kumani. The district was famous in antiquity for its cattle, horses and byssus.

(2) *Pisatis* extended south from Hollow Elis to the right bank of the Alpheus, and was divided into eight departments called after as many towns. From ancient times it has been disputed whether Pisa, which gave its name to the district, had ever been a city, or was only a fountain or a hill. By far the most important spot in Pisatis was the scene of the Olympic games, on the northern bank of the Alpheus (*see* OLYMPIA).

(3) *Triphylia* stretches south from the Alpheus to the Neda, which forms the boundary towards Messenia. Of nine towns mentioned by Polybius, Lepreum and Macistus gave their names to southern and northern Triphylia. The former had a strongly independent population, and took every opportunity of resisting the supremacy of the Eleans. In the time of Pausanias it was decadent, and possessed only a brick-built temple of Demeter; but its outer walls still exist near the village of Strovitzi.

The original inhabitants of Elis were called Caucones and Paroreatae. Under the title of Epeians they are mentioned as setting out for the Trojan War, and as living in constant hostility with the Pylians. At the close of the 11th century B.C. the Dorians invaded the Peloponnesus, and Elis fell to the share of Oxylus and the Aetolians, who, amalgamating with the Epeians, formed a powerful kingdom in the north of Elis. After this many changes took place, till only three tribes, Epeians, Minyae and Eleans, remained independent. Before the end of the 8th century B.C., however, the Eleans had established supremacy over the whole country with the right of celebrating the Olympic games, which had formerly been the prerogative of the Pisatans. The attempts which this people made to recover their lost privilege ended in the total destruction of their city by the Eleans in 572 B.C. Till the Peloponnesian War, Elis remained undisturbed. Though Elis sided at first with Sparta, that power, jealous of the increasing prosperity of its ally, picked a quarrel. At the battle of Mantinea (418 B.C.) the Eleans fought against the Spartans, who, as soon as the war came to a close, took vengeance upon them by depriving them of Triphylia and the towns of the Acrorea. The Eleans made no attempt to re-establish their authority till after the battle of Leuctra (371 B.C.), when they might have effected their purpose had not the Arcadian confederacy come to the assistance of the Triphylians. In 366 B.C. hostilities broke out and, though the Eleans were at first successful, their capital very nearly fell and they applied for assistance to the Spartans, who forced the Arcadians to recall their troops from Elis. The result was the restoration of their territory to the Eleans, with the right of holding the Olympic games. During the Macedonian supremacy in Greece they sided with the victors, but refused to fight against their countrymen. After the death of Alexander they renounced the Macedonian alliance and later joined the Aetolian League, persistently refusing to identify themselves with the Achaeans. When the whole of Greece fell under the Roman yoke, the sanctity of Olympia secured for the Eleans a certain amount of indulgence. The games continued to attract large numbers of strangers, until they were finally put down by Theodosius in 394, two years before the Gothic invasion under Alaric. In later times Elis fell successively into the hands of the Franks and the Venetians, under whose rule it recovered to some extent its ancient prosperity.

See Pauly Wissowa, *Realencyklopädie, s.v.*

ELIS, the chief city of the ancient Greek district of Elis, on the ridge now called Kalaskopi, south of the river Peneus, where it passes from the mountainous Acrorea into the lowland. It was traditionally founded by Oxylus, leader of the Aetolian immigrants, whose statue stood in the market-place. In 471 B.C. it incorporated various small hamlets, whose inhabitants took up their abode in the city. As all the athletes in the Olympic games were obliged to undergo a month's training in the city, its gymnasiums were among its principal institutions. Other objects of interest are described in detail by Pausanias, but no buildings can be identified, the only remains visible dating from Roman times. On the acropolis was a temple of Athena, with a gold and ivory statue by Pheidias. The history of the town follows that of the country (*q.v.*). In 399 B.C. it was occupied by Agis, king of Sparta. The acropolis, now called Palaeopolis, was fortified in 312 by Telesphorus, the admiral of Antigonus, but it was shortly afterwards dismantled by Philemon, another of his generals.

See Pausanias vi. 23–26; J. Spencer Stanhope, *Olympia and Elis* (1824), folio (view of the site); W. M. Leake, *Morea* (1830); E. Curtius, *Peloponnesus* (1851–52); Schiller, *Stämme und Staaten Griechenlands;* C. Bursian, *Geographie von Griechenland* (1868–72); P. Gardner, "The Coins of Elis," *Num. Chr.* (1879).

ELIS, PHILOSOPHICAL SCHOOL OF. This school was founded by Phaedo, a pupil of Socrates. It existed for a very short time and was then transferred by Menedemus to Eretria, where it became known as the Eretrian school. Its chief members beside Phaedo, were Anchipylus, Moschus and Pleistanus (*see* PHAEDO and MENEDEMUS).

ELISAVETPOL: *see* GANJA.

ELISAVETGRAD: *see* ZINOVIEVSK.

ELISHA, a prophet, reputed successor of Elijah (*q.v.*). He is a much more shadowy figure than Elijah, though he occupies a larger space in the Books of Kings. The stories there told about him, which seem to have come from several sources and not to be in their original order (*e.g.*, 2 Kings viii. 1–6 should precede v. 26 *seq.*), may be divided into two groups: (*a*) Anecdotes of his private life, showing how, except when he caused two she-bears to fall upon 42 boys who insulted him (ii. 23–25), and transferred Naaman's leprosy to his own servant Gehazi (v. 20, *seq.*), he used the miraculous power he had inherited from Elijah (ii. 9, *seq.*) in works of homely beneficence; how he made wholesome a poisonous spring (ii. 19, 20) and a poisonous soup (iv. 38.–41); saved an insolvent widow from selling her sons into slavery by miraculously increasing her oil (iv. 1–7); cured the sterility of a barren woman, raised to life her dead son, and induced the king to right her wrongs (iv. 8–37, viii. 1–6); fed 100 men with 20 loaves and had bread to spare (iv. 42–44); caused a borrowed axe-head to float upon the water into which it had fallen (vi. 1–7); gave a vision of the heavenly host to his terrified servant (vi. 17); and by the power of his dead bones raised a corpse to life (xiii. 21). These are simple folk-tales, some of which are also told of Elijah and of other Old Testament heroes (*cf.* Genesis xviii. 10, *seq.*, Exod. xv. 23, 24). The place names contained in the stories (Jericho, ii. 18 *seq.;* Bethel, ii. 23; Carmel, ii. 25; iv. 25; Shunem, iv. 8; Gilgal, iv. 38; Dothan, vi. 13) may indicate where the stories originated. Several are places where "sons of the prophets" lived. (*b*) The second group consists of stories of the public life of Elisha, showing how he earned the title "the chariots and horsemen of Israel" (2 Kings, xiii. 14); how, during a campaign against Moab, he saved the armies of Israel and Judah from dying of thirst (iii. 10–24); how he gave the signal for Jehu's rebellion against the house of Omri by sending a young prophet to anoint Jehu king of Israel (ix. 1); how he went to Damascus, told the sick king Benhadad that he would recover, and, at the same time, by foretelling the havoc that Benhadad's messenger Hazael would make of Israel, incited him to murder Benhadad and usurp his throne (viii. 7–15); how, in a time of peace between Israel and Syria, he prevented the outbreak of war by healing Naaman the Syrian general (v. 1–19), and, in a time of war, helped the king of Israel by his foreknowledge of the enemy's plans (vi. 12) and *moral* (vii. 1, 6), and by delivering into his hands a Syrian army smitten with supernatural blindness (vi. 13–23); how on his death-bed he predicted (or contrived by magic) three victories against Syria for Joash, king of Israel.

Some of these stories probably preserve memories of historical fact. The account of Jehu's rebellion seems to come from a trustworthy, perhaps contemporary, source; the evidence of the Moabite Stone gives support to the story of a campaign of Israel against Moab in the last days of the House of Omri; and a siege of Samaria of which no other record except 2 Kings vi. survives, may well have happened in the days when "the king of Syria oppressed Israel" (xiii. 22). There are indications, however, that these days did not begin before the accession of Jehu (*e.g.* x. 32); and if so, then, so far as they are historical, the stories in which Elisha aids kings of Israel against Syria must be taken to refer

to the dynasty of Jehu.

The historical person behind the Elisha stories was probably a prophetic supporter of the house of Jehu, who encouraged Israel in the darkest days of the Syrian wars. The precise nature of his religious ideas and of his connection, if any, with the historical person behind the Elijah stories must be left uncertain.

Elisha is mentioned in Ecclus. xlviii. 12–16, Luke iv. 27. For further information and literature *see* ELIJAH. (F. S. M.)

ELISHA BEN ABUYAH (*fl. c.* A.D. 100), a unique figure among the Palestinian Jews of his day, was born before the destruction of the Temple (A.D. 70). He refused to accept the current rabbinical views, though the Talmud cites his legal decisions. Most authorities believe that he was a Gnostic, but it is possible that he was simply a Sadducee, and thus an opponent not of Judaism but of Pharisaism. The efforts of his disciple, the famous Pharisee Meir, to reclaim his former master are among the most pathetic incidents in the Talmud. In later ages Elisha was regarded as the type of a heretic whose pride of intellect betrayed him into infidelity to law and morals.

ELIXIR, in alchemy, the medium which would effect the transmutation of base metals into gold; it probably had a wider meaning than "philosopher's stone." The same term, more fully *elixir vitae*, elixir of life, was given to the substance which would indefinitely prolong life; it was considered to be closely related to, or even identical with, the substance for transmuting metals. In pharmacy the word was formerly given to a strong extract or tincture.

ELIZABETH, SAINT (1207–1231), daughter of Andrew II., king of Hungary (d. 1235), was born in Pressburg. Married at the age of fourteen to Louis IV., landgrave of Thuringia, she devoted herself to religion and to works of charity. According to the legend, much celebrated in German art, Louis at first forbade her unbounded gifts to the poor. One day he saw his wife descending from the Wartburg with a heavy bundle of bread. He sternly bade her open it; she did so, and he saw nothing but a mass of red roses. The miracle converted him. On the death of Louis "the Saint" in 1227, Elizabeth was deprived of the regency by his brother, Henry Raspe IV. (d. 1247), on the pretext that she was wasting the estates by her alms. With her three infants she was driven from her home without even the barest necessities, but ultimately her maternal uncle, Egbert, bishop of Bamberg, offered her a house adjoining his palace. Through the intercession of some of the principal barons, the regency was again offered her, and her son Hermann was declared heir to the landgraviate. Renouncing all power, Elizabeth chose to live in seclusion at Marburg under the direction of her confessor, Conrad of Marburg, doing penance and ministering to the sick. She died at Marburg on Nov. 17, 1231, and was canonized by Gregory IX. in 1235.

BIBLIOGRAPHY.—Lives of St. Elizabeth were written by Theodoricus (Dietrich) of Apolda (b. 1228), Caesarius of Heisterbach (d. *c.* 1240), Conrad of Marburg and others (*see* Potthast, *Bibl. Hist. Med. Aev.* p. 1284). *See* also Montalembert, *L'Histoire de Élisabeth de Hongrie* (1836); A. Saubin, *S. Élisabeth de Hongrie* (1902); A. Huyskens, *Quellenstudien zur Gesch. der hl. Elisabeth* (Marburg, 1908); Wenck, *Die hl. Elisabeth* (Tübingen, 1908) and M. Maresch, *Elisabeth Landgräfin v. Thüringen* (2nd ed., 1921). The life of Elizabeth inspired Kingsley's poem "The Saint's Tragedy."

ELIZABETH [PETROVNA] (1709–1762), EMPRESS OF RUSSIA, the daughter of Peter the Great and Martha Skovronskaya, born at Kolomenskoye, near Moscow, on Dec. 18, 1709. From her earliest years she delighted every one by her extraordinary beauty and vivacity, and she developed a keen political and diplomatic sense in spite of the deficiencies of her early education. Various proposals for her marriage failed, so that on the death of her mother (May 1727) and the departure to Holstein of her sister Anne, her only remaining near relation, the princess found herself at the age of 18 practically her own mistress. So long as Menshikov remained in power, she was treated with liberality and distinction by the Government of Peter II., but the Dolgorukis, who supplanted Menshikov and hated the memory of Peter the Great, practically banished Peter's daughter from court. While still in her teens Elizabeth made a lover of Alexius Shubin, a sergeant in the Semenovsky Guards, and after his banishment to Siberia, minus his tongue, by order of the empress Anne, consoled herself with a young Cossack, Alexius Razumovski, whom she is said actually to have married. During the reign of her cousin Anne (1730–40), Elizabeth effaced herself as much as possible; but under the regency of Anna Leopoldovna the course of events drove her to overthrow the existing government. The French ambassador, La Chétardie, who was plotting to destroy the Austrian influence then dominant at the Russian court, seems to have urged her on, and lent her a small sum of money, but he took no part in the coup when it came. Elizabeth acted because she had reason to fear imprisonment in a convent for life. On the night of Dec. 6–7, 1741, she assembled her personal friends and members of her household, drove to the barracks of the Preobrazhensky Guards, enlisted their sympathies by a stirring speech, and led them to the Winter Palace. She seized the regent and her children in their beds, and summoned all the notables, civil and ecclesiastical, to her presence. Elizabeth had secured the ministers on her way to the Winter Palace, and the revolution was accomplished without further ado. Fortunately, Elizabeth Petrovna, with all her shortcomings, had inherited some of her father's genius for government. Her usually keen judgment and her diplomatic tact again and again recall Peter the Great. What in her sometimes seemed irresolution and procrastination, was, most often, a wise suspense of judgment.

After abolishing the cabinet council system in favour during the rule of the two Annes, and reconstituting the senate as it had been under Peter the Great,—with the chiefs of the departments of State, all of them now Russians again, as *ex-officio* members under the presidency of the sovereign—the first care of the new empress was to compose her quarrel with Sweden. On Jan. 23, 1743, direct negotiations between the two powers were opened at Åbo, and on Aug. 7, 1743, Sweden ceded to Russia all the southern part of Finland east of the river Kymmene, including the fortresses of Villmanstrand and Fredrikshamn. Much of this success in foreign policy was due to the new vice chancellor, Alexius Bestuzhev-Ryumin (*q.v.*). He represented the anti-Franco-Prussian portion of the council, and his object was to bring about an Anglo-Austro-Russian alliance which, at that time, was undoubtedly Russia's proper system. Hence the reiterated attempts of Frederick the Great and Louis XV. to get rid of Bestuzhev, which made the Russian court during the earlier years of Elizabeth's reign the centre of a tangle of intrigue (*see* BESTUZHEV-RYUMIN, ALEXIUS.) By the treaty of Aix-la-Chapelle (Oct. 18, 1748) Bestuzhev had extricated his country from the Swedish imbroglio; he had reconciled his imperial mistress with the courts of Vienna and London, her natural allies; enabled Russia to assert herself effectually in Poland, Turkey and Sweden, and isolated the king of Prussia by environing him with hostile alliances. All this would have been impossible but for the steady support of Elizabeth, who trusted him implicitly, despite the insinuations of the chancellor's innumerable enemies, most of whom were her personal friends.

The great event of Elizabeth's later years was the Seven Years' War. Elizabeth rightly regarded the treaty of Westminster (Jan. 16, 1756, whereby Great Britain and Prussia agreed to unite their forces to oppose the entry into, or the passage through, Germany of the troops of every foreign power) as utterly subversive of the previous conventions between Great Britain and Russia. Fear of the king of Prussia, who was "to be reduced within proper limits," so that "he might be no longer a danger to the empire," induced Elizabeth to accede to the treaty of Versailles, in other words the Franco-Austrian league against Prussia, and on May 17, 1757 the Russian army, 85,000 strong, advanced against Königsberg. Neither the serious illness of the empress, which began with a fainting-fit at Tsarskoe Selo (Sept. 19, 1757), nor the fall of Bestuzhev (Feb. 21, 1758), nor the cabals and intrigues of the various foreign powers at St. Petersburg, interfered with the progress of the war, and the crushing defeat of Kunersdorf (Aug. 12, 1759) at last brought Frederick to the verge of ruin. From the end of 1759 to the end of 1761, the unshakable firmness of the Russian empress was the one constraining political force which held together the heterogeneous, incessantly jarring elements of the anti-

Prussian combination.

On May 21, 1760, a fresh convention was signed between Russia and Austria, a secret clause of which, never communicated to the court of Versailles, guaranteed East Prussia to Russia, as an indemnity for war expenses. The failure of the campaign of 1760, so far as Russia and France were concerned, induced the court of Versailles to present (Jan. 22, 1761) to the court of St. Petersburg a despatch to the effect that the king of France desired peace. The Austrian ambassador, Esterhazy, presented a similar despatch. The Russian empress's reply was delivered on Feb. 12. Elizabeth declined any pacific overtures until the original object of the league had been accomplished. Simultaneously, Elizabeth proposed in a secret letter to Louis XV. a new treaty of closer alliance without the knowledge of Austria. Elizabeth's object seems to have been to reconcile France and Great Britain, in return for which service France was to throw all her forces into the German war. This project, which lacked neither ability nor audacity, foundered upon Louis XV.'s jealousy of Russian influence in eastern Europe and his fear of offending the Porte. It was finally arranged by the allies that their envoys at Paris should fix the date for a peace congress, and that, in the meantime, the war against Prussia should be vigorously prosecuted. Frederick acted on the defensive with consummate skill, but his situation had become desperate, when his difficulties were dispersed by the death of the Russian empress (Jan. 5, 1762), which he described in a letter to Prince Frederick of Brunswick as a great event.

See Robert Nisbet Bain, *The Daughter of Peter the Great* (1899); Sergyei Solovev, *History of Russia* (Rus.), vols. xx.–xxii. (St. Petersburg, 1857–77); *Politische Correspondenz Friedrichs des Grossen*, vols. i.–xxi. (1879, etc.); Colonel Masslowski, *Der siebenjährige Krieg nach russischer Darstellung* (1888–93); Kazinsierz Waliszewski, *La Dernière des Romanov* (1902).

ELIZABETH (1533–1603), queen of England and Ireland, born on Sunday, Sept. 7, 1533, and, like all the Tudors except Henry VII., at Greenwich palace, was the only surviving child of Henry VIII. by his second queen, Anne Boleyn. Charles V.'s ambassador, Chapuys, hardly deigned to mention the fact that the king's *amie* had given birth to a daughter, and both her parents were bitterly disappointed with her sex. She was, however, given precedence over Mary, her elder sister by 16 years, and Mary never forgave the infant's offence. Even this dubious advantage only lasted three years until her mother was beheaded, and "divorced." Elizabeth has been censured for having made no effort in later years to clear her mother's memory; but no vindication of Anne's character could have rehabilitated Elizabeth's legitimacy. Her mother was not "divorced" for her alleged adultery, because that crime was no ground for divorce by Roman or English canon law. The marriage was declared invalid *ab initio* either on the ground of Anne's precontract with Lord Percy or more probably on the ground of the affinity established between Henry and Anne by Henry's previous relations with Mary Boleyn.

Elizabeth thus lost the hereditary title to the throne. Nor was her legitimacy ever legally established; but after Jane Seymour's death, when Henry seemed likely to have no further issue, she was by act of parliament placed next in order of the succession after Edward and Mary and their issue; and this statutory arrangement was confirmed by the will which Henry VIII. was empowered by statute to make. Queen Catherine Parr introduced some humanity into Henry's household, and Edward and Elizabeth were well and happily educated together, principally at old Hatfield house. They were there when Henry's death called Edward VI. away to greater dignities, and Elizabeth was left in the care of Catherine Parr, who married in indecent haste Thomas, Lord Seymour, brother of the protector Somerset. This unprincipled adventurer, even before Catherine's death in September 1548, paid indelicate attentions to Elizabeth. Any attempt to marry her without the council's leave would have been treason on his part and would have deprived Elizabeth of her contingent right to the succession. Accordingly, when Seymour's other misbehaviour led to his arrest, his relations with Elizabeth were made the subject of a very trying investigation, which gave Elizabeth her first lessons in the feminine arts of self-defence. Although in later years Elizabeth seems to have cherished his memory, and certainly showed no love for his brother's children, at the time she only showed resentment at the indignities inflicted on herself.

For the rest of Edward's reign Elizabeth's life was less tempestuous. She hardly rivalled Lady Jane Grey as the ideal Puritan maiden, but she swam with the stream, and was regarded as a foil to her stubborn Catholic sister. She thus avoided the enmity and the still more dangerous favour of Northumberland; and some unknown history lies behind the duke's preference of the Lady Jane to Elizabeth as his son's wife and his own puppet for the throne. She thus escaped shipwreck in his crazy vessel, and rode by Mary's side in triumph into London on the failure of the plot. For a time she was safe enough; she would not renounce her Protestantism until Catholicism had been made the law of the land, but she followed Gardiner's advice to her father when he said it was better that he should make the law his will than try to make his will the law. As a presumptive ruler of England she was, like Cecil, and for that matter the future archbishop Parker also, too shrewd to commit herself to passive or active resistance to the law. Their position was well enough understood in those days; it was known that they were heretics at heart, and that when their turn came they would once more overthrow Catholicism and expect a similar submission from the Catholics.

It was not so much Elizabeth's religion as her nearness to the throne and the circumstances of her birth that endangered her life in Mary's reign. While Mary was popular Elizabeth was safe; but as soon as the Spanish marriage project had turned away English hearts Elizabeth inevitably became the centre of plots and the hope of the plotters. Had not Lady Jane still been alive to take off the edge of Mary's indignation and suspicion Elizabeth might have paid forfeit for Wyat's rebellion with her life instead of imprisonment. She may have had interviews with French agents who helped to foment the insurrection; but she was strong and wary enough to avoid Henry II.'s, as she had avoided Northumberland's, toils; for even in case of success she would have been the French king's puppet, placed on the throne, if at all, merely to keep it warm for Henry's prospective daughter-in-law, Mary Stuart. This did not make Mary Tudor any more friendly, and, although the story that Elizabeth favoured Courtenay and that Mary was jealous is a ridiculous fiction, the Spaniards cried loud and long for Elizabeth's execution. She was sent to the Tower in March 1554, but few Englishmen were fanatic enough to want a Tudor beheaded. The great nobles, the Howards, and Gardiner would not hear of such a proposal; and all the efforts of the court throughout Mary's reign failed to induce parliament to listen to the suggestion that Elizabeth should be deprived of her legal right to the succession. After two months in the Tower she was transferred to Sir Henry Bedingfield's charge at Woodstock, and at Christmas, when the realm had been reconciled to Rome and Mary was expecting issue, Elizabeth was once more received at court. In the autumn of 1555 she went down to Hatfield, where she spent most of the rest of Mary's reign, enjoying the lessons of Ascham and Baldassare Castiglione, and planting trees which still survive.

She had only to bide her time. The Protestant martyrs and Calais between them removed all the alternatives to an insular national English policy in church and in state; and no sovereign was better qualified to lead such a cause than the queen who ascended the throne amid universal rejoicings at Mary's death on Nov. 17, 1558. "Mere English" she boasted of being, and after Englishmen's recent experience there was no surer title to popular favour. No sovereign since Harold had been so purely English in blood; her nearest foreign ancestor was Catherine of France, the widow of Henry V., and no English king or queen was more superbly insular in character or in policy. She was the unmistakable child of the age so far as Englishmen shared in its characteristics, for with her English aims she combined some Italian methods and ideas. "An Englishman Italianate," ran the current jingle, "is a devil incarnate," and Elizabeth was well versed in Italian scholarship and statecraft. Italians, especially Bernardino Ochino, had given her religious instruction, and the Italians who rejected Catholicism usually adopted far more advanced forms of heresy than Lutheranism, Zwinglianism or even

Calvinism. Elizabeth herself patronized Giacomo Acontio, who thought dogma a "stratagema Satanae," and her last favourite, Essex, was accused of being the ringleader of "a damnable crew of atheists." A Spanish ambassador early in the reign thought that Elizabeth's own religion was equally negative, though she told him she agreed with nearly everything in the Augsburg Confession. She was probably not at liberty to say what she really thought, but she made up by saying a great many things which she did not mean. It is clear enough that, although, like her father, she was fond of ritual, she was absolutely devoid of the religious temperament, and that her ecclesiastical preferences were dictated by political considerations. She was sincere enough in her dislike of Roman jurisdiction and of Calvinism; a daughter of Anne Boleyn could have little affection for a system which made her a bastard, and all monarchs agreed at heart with James I.'s aphorism about "no bishop, no king." It was convenient, too, to profess Lutheran sympathies, for Lutheranism was now an established, monarchical and comparatively respectable religion, very different from the Calvinism against which monarchs directed the Counter-reformation from political motives. Lutheran dogma, however, had few adherents in England, though its political theory coincided with that of Anglicanism in the 16th century. The compromise that resulted from these conflicting forces suited Elizabeth very well; she had little dislike of Catholics who repudiated the papacy, but she was forced to rely mainly on Protestants, and had little respect for any form of ecclesiastical self-government. She valued uniformity in religion, not as a safeguard against heresy, but as a guarantee of the unity of the state. She respected the bishops only as supporters of her throne; and although the well-known letter beginning "Proud Prelate" is an 18th century forgery, it is hardly a travesty of Elizabeth's attitude.

The outlines of her foreign policy are sketched elsewhere (*see* ENGLISH HISTORY), and her courtships were diplomatic. Contemporary gossip, which was probably justified, said that she was debarred from matrimony by a physical defect; and her cry when she heard that Mary queen of Scots had given birth to a son is the most womanly thing recorded of Elizabeth. Her features were as handsome as Mary's, but she had little fascination, and in spite of her many suitors no man lost his head over Elizabeth as men did over Mary. She was far too masculine in mind and temperament, and her extravagant addiction to the outward trappings of femininity was probably due to the absence or atrophy of deeper feminine instincts. In the same way the impossibility of marriage made her all the freer with her flirtations, and she carried some of them to lengths that scandalized a public unconscious of Elizabeth's security. She had every reason to keep them in the dark, and to convince other courts that she could and would marry if the provocation were sufficient. She could not marry Philip II., but she held out hopes to more than one of his Austrian cousins whenever France or Mary Stuart seemed to threaten; and later she encouraged two French princes when Philip had lost patience with Elizabeth and made Mary Stuart his protégée. Her other suitors were less important, except Leicester, who appealed to the least intellectual side of Elizabeth and was always a cause of distraction in her policy and her ministers.

Elizabeth was terribly handicapped by having no heirs of her body and no obvious English successor. She could not afford to recognize Mary's claim, for that would have been to alienate the Protestants, double the number of Catholics, and, in her own phrase, to spread a winding-sheet before her eyes; for all would have turned to the rising sun. Mary was dangerous enough as it was, and no one would willingly make his rival his heir. Elizabeth could hardly be expected to go out of her way and ask parliament to repeal its own acts for Mary's sake; probably it would have refused. Nor was it personal enmity on Elizabeth's part that brought Mary to the block. Parliament had long been ferociously demanding Mary's execution, not because she was guilty but because she was dangerous to the public peace. She alone could have given the Spanish Armada any real chance of success; and as the prospect of invasion loomed larger on the horizon, fiercer grew the popular determination to remove the only possible centre of a domestic rising, without which the external attack was bound to be a failure. Elizabeth resisted the demand, not from compassion or qualms of conscience, but because she dreaded the responsibility for Mary's death. She wished Paulet would manage the business on his own account, and when at last her signature was extorted she made a scapegoat of her secretary Davison who had the warrant executed.

The other great difficulty, apart from the succession, with which Elizabeth had to deal arose from the exuberant aggressiveness of England, which she could not, and perhaps did not want to, repress. Religion was not really the cause of her external dangers, for the time had passed for crusades, and no foreign power seriously contemplated an armed invasion of England for religion's sake. But no state could long tolerate the affronts which English seamen offered Spain. The common view that the British Empire has been won by purely defensive action is not tenable, and from the beginning of her reign Englishmen had taken the offensive, partly from religious but also from other motives. They were determined to break up the Spanish monopoly in the New World, and in the pursuit of this endeavour they were led to challenge Spain in the old. For nearly 30 years Philip put up with the capture of his treasure-ships, the raiding of his colonies and the open assistance rendered to his rebels. Only when he had reached the conclusion that his power would never be secure in the Netherlands or the New World until England was conquered, did he despatch the Spanish Armada. Elizabeth delayed the breach as long as she could, probably because she knew that war meant taxation, the most prolific parent of revolt.

With the defeat of the Spanish Armada Elizabeth's work was done, and during the last 15 years of her reign she got more out of touch with her people. That period was one of gradual transition to the conditions of Stuart times; during it practically every claim was put forward that was made under the first two Stuarts either on behalf of parliament or the prerogative, and Elizabeth's attitude towards the Puritans was hardly distinguishable from James I.'s. But her past was in her favour, and so were her sex and her Tudor tact, which checked the growth of discontent and made Essex's rebellion a ridiculous fiasco. He was the last and the most wilful but perhaps the best of her favourites, and his tragic fate deepened the gloom of her closing years. She was desolate in old age after the deaths of Leicester, Walsingham, Burghley and Essex, and Elizabeth died, the last of her line, on March 24, 1603.

Bishop Creighton's *Queen Elizabeth* (1896) is the best biography; there are others by E. S. Beesly, *Twelve English Statesmen* (1892); Lucy Aikin, *Memoirs of the Court of Queen Elizabeth* (1818); and T. Wright, *Queen Elizabeth and her Times* (1838). *See* also A. Jessopp's article in the *Dict. Nat. Biog.*; Rowe, *Cal. of State Papers, relative to English affairs*, vol. 1, *Elizabeth, 1558–71* (1917); State Papers, *Cal. of S.P., Foreign Ser. of the reign of Elizabeth*, vol. xvii. (1913); and G. Lytton Strachey, *Elizabeth and Essex; a tragic history* (1928).

ELIZABETH [AMELIE EUGENIE] (1837–1898), consort of Francis Joseph, emperor of Austria and king of Hungary, was the daughter of Duke Maximilian Joseph of Bavaria and Louisa Wilhelmina, daughter of Maximilian I. of Bavaria, and was born on Dec. 24, 1837 at the castle of Possenhofen on Lake Starnberg. She inherited the quick intelligence and artistic taste displayed in general by members of the Wittelsbach royal house, and her education was the reverse of conventional. She accompanied her eccentric father on his hunting expeditions, becoming an expert rider and climber, visiting the peasants in their huts and sharing in rustic pleasures. The emperor of Austria, Francis Joseph, met the Bavarian ducal family at Ischl in Aug. 1853, and immediately fell in love with Elizabeth, then a girl of 16, and reported to be the most beautiful princess in Europe. The marriage took place in Vienna on April 24, 1854. In the early days of her married life she frequently came into collision with Viennese prejudice. Her attempts to modify court etiquette, and her extreme fondness for horsemanship and frequent visits to the imperial riding school, scandalized Austrian society, while her predilection for Hungary and for everything Hungarian offended German sentiment. There is no doubt that her influence helped the establishment of the *Ausgleich* with Hungary, but outside

Hungarian affairs the empress took small part in politics. She first visited Hungary in 1857, and ten years later was crowned queen. Her popularity with the Hungarians remained unchanged throughout her life; and the castle of Gödöllö, presented as a coronation gift, was one of her favourite residences. Elizabeth was one of the most charitable of royal ladies, and her popularity with her Austrian subjects was more than restored by her assiduous care for the wounded in the campaign of 1866. Besides her public benefactions she constantly exercised personal and private charity. Her eldest daughter died in infancy; Gisela (b. 1856) married the Prince Leopold of Bavaria; and her youngest daughter Marie Valerie (b. 1868) married the Archduke Franz Salvator. The tragic death of her only son, the crown prince Rudolph, in 1889, was a shock from which she never really recovered. She was also deeply affected by the suicide of her cousin Louis II. of Bavaria, and again by the fate of her sister Sophia, duchess of Alençon, who perished in the fire of the Paris charity bazaar in 1897. The empress had shown signs of lung disease in 1861, when she spent some months in Madeira; but she was able to resume her outdoor sports, and for some years before 1882, when she had to give up riding, was a frequent visitor on English and Irish hunting fields. In her later years her dislike of publicity increased. Much of her time was spent in travel or at the Achilleion, the palace she had built in the Greek style in Corfu. She was walking from her hotel at Geneva to the steamer when she was stabbed by the anarchist Luigi Luccheni, on Sept. 10, 1898, and died of the wound within a few hours. This aimless crime lengthened the list of misfortunes of the Austrian house, and aroused intense indignation throughout Europe.

See A. de Burgh, *Elizabeth, Empress of Austria, a Memoir* (London, 1898); E. Friedmann and J. Paves, *Kaiserin Elisabeth* (Berlin, 1898); and the anonymous *Martyrdom of an Empress* (1899), containing a quantity of court gossip.

ELIZABETH, QUEEN OF RUMANIA (1843–1916), best known by her pen-name of CARMEN SYLVA, was born on Dec. 29, 1843, the daughter of Prince Hermann of Neuwied, and married Prince (afterwards King) Charles of Rumania in 1869. The only daughter of the marriage died in 1874. She took a keen interest in the cultural development of her adopted country, especially in Rumanian poetry and folklore, and collected and edited many Rumanian legends. Much of her literary work was done in collaboration with Mite Kremnitz, her lady-in-waiting. She wrote easily in English, French, German and Rumanian. Her more important works were translated into many languages. Among them may be mentioned *Pensées d'une Reine* (1882), and, with Alma Strettell, *The Bard of the Dimbovitza* (1891), a fine English version of Hélène Vacarescu's collection of Rumanian folksongs. "Carmen Sylva" died on March 2, 1916.

See her own *Reminiscences* (1911); also M. Kremnitz, *Carmen Sylva—eine Biographie* (Leipzig, 1903); and, for a full bibliography, G. Bengescu, *Carmen Sylva—bibliographie et extraits de ses oeuvres* (1904).

ELIZABETH (1596–1662), consort of Frederick V., elector palatine and titular king of Bohemia, was the eldest daughter of James I. of Great Britain and of Anne of Denmark, and was born at Falkland Castle, Fifeshire, in Aug. 1596. She was entrusted to the care of the earl of Linlithgow, and after the departure of the royal family to England, to the countess of Kildare, subsequently residing with Lord and Lady Harington at Combe Abbey in Warwickshire. In Nov. 1605 the Gunpowder Plot conspirators formed a plan to seize her person and proclaim her queen after the explosion, in consequence of which she was removed by Lord Harington to Coventry. In 1608 she appeared at court, where her beauty soon attracted admiration and became the theme of the poets, her suitors including the dauphin, Maurice, prince of Orange, Gustavus Adolphus, Philip III. of Spain and Frederick V., the elector palatine. A marriage with the elector palatine was finally arranged, in spite of the queen's opposition, in order to strengthen the alliance with the Protestant powers in Germany; it took place on Feb. 14, 1613, midst great rejoicing and festivities, described in Nichols's *Progresses of James I.* Among the many poems written in commemoration of the marriage is the *Epithalamion* by John Donne. The prince and princess entered Heidelberg on June 17. On Aug. 26, 1618, Frederick, as a leading Protestant prince, was chosen king by the Bohemians, who deposed the emperor Ferdinand, then archduke of Styria. Elizabeth accompanied Frederick to Prague in Oct. 1619, and was crowned on Nov. 7. Here her unrestrainable high spirits and levity gave great offence to the citizens. But in misfortune she showed great courage and fortitude. She left Prague on Nov. 8, 1620, after the fatal battle of the White Hill, for Küstrin, travelling thence to Berlin and Wolfenbüttel, finally with Frederick taking refuge at The Hague with Prince Maurice of Orange.

It was not until the peace of Westphalia in 1648 that her son, Charles Louis, regained a portion of his dominions, the Rhenish Palatinate. Meanwhile, the payment of Elizabeth's English annuity of £12,000 ceased after the outbreak of the troubles with the parliament; the execution of Charles I. in 1649 put an end to all hopes from that quarter; and the pension allowed her by the house of Orange ceased in 1650. Her children abandoned her, and her son Charles Louis refused her a home in his restored electorate. Nor did Charles II. at his restoration show any desire to receive her in England. Parliament voted her £20,000 in 1660 for the payment of her debts, but Elizabeth did not receive the money, and on May 10, 1661, she left The Hague for England, where Charles, who had opposed her coming, ultimately granted her a pension. She died on Feb. 13, 1662, and was buried in Westminster Abbey. Her beauty, grace and vivacity exercised a great charm over her contemporaries, who were also moved by her misfortunes incurred in the Protestant cause. As the ancestress of the Protestant Hanoverian dynasty, she became a prominent figure in English history. She had 13 children—Frederick Henry, drowned at sea in 1629; Charles Louis, elector palatine, whose daughter married Philip, duke of Orleans, and became the ancestress of the elder and Roman Catholic branch of the royal family of England; Elizabeth, abbess and friend of Descartes; Prince Rupert and Prince Maurice, who died unmarried; Louisa, abbess; Edward, who married Anne de Gonzaga, "princesse palatine," and had children; Henrietta Maria, who married Count Sigismund Ragotzki, but died childless; Philip and Charlotte, who died childless; Sophia, who married Ernest Augustus, elector of Hanover, and was mother of George I. of England; and two others who died young.

BIBLIOGRAPHY.—*See* the article in *Dict. of Nat. Biography* and authorities there collected; *Five Stuart Princesses*, ed. by R. S. Rait (1902); A. Wendland, *Briefe der Elizabeth Stuart . . . an . . . den Kurfürsten Carl Ludwig von der Pfalz* (Bibliothek des literarischen Vereins, 228, Stuttgart, 1902); J. O. Opel, "Elizabeth Stuart," in Sybel's *Historische Zeitschrift*, xxiii. 289; *Thomason Tracts* (Brit. Mus.), E., 138 (14), 122 (12), 118 (40), 119 (18). Important material regarding the princess exists in the MSS. of the earl of Craven, at Combe Abbey.

ELIZABETH (1635–1650), English princess, second daughter of Charles I., was born on Dec. 28, 1635, at St. James's Palace. On the outbreak of the Civil War and the departure of the king from London, while the two elder princes accompanied their father, the princess and the infant duke of Gloucester were left under the care of the parliament. In July 1644 the royal children were sent to Sir John Danvers at Chelsea, and in 1645 to the earl and countess of Northumberland. After the final defeat of the king they were joined in 1646 by James, and during 1647 paid several visits to the king at Caversham, near Reading, and Hampton Court, but were again separated by Charles's imprisonment at Carisbrooke castle. On April 21, 1648, James was persuaded to escape by Elizabeth, who declared that were she a boy she would not long remain in confinement. The last sad meeting between Charles and his two children, at which the princess was overcome with grief, and of which she wrote a short and touching account, took place on Jan. 29, 1649, the day before his execution. In June she was sent to the earl and countess of Leicester at Penshurst, but in 1650, upon the landing of Charles II. in Scotland, the parliament ordered the royal children to be taken for security to Carisbrooke castle. The princess fell ill, and died of fever on Sept. 8. She was buried in St. Thomas's church at Newport, Isle

of Wight, where the initials "E.S." alone marked her grave till 1856, when a monument was erected to her memory by Queen Victoria. Several books were dedicated to the princess, including the translation of the *Electra* of Sophocles by Christopher Wase in 1649. Her mild nature and gentleness towards her father's enemies gained her the name of "Temperance."

See M. A. E. Green, *Lives of the Princesses of England* (1855), vol. vi.

ÉLIZABETH (Élisabeth Philippine Marie Hélène of France) (1764–1794), commonly called MADAME ÉLIZABETH, daughter of Louis the Dauphin and Marie Josephine of Saxony, and sister of Louis XVI., was born at Versailles on May 3, 1764. At the outset of the revolution she foresaw the gravity of events, and refused to leave the king, whom she accompanied in his flight on June 20, 1792, and with whom she was arrested at Varennes. She was present at the Legislative Assembly when Louis was suspended, and was imprisoned in the Temple with the royal family. By the execution of the king and the removal of Marie Antoinette to the Conciergerie, Madame Élizabeth was deprived of her companions in the Temple prison, and on May 9, 1794 she was herself transferred to the Conciergerie, and brought before the revolutionary tribunal. She was condemned to death, and executed on May 10, 1794.

The *Mémoires de Madame Élisabeth* (Paris, 1858), by F. de Barghon and Fort-Rion, are of doubtful authenticity; and the collection of letters and documents published in 1865 by F. Feuillet de Conches must be used with caution. *See* le Comte A. F. C. Ferrand, *Éloge historique de Madame Élisabeth* (1814, containing 94 letters; 2nd ed., 1861, containing additional letters, but correspondence mutilated); Du Fresne de Beaucourt, *Étude sur Madame Élisabeth* (Paris, 1864); A. de Beauchesne, *Vie de Madame Élisabeth* (1869); La comtesse d'Armaillé, *Madame Élisabeth* (Paris, 1886); Madame d'Arvor, *Madame Élisabeth* (Paris, 1898); and Hon. Mrs. Maxwell-Scott, *Madame Elisabeth of France* (1908).

ELIZABETH, a city of New Jersey, U.S.A., the county seat of Union county; on Newark bay, opposite Staten island, with which it is connected by the Goethals bridge (opened on June 20, 1928). It is on the Lincoln highway, and is served by the Baltimore and Ohio, the Central of New Jersey, the Lehigh Valley and the Pennsylvania railways. The population was 95,783 in 1920 (29·5% foreign-born white) and was estimated locally at 120,000 in 1928. Elizabeth combines the character of a residential suburb of New York with that of an important independent industrial centre. It has a vast plant (with 8,000 workers) making Singer sewing-machines, an oil refinery covering 800ac., shipbuilding yards, automobile factories and numerous other manufacturing industries. The total factory output in 1925 was $116,245,464. Elizabethport, the city's harbour on Staten island sound, is a receiving and distributing point for coal from the Pennsylvania anthracite fields. The assessed valuation of property for 1928 was $156,506,487. Elizabeth was settled in 1665 by colonists from Long island, for whom the land had been bought from the Indians and a grant obtained from the agent of the duke of York. But about the same time the duke conveyed the entire province to Lord Berkeley and Sir George Carteret, and the conflicting grants gave rise to a long controversy. The town was named after the wife of Sir George, and was at first called Elizabethtown. It was the capital of the province from 1665 to 1686, and until 1790 the legislature sat here occasionally. The first sessions of the College of New Jersey (now Princeton university) were held (1747) in the home of the Rev. Jonathan Dickinson (1688–1747). In Dec. 1776, and twice in June 1780, the British entered the town and made it a base of operations, but on each occasion they were soon driven out. Elizabeth became a free town and borough in 1739; the borough charter was confirmed in 1789 and repealed in 1790; and a city charter was received in 1855. Among the historic buildings still standing are Liberty hall (1772), the mansion of William Livingston, first governor of the State; Boxwood hall, the home of Elias Boudinot; the brick mansion (1742) of Jonathan Belcher (1681–1757), governor of the province from 1747–1757; the home of General Winfield Scott; and the First Presbyterian church (present building erected 1784–86), where in 1668 the first general assembly of the province convened. Several smaller structures (including Hetfield house, built in 1667) date from the 17th century.

ELIZABETHAN STYLE, in architecture, a term loosely applied to the early Renaissance work in England up to the end of the 16th century. The term Tudor Period (*q.v.*) is generally limited to the earlier Elizabethan work, in which Gothic elements are still dominant; the Jacobean style (*q.v.*) is used of the later portion of the period, in which Renaissance ideas had finally conquered. These three terms are overlapping and there is much variety of usage in the meanings given to them by different authorities. In general, the Elizabethan style is that which resulted from the impingement upon the vivid perpendicular Gothic tradition, first of Italian Renaissance artists, such as Pietro Torregiano, who designed the tomb of Henry VII., and later of a great number of Flemish craftsmen who settled in England. Thus, such buildings as Hampton Court palace, Sutton place in Surrey, Hatfield House and Audley End, varying as they do from the Gothic of Hampton Court to the Renaissance of Hatfield, are all spoken of as in the Elizabethan style.

ELIZABETH CITY, a city of North Carolina, U.S.A., 46m. S. of Norfolk, at the head of navigation on the Pasquotank river; a port of entry and the county seat of Pasquotank county. It is on Federal highway 17, and is served by the Norfolk Southern railroad and by steamers through the Dismal Swamp and the Albemarle and Chesapeake canals. The population was 8,925 in 1920 (39% negroes) and was estimated locally at 12,000 in 1928. It is the commercial centre of the north-eastern part of the State; the shipping point for quantities of market-garden produce; a rendezvous for hunters and fishermen; the seat of a State normal school for negroes; and has shipyards, hosiery and cotton mills, and various other manufacturing industries. The city was founded and incorporated in 1793. It has a council-manager form of government. On Roanoke island, 45m. S.E., the followers of Sir Walter Raleigh landed in 1584 and Virginia Dare was born in 1587; and near by is Kitty Hawk, where the Wright brothers in 1903 made their first successful flight. Just outside the city, on the banks of Halls Creek, is the spot where the first general assembly of Virginia met on Feb. 6, 1665.

ELIZABETHTON, a rapidly growing city of north-eastern Tennessee, U.S.A., at the junction of the Doe and Watauga rivers, 1,575ft. above sea-level; the county seat of Carter county. It is served by the East Tennessee and Western North Carolina and the Southern railways. The population was 2,749 in 1920 (98% native white) and was estimated locally at over 10,000 in 1928. It is in one of the most beautiful spots of the southern Appalachian mountains, in a region rich in minerals, timber, fertile soil and water power. Hydro-electric power is available from a plant on the Watauga river. The city has various manufacturing industries, including two large plants making artificial silk, which when completed will employ 30,000 workers. It is one of the oldest settlements of the region, and is rich in historic associations. Under a giant sycamore still standing on the Doe was held (by Gen. Andrew Jackson) the first court in what is now Tennessee. At Sycamore Shoals, Revolutionary soldiers met for drill, and from here marched to the battle of King's Mountain. There is an iron furnace that was used in Revolutionary days, and on the banks of the Watauga is the last home of President Johnson. Elizabethton was chartered as a city in 1905. It has a commission-manager form of government.

ELIZABETH TUNNEL, 60 m. N. of Los Angeles, Calif., is the longest of the 164 Los Angeles aqueduct tunnels, being 5·1 m. in length. It was constructed through the Coast Range mountains, a region of great topographic difficulty, at a cost of $70.20 per ft., requiring five years to bring it to completion (Feb. 28, 1911). Horseshoe in shape, it was constructed from two headings, 20 m. from a railroad base, is lined throughout with concrete, and measures 9 ft. 6 in. in width and 10 ft. 10 in. in height.

ELK or MOOSE (*Alces machlis*), the largest of the deer tribe, inhabiting the subarctic forests of both the New and the Old Worlds, though the American form (to which the name "Moose" is properly restricted) is sometimes separated as *A. americana*. The distinguishing features of the elk are the huge palmate, projecting antlers, the long legs, the long fleshy muzzle, and the short

neck. Despite its ungainly appearance, the moose can gallop at a considerable speed. It feeds on leaves and shoots of the willow and birch. During the winter the American race assemble in small herds, composed of a male and several females, and, by trampling the snow, form an open space known as a "moose-yard," in which they can move about with some freedom. Generally very shy, in the breeding season, which is in the autumn, the males become bold and fierce and fight savagely with antlers and hoofs. "Moose-calling" is a favourite sport in Canada. In most parts of Europe and America the elk is now protected by law. In North America the name elk is commonly applied to the Wapiti (*Cervus canadensis*). For "Irish-Elk," *see* FALLOW-DEER.

ELKHART, a city of Elkhart county, Indiana, U.S.A., at the confluence of the St. Joseph and the Elkhart rivers, 100m. E. of Chicago. It is on Federal highways 20 and 112; has an airport; and is served by the Big Four and the New York Central railways. Pop. 24,277 in 1920 (92·4% native white), and was estimated locally at 40,000 in 1928. The city is pleasantly situated at an altitude of 757ft., and within 30 miles there are about 100 lakes. A super-power plant eight miles west has a capacity of 300,000 h.p. Elkhart is a division point on the main line of the New York Central, which has large shops and classification yards here. The output of the factories of all kinds in 1925 was valued at $28,871,728. Chief among the manufactures are band instruments (to a value of $7,500,000 per year), automobiles, railway and steamship supplies, iron, bridges, paper and sheet-metal products. The assessed valuation of property in 1927 was $44,968,440. Elkhart was settled about 1834, and chartered in 1875.

ELKINGTON, GEORGE RICHARDS (1801–1865), founder of the electro-plating industry in England, was born in Birmingham on Oct. 17, 1801, the son of a spectacle manufacturer. Apprenticed to his uncles, silver platers in Birmingham, he became, on their death, sole proprietor of the business, but subsequently took his cousin, Henry Elkington, into partnership. The Elkingtons had already taken out certain patents for the application of electricity to metals when, in 1840, John Wright, a Birmingham surgeon, discovered the properties of a solution of cyanide of silver in cyanide of potassium for electro-plating purposes. The Elkingtons purchased and patented Wright's process, subsequently acquiring the rights of other processes and improvements. George Richards Elkington died on Sept. 22, 1865, and Henry Elkington on Oct. 26, 1852.

ELKINS, a city of West Virginia, U.S.A., in the mountainous eastern part of the state; the county seat of Randolph county. It is served by the Baltimore and Ohio and the Western Maryland railways. The population was 9,338 in 1928 (93% native white). It is in a lumbering and coal-mining region; has various manufacturing industries; and is the seat of Davis and Elkins college (Presbyterian), founded in 1903 by Senators Henry G. Davis and Stephen B. Elkins, who in 1889 had founded the town. Elkins was chartered as a city in 1889.

ELLA or **AELLA,** the name of three Anglo-Saxon kings.

ELLA (d. *c.* 514), king of the South Saxons and founder of the kingdom of Sussex, was a Saxon ealdorman, who landed near Arundel in Sussex with his three sons in 477. Defeating the Britons, Ella and his followers established themselves along the south coast. In 491, strengthened by the arrival of fresh bands of immigrants, they captured the Roman city of Anderida and "slew all that were therein." Ella, who is reckoned as the first Bretwalda, then became king of the South Saxons, and, when he died about 514, he was succeeded by his son Cissa.

ELLA (d. 588), king of the Deirans, the son of Iffa, became the first king of Deira when, in 559, the Deirans separated themselves from the kingdom of Bernicia. When Ella died in 588 Deira was conquered by Bernicia. One of his sons was Edwin, afterwards king of the Northumbrians.

ELLA (d. 867), king of the Northumbrians, became king about 862 on the deposition of Osbert, although he was not of royal birth. Afterwards he joined Osbert in an attack on the Danes, who had invaded Northumbria, and drove them into York. The Danes, however, defeated the Northumbrians, and both Ella and Osbert were slain.

See *The Anglo-Saxon Chronicle*, ed. by C. Plummer (1892–99); Bede, *Historiae ecclesiasticae*, ed. by C. Plummer (Oxford, 1896); Henry of Huntingdon, *Historia Anglorum*, ed. by T. Arnold, Rolls Series (1879); Asser, *De rebus gestis Aelfredi*, ed. by W. H. Stevenson (1904); J. R. Green, *The Making of England* (1897); and the *Dictionary of National Biography*, vol. i. (1895).

ELLAND, an urban district in Yorkshire, England, on the river Calder, 2½ m. S. of Halifax by the L.M.S. railway. Pop. (1921), 10,552. It is situated on the south bank of the Calder, on gently sloping ground, which rises steeply away from the town to an altitude of 800 feet. A col in the high land is used by a road which communicates with Huddersfield, Brighouse and Oldham. Communication is also effected with Halifax by road along the valley bottom and by the Calder canal. The Church of St. Mary is Decorated and Perpendicular.

Cotton mills, woollen factories, ironworks, flagstone quarries at Elland Edge, and fireclay works employ the industrial population.

ELLENBOROUGH, EDWARD LAW, 1ST BARON (1750–1818), English judge, was born on Nov. 16, 1750, at Great Salkeld, Cumberland, where his father, afterwards bishop of Carlisle, was rector. He was educated at the Charterhouse and at Peterhouse, Cambridge, and afterwards was entered at Lincoln's Inn. He spent five years as a special pleader and was called to the bar in 1780. He was unexpectedly chosen to lead the defence of Warren Hastings before the House of Lords, in 1787, Erskine having declined for political reasons. This most famous trial in English history lasted until 1795, when a verdict of acquittal was given. Law did not open the defence till 1792. At the end of it he was second only to Erskine at the bar. During the French Revolution he joined Pitt, was made attorney-general in 1801, and chief justice of the King's Bench with the title of Lord Ellenborough in 1802. He was the judge in the famous case of Ashford v. Thornton, the last case of Appeal of Battle in England. In 1806, on the formation of Lord Grenville's ministry "of all the talents," Lord Ellenborough declined the offer of the great seal, but accepted a seat in the cabinet while retaining the chief justiceship. This action was much criticized and, though not without precedent, was open to such obvious objections on constitutional grounds that the experiment has not been repeated. As a judge his decisions displayed profound legal knowledge, and in mercantile law especially were reckoned of high authority. He was harsh and overbearing to counsel, and in political trials showed an unmistakable bias. In the trial of William Hone (*q.v.*) for blasphemy in 1817, Ellenborough directed the jury to find a verdict of guilty, and their acquittal of the prisoner is generally said to have hastened his death. He resigned his judicial office in Nov. 1818, and died the following month. He had married in 1789 Miss Towry, and had a large family.

ELLENBOROUGH, EDWARD LAW, EARL OF (1790–1871), the eldest son of the 1st Lord Ellenborough, was born on Sept. 8, 1790. He was educated at Eton and St. John's College, Cambridge. He represented the subsequently disfranchised borough of St. Michael's Cornwall, in the House of Commons, until the death of his father in 1818 gave him a seat in the House of Lords. He was twice married; his only child died young; his second wife was divorced by act of parliament in 1830. Ellenborough was lord privy seal (1828) and member of the board of control (1828–30). He had just returned to the board of control in 1841 when he was appointed by the court of directors of the East India Company to succeed Lord Auckland as governor-general of India.

India.—Ellenborough went to India in order "to restore peace to Asia," but the whole term of his office was occupied in war. On his arrival he was greeted by news of the massacre of Kabul, and the sieges of Ghazni and Jalalabad, while the sepoys of Madras were on the verge of open mutiny. In his proclamation of March 15, 1842, as in his memorandum for the queen dated the 18th, he stated the duty of first inflicting some signal and decisive blow on the Afghans, and then leaving them to govern themselves under the sovereign of their own choice. Unhappily, when he left his council for upper India, and learned the trifling failure of General England, he instructed Pollock and Nott, who were

advancing triumphantly with their avenging columns to rescue the British captives, to fall back. The army proved true to the governor-general's earlier proclamation rather than to his later fears; the hostages were rescued, the scene of Sir Alexander Burnes's murder in the heart of Kabul was burned down. Dost Mahommed was quietly dismissed from a prison in Calcutta to the throne in the Bala Hissar, and Ellenborough presided over the painting of the elephants for an unprecedented military spectacle at Ferozepur, on the south bank of the Sutlej. The farce of the recovery of the sandalwood gates of the Hindu temple of Somnath from the Afghans followed. The gates, conveyed to Agra in a triumphal car, were found to be a fraudulent imitation. The Somnath proclamation made Ellenborough ridiculous.

Hardly had Ellenborough issued his medal with the legend "Pax Asiae Restituta" when he was at war with the amirs of Sind. The tributary amirs had on the whole been faithful, for Major (afterwards Sir James) Outram controlled them. But he had reported the opposition of a few, and Ellenborough ordered an inquiry. His instructions were admirable, in equity as well as energy, and if Outram had been left to carry them out all would have been well. But the duty was entrusted to Sir Charles Napier, with full political as well as military powers. Mir Ali Morad intrigued with both sides; he betrayed the amirs on the one hand, while he deluded Napier to their destruction on the other. Ellenborough was led on till events were beyond his control, and his own just and merciful instructions were forgotten. Napier admitted that the seizure of Sind was an "advantageous, useful and humane piece of rascality." The battles of Meeanee and Hyderabad followed; and the Indus became a British river from Karachi to Multan.

On the north the disordered kingdom of the Sikhs was threatening the frontier. In Gwalior to the south, the feudatory Mahratta State, there were a large mutinous army, a Ranee only 12 years of age, an adopted chief of eight, and factions in the council of ministers. These conditions brought Gwalior to the verge of civil war. Ellenborough reviewed the danger in the minute of Nov. 1, 1845, and told Sir Hugh Gough to advance. Further treachery and military licence rendered the battles of Maharajpur and Punniar, fought on the same day, inevitable though they were, a surprise to the combatants. The treaty that followed was merciful and wise. The pacification of Gwalior also had its effect beyond the Sutlej, where anarchy was restrained for yet another year, and the work of civilization was left to Ellenborough's two successors. But by this time the patience of the directors was exhausted. They had no control over Ellenborough's policy; his despatches to them were haughty and disrespectful; and in June 1844 they recalled him.

England.—On his return to England Ellenborough was created an earl and received the thanks of parliament; but his administration was attacked in parliament, though it was successfully vindicated by Peel and Wellington. When Peel's cabinet was reconstituted in 1846 Ellenborough became first lord of the admiralty. In 1858 he took office under Lord Derby as president of the board of control, for the fourth time. There he drafted the new scheme for the government of India which the mutiny had rendered necessary. But he wrote a caustic despatch censuring Lord Canning for the Oudh proclamation, and allowed it to be published in *The Times* without consulting his colleagues, who disavowed his action. Votes of censure were announced in both Houses; and, to save the cabinet, Ellenborough resigned.

But for this act of rashness he might have enjoyed the task of carrying into effect the home constitution for the government of India which he sketched in his evidence before the select committee of the House of Commons on Indian territories on June 8, 1852.

Paying off his old score against the East India Company, he then advocated the abolition of the court of directors as a governing body, the opening of the civil service to the army, the transference of the government to the Crown, and the appointment of a council to advise the minister who should take the place of the president of the board of control. These suggestions of 1852 were carried out by his successor Lord Stanley, afterwards earl of Derby, in 1858, so closely even in details, that Ellenborough must be pronounced the author, for good or evil, of the home constitution of the government of India. Ellenborough never held office again. He died at his seat, Southam House, near Cheltenham, on Dec. 22, 1871, when the barony reverted to his nephew Charles Edmund Law (1820–1890), the earldom becoming extinct.

Bibliography.—*Minutes of Evidence taken before the Select Committee on Indian Territories,* Parl. Papers vol. x. (1852); *History of the Indian Administration under Lord Ellenborough* (ed. Lord Colchester, 1874); *India under Lord Ellenborough, March 1842–June 1844* (ed. Sir A. Law 1926). *See* also *The Friend of India* during the years 1842–45; *The Calcutta Review,* vol. i. (1846); and the numerous books by and against Sir Charles Napier, on the conquest of Sind.

ELLESMERE, FRANCIS EGERTON, 1st Earl of (1800–1857), born in London on Jan. 1, 1800, was the second son of the 1st duke of Sutherland. As Lord Francis Leveson Gower he sat in parliament for various constituencies. He took the name of Egerton in 1833, and in 1846 was elevated to the peerage as earl of Ellesmere and Viscount Brackley. Appointed a lord of the treasury in 1827, he held the post of chief secretary for Ireland from 1828 till July 1830, when he became secretary-at-war for a short time.

Ellesmere translated Goethe's *Faust,* and published several works in prose and verse. He was a munificent and yet discriminating patron of artists. To the splendid collection of pictures which he inherited from his great-uncle, the 3rd duke of Bridgewater, he made numerous additions, and he built a gallery to which the public were allowed free access. Lord Ellesmere served as president of the Royal Geographical Society and as president of the Royal Asiatic Society, and he was a trustee of the National Gallery. He died on Feb. 18, 1857.

ELLESMERE, LORD CHANCELLOR: *see* Brackley, Thomas Egerton, Viscount.

ELLESMERE, urban district, Shropshire, England, situated near the north-west border of the county in a region of indeterminate drainage between the river systems of the Dee and Severn. Pop. (1921) 1,832. It lies on the west shore of the mere—a small lake of glacial origin—from which it takes its name. In the neighbourhood are other sheets of water, as Blake Mere, Cole Mere and Newton Mere. The manor of Ellesmere was granted by William I. to Roger, earl of Shrewsbury. The castle, of which nothing but a mound remains, was given by King John to Llewellyn. Position on the Welsh border ensured importance, and Ellesmere was granted all the free customs of Breteuil. The market granted to Llewellyn was discontinued in the 16th century, when the population of the town was severely reduced by the plague. Now disused, the Ellesmere canal, one of Telford's works, connects the Severn with the Mersey, crossing the Vale of Llangollen, in Denbighshire, by an immense aqueduct. The church of St. Mary contains some Norman work. Ellesmere is the centre of a dairy farming district, and has fairs and markets. It forms part of the Oswestry parliamentary division of Shropshire.

ELLICE (LAGOON) ISLANDS, an archipelago of the Pacific ocean, lying between 5° and 11° S. and about 178° E., nearly midway between Fiji and Gilbert. It was annexed by Britain in 1892, and has been since Jan. 1916 part of the Gilbert and Ellice Isles colony. It comprises a large number of low coral islands and atolls, in nine clusters extending over a distance of about 400 m. from north-west to south-east. Their total area is 14 sq.m. and the population is a little over 3,000. The chief groups are Funafuti or Ellice, Nukulailai or Mitchell, Nurakita or Sophia, Nukufetau, Nui or Egg, Hudson and Niutao or Lynx. Nearly all the natives are Christians, Protestant missions having been long established in several of the islands. Those of Nui speak the language of the Gilbert islanders, and have a tradition that they came some generations ago from that group. All the others are of Samoan speech, and their tradition that they came 30 generations back from Samoa is supported by recent research. The islands have a plentiful rainfall and uniformly high temperatures. The coconut and pandanus are staple foods, and much copra is exported. "Babai" (a taro) is grown in increasing quantities and many fruits grow. Bêche-de-mer is plentiful in the

surrounding seas. Borings and soundings taken at Funafuti in 1897 indicate almost beyond doubt that the whole of this Polynesian region is an area of comparatively recent subsidence.

See *Geographical Journal*, passim; *Atoll of Funafuti: Borings into a Coral Reef* (Report of Coral Reef committee of Royal Society, London, 1904); and Stewart's *Handbook of the Pacific Isles.*

ELLICHPUR, an old Mohammedan capital in Berar, India, which was the headquarters of a British district now merged with the district of Amraoti. The abolition of the district has reduced the importance of the town, but a narrow gauge railway connects it with Martizapur on the main line to Bombay. It carries on a timber trade with Melghat and the Betul district. Pop. 23,899 (over 7,000 Mohammedans). There are many old Muslim families in reduced circumstances, but some revival of trade has followed the construction of the railway. It has several ginning factories and is connected by good roads with Amraoti and Chikalda. The adjacent civil station of Ellichpur (Paratwara), which includes the abandoned cantonment, has a population of 7,743 compared with 11,000 in 1872.

ELLICOTT, CHARLES JOHN (1819–1905), bishop of Gloucester, was born on April 25, 1819, at Whitwell, near Stamford, and educated at Oakham, Stamford, and St. John's college, Cambridge. He was elected a fellow of St. John's in 1845, but his fellowship lapsed on his marriage in 1848. After ten years in the living of Pilton, Rutlandshire, he became professor of New Testament exegesis at King's college, London. In 1859 he was Hulsean lecturer, and in 1860 professor, at Cambridge. In 1861 he was made dean of Exeter, and organized a diocesan training college there, and in 1863 was made bishop of Gloucester and Bristol. During the 42 years of his episcopate he helped to establish the Gloucester Theological college, and the Church Aid Society in Bristol (1867). He was secretary to the Lambeth conferences of 1867, 1878 and 1888, and registrar in 1898. He took an important part in the work of the royal commission on ritual and the rubrics (1867). In 1897, when the sees of Gloucester and Bristol were divided, Ellicott remained bishop of Gloucester, resigning on March 25, 1905. He died on Oct. 15, 1905.

His publications include: *Historical Lectures on the Life of Our Lord Jesus Christ* (1860, 6th ed. 1876); *Addresses on the Revised Version* (1901); *Christus Comprobatur* (1891); he also edited, with the collaboration of Plumptre, Sanday and others, *A New Testament Commentary for English Readers* (3 vols. 1878–79, 2nd ed. 2 vols. 1892–96), *An Old Testament Commentary* (5 vols., 1882–84 and 1884–92), and *The Complete Bible Commentary for English Readers* (7 vols. 1897, new ed. 1905).

ELLIOT, JANE (or JEAN) (1727–1805), poet, daughter of Sir G. Elliot, 2nd baronet of Miabo, was born at Minto House, Teviotdale, in 1727. By her courage and wit she saved her father from the Jacobites in 1745; but she is best known for her beautiful ballad "The Flowers of the Forest," which is said to have been written as the result of a wager with her brother, Gilbert Elliot, also an author. No other poems by Jane Elliot are known. She died on March 29, 1805.

ELLIOTSON, JOHN (1791–1868), English physician, was born at Southwark, London, on Oct. 29, 1791. He studied medicine at Edinburgh, Cambridge, and subsequently in London at St. Thomas's and Guy's hospitals. In 1831 he was elected professor of the principles and practice of physic in London university, and in 1834 he became physician to University college hospital. His interest in mesmerism eventually brought him into collision with the medical committee of the hospital, and he resigned his offices in 1838. In 1849 he founded a mesmeric hospital. He died in London on July 29, 1868. Elliotson was one of the first teachers in London to appreciate the value of clinical lecturing, and one of the earliest among British physicians to advocate the employment of the stethoscope. He contributed numerous papers to the *Transactions* of the Medico-Chirurgical Society, of which he was at one time president; he was founder and president of the Phrenological Society. W. M. Thackeray's *Pendennis* was dedicated to him.

ELLIOTT, EBENEZER (1781–1849), English poet, was born at Masborough in Yorkshire, the son of an ironmaster. At the age of 16 he entered his father's foundry, where he worked for seven years. In an autobiographical sketch printed in *The Athenaeum* (Jan. 12, 1850), he says he was entirely self-taught, and owed his poetical development to long country walks and a collection of books left to his father. His early poetry is of a romantic nature, and begins with *The Vernal Walk,* in imitation of Thomson, which was not successful. He and his father later lost all their money when the iron foundry failed, and he attributed this to the effect of the Corn Laws. He became an active Chartist, and his political interests produced a complete change in the character of his verse. The *Corn Law Rhymes* (1831) are notable for a vigorous denunciation of injustice and for vivid description. In 1833–35 he published *The Splendid Village; Corn Law Rhymes and Other Poems* (3 vols.). He retired from business in 1841 and died at Great Haughton on Dec. 1, 1849. In 1850 appeared *More Prose and Verse by the Corn Law Writer* (2 vols.). The sincerity of Elliott's poetry has saved it from the usual fate of political verse.

See an article by Carlyle in the *Edinburgh Review* (July, 1832); obituary notice in *Gentleman's Magazine* (Feb. 1850); "January Searle" (G. S. Phillips), *Life, Character and Genius of Ebenezer Elliott* (1850); J. Watkins, *Life, Poetry and Letters of Ebenezer Elliott* (1850); J. W. King, *Ebenezer Elliott* (Sheffield, 1854).

ELLIOTT, HOWARD (1860–1928), American railway manager, was born in New York city, Dec. 6, 1860. After graduating from the Lawrence scientific school, Harvard, in 1881, he was for several years a clerk in various offices of the Chicago, Burlington and Quincy Railroad. Later he was appointed general freight agent and then general manager of several lines belonging to the Burlington system. In 1902 he became second vice president of the company and the following year president of the Northern Pacific Railway. In 1913 he was made president of the New York, New Haven and Hartford Railroad and at the same time chairman of its board of directors. In 1917 he resigned and was made chairman of the committee on inter-corporate relations of the New Haven system, a position he retained until 1922. In 1917 he was nominated by the American Railway Association one of the six members of the railroads war board. In the same year he also became chairman of the executive committee of the Northern Pacific Railway Company, was president 1919–20 and then chairman of the board of directors. He took an active part in obtaining legislation from Congress for the protection of the railroads, urged higher freight rates and suggested the creation of a department of transportation, with a secretary in the cabinet. He was three times elected an overseer of Harvard college, and in 1927 served his fourth year as president of the board of overseers of Harvard. He died at Dennis, Mass., on July 8, 1928.

ELLIPSE, in geometry, a closed plane curve of second degree (order and class), or a conic section (*q.v.*) made by a plane cutting all elements of a circular cone, considered either as solid or as surface. It may be regarded either as the plane area enclosed or preferably as its bounding curve. In fig. 1, OVE represents the trace of a cone cut through its axis by the plane of the paper; and OV, OM, OE, etc., represent the positions of a plane, at right-angles to the plane of the paper, rotating about O. In the position OV, the ellipse collapses into a double line OV; in the middle position OM it becomes a circle; in position OP, parallel to the opposite element VM, the section expands into a parabola; on further turning, in position OH, it becomes an hyperbola. This is the view taken by Apollonius (*c.* 220 B.C.). Menaechmus (*c.* 350 B.C.) probably conceived the ellipse as made by a plane perpendicular to OV, the cone-angle V being acute. On V's retiring to infinity (∞), the cone becomes a cylinder (*q.v.*), but the section remains an ellipse, the parabola becoming a pair of parallel lines.

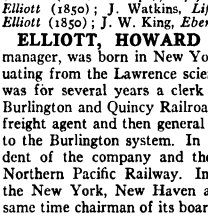


FIG. 1.—FORMS OF AN ELLIPSE

Viewed solely as a plane curve, the ellipse may be variously defined by some distinctive property. Most simply, it is the compression of a circle $x'^2+y'^2=a^2$ (called the *major* or *auxiliary*

circle) by the affine transformation $x=x'$, $y=\frac{b}{a}y'$. Suppose the whole plane to settle toward the horizontal x-axis (fig. 2) every vertical line shrinking uniformly in the ratio $b:a$; then the circle $x^2+y^2=a^2$ shrinks into the ellipse $x^2/a^2+y^2/b^2=1$.

Imagine the shadow cast by a circular disc, in sunlight perpendicular to a vertical wall, as the disc rotates round a horizontal

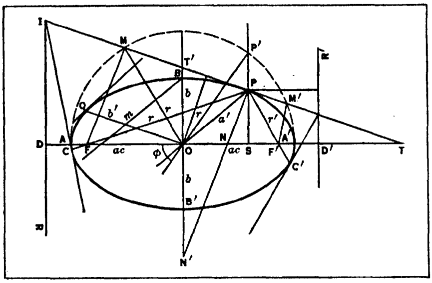


FIG. 2.—SHOWING HOW THE COMPRESSED CIRCLE, $x^2+y^2=a^2$ SHRINKS INTO THE ELLIPSE $x^2/a^2+y^2/b^2=1$

diameter parallel to the wall. In the shadow the vertical chords are all shortened, being multiplied by $\sin\theta$ (the slope of the disc to the light-rays). It is seen instantly that the circle-area πa^2 is reduced in the same ratio b/a and becomes πab for the ellipse, and that any tangent to the circle becomes a tangent to the ellipse, merely rotating about its intersection T with the axis.

The central vertical BB' is called the *minor axis*, and the circle about it as diameter is called the *minor circle*. The circle of radius a about B as centre cuts the major axis AA' at F and F', points of special importance (called foci); $OF=OF'=\sqrt{(a^2-b^2)}$. If we call this ae, we have

$$e=\sqrt{(1-b^2/a^2)},\ 1-e^2=b^2/a^2;$$

e is the *eccentricity*, and ae the *linear eccentricity*. If P' and P be any two corresponding points on the major circle and the ellipse, and S the common foot of the ordinates $P'S$, PS, then the angle SOP' is termed the *eccentric angle* ϵ of P. Then

$$F'P^2=r'^2=(ae-x)^2+y^2=(ae-x)^2+(1-e^2)(a^2-x^2)=(a-ex)^2,$$
$$\text{and } r'=a-ex.$$

Similarly, $FP=r=a+ex$; hence $r+r'=2a$; *i.e., the sum of the distances of any point* (P) *of an ellipse from two fixed points* (F, F′) *is a constant* (the major axis, $2a$). This is the ordinary definition of an ellipse. If we think of F' as a *pole*; then its *polar* (the locus of the intersection I of tangents at the ends of a chord $C'F'C$) will be

$$aex/a^2+0\cdot y/b^2=1,$$

or $x=a/e$, the vertical $D'R'$ (*directrix*); with the points F' and D' in involution, OF'. $OD'=OA^2=a^2$. Hence the distance d, of any point P of the ellipse from $D'R'$, is $a/e-x$, which is equal to r/e; or $e=r/d$; *i.e., the ratio of the distances of any point of the ellipse from a focus* (F') *and the directrix is a constant, the eccentricity* (<1), which gives the preferred definition of an ellipse.

Conjugate diameters in the circle $x^2+y^2=a^2$, each bisecting all chords parallel to the other, do not remain mutually perpendicular in an ellipse, being pressed down towards the axis AA'; but they still bisect as in the circle, since all parallel lengths are shortened throughout in the same ratio, varying with the direction of the chord. Hence the equation of the ellipse referred to conjugate diameters $2a'$, $2b'$ as co-ordinate axes is $x^2/a'^2+y^2/b'^2=1$. It is easily shown that $a'^2+b'^2=a^2+b^2$, a constant. Again, if ϕ be the angle between two conjugates, then $\sin\phi=ab/a'b'$, or $4a'b'\sin\phi=4ab$; *i.e., the parallelogram of tangents at the ends of conjugate diameters is constant in area.*

The *tangent* and *normal* at any point P bisect the angles between the focal radii FP, $F'P$; hence any ray from F is reflected at P through F' and then back to F, and all rays from either focus converge in reflection, on the other; a fact of significance in the study of light, sound, etc. Any perpendicular from a focus on a tangent meets it on the major circle; the product of two such perpendiculars (from F, F') is b^2, a constant. From any outside point Q two tangents QT, QT' may be drawn to E; then the angles of these tangents with focal radii to Q will be equal; *i.e.*, $\angle TQF=\angle T'QF'$. If $\angle\ TQT'$ be a right angle, then Q is on the *director circle* $x^2+y^2=a^2+b^2$. This follows at once from the equation of the tangent, $y=mx+\sqrt{(m^2a^2+b^2)}$. To obtain the equation of the perpendicular tangent, change m into $-1/m$, then eliminate m. Various simple relations connect the subtangents and subnormals.

The *area* of *an ellipse* is πab. To find the *arc-length* involves the use of elliptic integrals and their Abelian inverses, elliptic functions, and doubly periodic functions in general (*see* ELLIPTIC FUNCTIONS.) Kepler's approximation $\pi(a+b)$ is about $\frac{1}{300}$ too large, and $\pi\sqrt{a^2+b^2}$ is about as much too small; their mean errs by about $\frac{1}{3000}$.

Construction and Analysis.—An ellipse may be drawn by fastening the ends of a cord $2a$ units in length at F and F', and then passing a pencil point along the cord held taut by the point (all in the same plane). Alternatively any number of points may be found as follows: Draw concentric major and minor circles (radii a and b) about O; and any radius cutting them at P and Q. Through P draw the vertical chord VV', and through Q the horizontal chord HH'; these meet in a point M on the ellipse, for the x of V on the circle is unchanged, and y is shortened in ratio b/a.

To find the axes of an ellipse, bisect two pairs of parallel chords; the bisectors will be diameters meeting in the centre O. About O draw any circle cutting the ellipse in four points; these are obviously symmetrical with respect to the axes, which are the mid-parallels to the sides of their rectangle. The foci are F and F' on the major axis AA' ($2a$), each at a distance of a from the ends B, B' of the minor axis. The directrices are parallel to BB', and each is distant $d=a/e=a^2/\sqrt{(a^2-b^2)}$ = the intercept between the axes on a parallel to BF, through A. The ellipse is conspicuous in astronomy as the path of a single mass-centre about another obeying the Newtonian *law of inverse squares*. The attraction of other planets perturbs this path of any one planet round the central sun. (*See* also PROJECTIVE GEOMETRY.)

(W. B. SM.)

ELLIPSOGRAPHS. The earliest method of drawing ellipses is by means of a stretched string, a device still adopted by gardeners and others in setting out large ellipses. It is based on the property of the ellipse that if P is any point on the curve and F,F′ are the two foci, then PF+PF′ is of constant value, equal to the length AA′ of the ellipse. The positions of F and F′ on the major axis AA′ of the ellipse are found by setting off BF and BF′ each equal to half the length of the ellipse. The ends of a piece of string are secured at F and F′ in such a way that the length of the free portion FPF′ is equal to that of the ellipse. A pencil or other marking point P pressed outwards against the string, if moved so as to keep the string always taut, will draw the required ellipse. Though quite satisfactory for such work as setting out the shape of an elliptical flower-bed, the difficulty due to variable stretching of the string renders it unsuitable for accurate work. Various simple arrangements for facilitating the application of this method to the drawing of small ellipses have, however, been devised by W. F. Stanley, H. V. Hazard (1884), V. E. Contonze (1895), Professor Honey, R. Ramm and others.

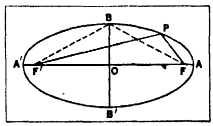
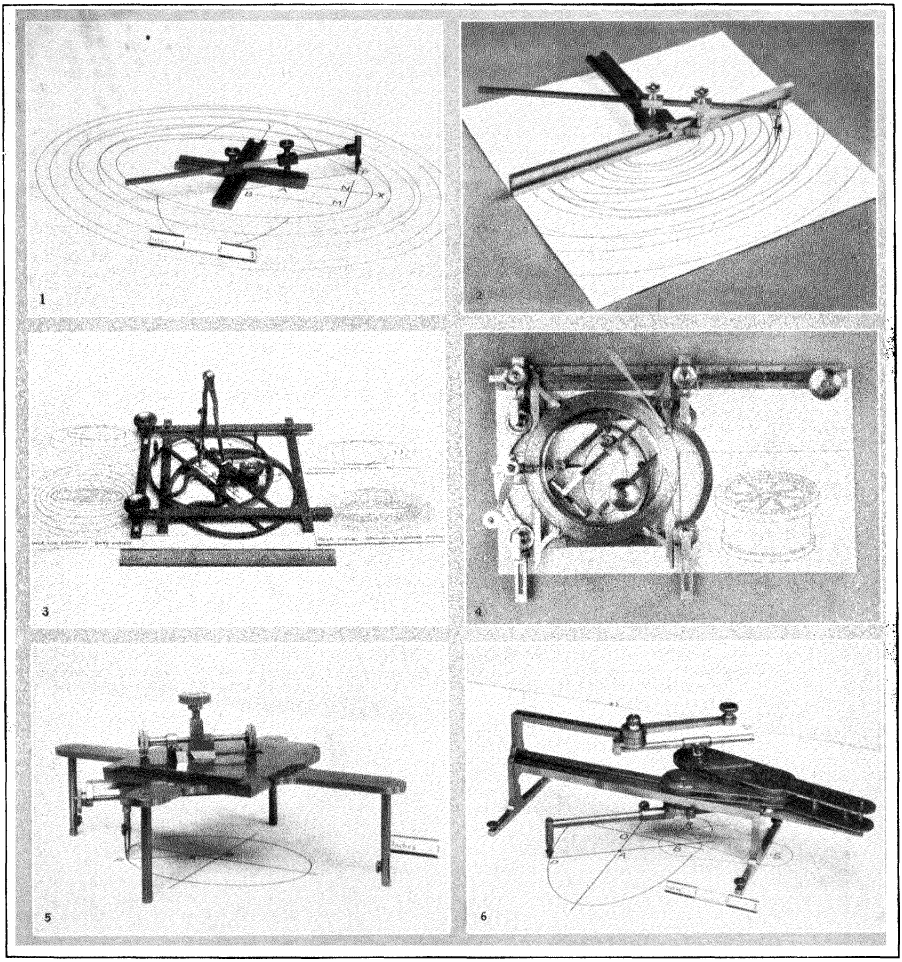


FIG. 1

The most simple and most widely used instruments for drawing ellipses such as are required in ordinary drawing office practice is the *elliptic trammel*. When two points A, B, a fixed distance apart, are constrained to move along two mutually perpendicular straight lines XX,YY, any point P in the line AB, or in that line produced, describes an ellipse. On this principle the elliptic



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DEVELOPMENT AND FORMS OF THE ELLIPSOGRAPH

1. Elliptic trammel. The cross-shaped, grooved base is held firmly by needle points upon the paper. The arm is adjusted by knurled screws above sliders, which move in the grooves of base. The inked pen is moved in an elliptical curve by the knob at right end of arm
2. Semi-elliptic trammel, a modification of the instrument shown in fig. 1. By adjusting the rocker arm, which moves in the two grooves of the base, one half of an elliptical curve is drawn. Reversing the instrument upon the paper, with the same adjustment, the other half of curve is made
3. Farey's ellipsograph, 1810. Two circular slides, moving as one piece, guide the compass point in tracing the ellipse. Knurled thumb screw at right of compass regulates the figure drawn. Figures traced at right and left show range of the instrument as compared with elliptic trammels
4. Improved Farey instrument, 1817. White knob at lower left moves the handle, geared to upper slider, which permits steadier rotation between the two friction wheels. Adjustment is made along the boxwood rule at top, fastened to the paper upon which the figure is to be drawn
5. James Finney's ellipsograph, 1855, with Stanley's improvements. Combination of circular and rectilinear motion occurs in this instrument. The milled head screws (above) are used for determining the radius; same at lower left for setting the pen
6. Edward Burstow's ellipsograph, 1871. By turning the handle at top, motion is transmitted through rocker arm to chain or wheel gearing in the moving arm at right, which slides in slotted frame of the instrument. Correct curve is transmitted through drawing arm to pen and paper below

trammel provides a convenient means of describing ellipses of various sizes and proportions. In the example shown in Plate I., fig. 1, a cross-shaped piece of metal has two undercut grooves at right angles to each other, and is fixed to the paper by needle-points underneath. Two sliders fitting in the grooves carry heads, through which passes a bar to which each head can be clamped. The describing pen or pencil is attached to the end of the bar.

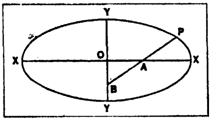

FIG. 2

Ellipses of a width less than the length of each groove cannot be drawn.

In the *semi-elliptic trammel* this difficulty is overcome to a certain extent by cutting away one arm of the cross. If a complete ellipse is required, the two halves of the curve must be drawn separately. An example is shown in Plate I., fig. 2. The long groove is in a plane below the short groove, and along the front of the instrument; the slides can therefore be made long so as to ensure steady working.

For drawing ellipses of small size, John Farey in 1810 devised his modification of the ordinary trammel, since known as *Farey's ellipsograph.* Plate I., fig. 3 shows the original instrument made by him and given in 1812 to the Society of Arts, who awarded him a gold medal for the invention. The grooves of the ordinary trammel are replaced by two pairs of parallel bars fixed at right angles to each other. Each of the two slides takes the form of a circular ring about 4 inches in diameter, and the distance between the centres of the rings can be varied from zero to about 1·2 inches by means of a small rack and pinion with milled head. This is the only relative motion possible between the two circles, which move as one rigid piece when an ellipse is being drawn. Attached to the upper circle is a swivel socket, in which the end of one arm of an ordinary pair of bow compasses may be fixed; this affords an easy and quick means of adjusting the position of the drawing point. Clamped to the frame by two milled-headed screws is a ruler having two needle points projecting from its under surface; this ruler being placed approximately in position, the frame can be adjusted exactly to the right position for drawing the required ellipse. The action of the instrument may be understood by consideration of the equivalent trammel shown drawn underneath the instrument in the illustration.

Farey improved the original form of the instrument by the addition of various adjustments. The example shown in Plate I., fig. 4, which was made in 1817, contains the following improvements. Steadier rotation of the instrument is secured by means of a handle and small pinion gearing with a toothed wheel attached to the upper slider, which slides between two pairs of friction wheels. For drawing ellipses whose major axes are parallel, the instrument is attached to a brass plate which, by means of rack and pinion, can slide along a groove in a boxwood rule 14in. long. This rule is divided into inches and twentieths, and is kept fixed to the paper by three projecting needle-points underneath. Instead of the ordinary pair of compasses for varying the radius, an arm is provided carrying a rack-and-pinion adjustment for the pen.

Another important addition, first introduced by Farey in 1813, is a dividing plate for facilitating such work as the drawing of orthogonal projections of the divisions on divided circles, in drawings such as that shown with the instrument. The dividing plate on this instrument is provided with five sets of holes, giving 360, 96, 90, 72 and 60 divisions to the complete circle.

With such instruments ellipses were often drawn by a diamond point direct on copper plates, and the high standard of performances of the instrument is indicated by the excellence of the engravings of mathematical instruments, etc., made by Farey and others, which form illustrations to scientific papers of that period. Other designers of efficient ellipsographs about this time were W. Cubitt (1817) and Joseph Clement (1818).

In another type of ellipsograph, the combination of a circular with a rectilinear motion forms the basis of the design. In the ordinary trammel, during the operation of drawing an ellipse, the point C, midway between A and B, describes a circle round O as centre, and the angle COA is always equal to the angle CAO. If an arm OC, attached to AB and capable of rotation about O, be provided, one rectilinear guide may be dispensed with.

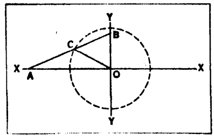

FIG. 3

James Finney's ellipsograph (1855), shown in Plate I., fig. 5 with Stanley's improvements, is of the overhead type on this principle. It is provided with milled-headed screw adjustments for varying the radius and setting the pen. Edward Burstow in his ellipsograph of 1871 used a chain or wheel gearing to effect the combination of motions, only one rectilinear slide being employed.

If in addition to providing for the circular motion of C about O as centre, other gearing carried on OC and CA ensures that CA moves so that the angles CAO and COA are always equal, the single rectilinear slide becomes unnecessary. A few instruments of this type have been constructed, since about 1860; one designed by Frank J. Gray in 1901 is described in detail in the Journal of the Society of Arts, 1902.

When an ordinary drawing pen is used as the describing point in the instruments previously mentioned, the lines drawn are not of uniform thickness unless the pen is guided so that its nibs are kept tangential to the curve. It will be seen from the adjacent diagram that if AD and BD be drawn parallel to the arms of the trammel or equivalent trammel in any ellipsograph, D is the instantaneous centre of motion of AB and of any point P in AB produced. As OD is of constant length, D describes a circle about O as centre, and it is possible to arrange for a rod PD, passing through a sleeve fixed to the arm OD at D, and attached to the pen at P, to keep the pen always tangential to the curve. On this principle a steering device was applied to the ellipsograph by Prof. Alexander, and by F. J. Gray in his instrument of 1901.

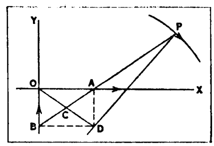

FIG. 4

REFERENCES:—John Farey, *Trans. Soc. Arts*, Vol. xxxi., 1813, pp. 117–130. W. Cubitt, *Trans. Soc. Arts*, Vol. xxxiv., 1817, pp. 131–136. Joseph Clement, *Trans. Soc. Arts*, Vol. xxxvi., 1819, pp. 133–177. Edward Burstow, *Pat. Spec.*, 1817, No. 312. James Finney, *Engineer and Machinist's Drawing-book* compiled from the works of M. Le Blanc and M. M. Armangand, published by Blackie & Son, 1855. Wm. Ford Stanley, *Mathematical Drawing Instruments*, 4th. Ed., 1873 and later editions. Frank J. Gray, *Journ. Soc. of Arts*, Jan. 17, 1902, pp. 143–153, vol. l. (D. B.)

ELLIPSOID, a closed surface of the second degree. Its plane sections are ellipses, its central (rectangular) equation being $x^2/a^2+y^2/b^2+z^2/c^2=1$. Obviously it may be formed after the analogy of the ellipse (*q.v.*) by *affine transformation* (*see* AFFINE GEOMETRY) of the sphere $x^2+y^2+z^2=a^2$, by compressing uniformly, in the ratios b/a and c/a, all y and z coordinates, two sets of mutually perpendicular chords, also perpendicular to OX.

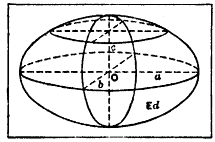

FIG. 1

Less vividly it may be imagined as the path of a varying ellipse always parallel to a fixed plane (XY), its vertices moving on two ellipses in two perpendicular planes, YZ and ZX (fig. 1). For any equality among a, b, c, the surface becomes a *spheroid.* (*See* CONOID.) The elliptic plane sections become circular for two directions. For suppose $a>b>c$, then the plane XY cuts out the ellipse $x^2/a^2+y^2/b^2=1$, having the major and minor axes $2a$, $2b$. Turn the plane about Y or $2b$, the minor axis $2b$ of the ellipse remains unchanged while the major axis decreases from $2a$ to $2c$, for on turning through 90° the ellipse becomes

$y^2/b^2+z^2/c^2=1$. At some stage $2b$ must have ceased to be *minor* and become *major;* at that stage the axes of the ellipse were equal, both being $2b$, and the ellipse was a circle, and so were all parallel sections. The sections shrink into *cyclic points* as the planes become tangent. If θ be the slope of the plane to the greatest axis $2a$ the opposite slope $-\theta$ would yield a like result; hence there two sets of cyclic sections and four cyclic points. (*See* fig. 2.)

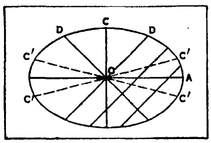

FIG. 2

The volume of the ellipsoid is that of the major sphere reduced in the ratio bc/a^2. In MECHANICS (*q.v.*), the ellipsoid plays an important rôle in the study of moments and inertia. (*See* SURFACE and MATHEMATICAL MODELS.)

ELLIPTIC FUNCTIONS. It is a familiar result of elementary integral calculus that, if R is a linear or quadratic function of a variable x, $\sqrt{R}$, $1/\sqrt{R}$ and, more generally, $f(x,\sqrt{R})$, where f is any rational function, can be integrated by means of elementary functions. In the next higher case, when R is a cubic or quartic with no repeated factor, no such integration is possible. It was gradually recognized by mathematicians of the 18th century that such integrals were essentially new functions requiring special investigation. Particular cases of $\int\sqrt{R}dx$ and of $\int(1/\sqrt{R})dx$ occurred respectively in the problem of finding the length of an arc of an ellipse, and in that of the motion of a pendulum, and on account of the former problem the name *elliptic* was given to the new functions. Some isolated results connecting two or more arcs of ellipses or of other curves were obtained in the first half of the 18th century, and an important formula connecting two integrals was discovered in 1761 by Leonhard Euler (1707–83), a formula equivalent to one of what we now call addition theorems (sec. 3). An algebraic transformation of one elliptic integral into another, which was afterwards found to be of great importance for numerical calculation, was given in 1775 by John Landen (1719–90), in a geometrical form.

1. Elliptic Integrals.—The first systematic treatment of the new functions is due to Adrien Marie Legendre (1752–1833), whose main results were embodied in the great *Traité des fonctions elliptiques et des intégrales Eulériennes* (1825–28). In particular Legendre showed that any integral of the form $\int f(x\sqrt{R})dx$, where, as before, R is a cubic or quartic and f is a rational function, can be reduced to the sum of an elementary function and of constant multiples of integrals of the three standard forms

$$\int\frac{d\phi}{\Delta(\phi)},\qquad\int\Delta(\phi)d\phi,\qquad\int\frac{d\phi}{(1+n\sin^2\phi)\Delta(\phi)},$$

where $\Delta(\phi)=\sqrt{(1-k^2\sin^2\phi)}$, and k, n are constants. These integrals are called Legendre's standard (or normal) elliptic integrals of the first, second and third kinds, respectively; and, if the integration is from 0 to ϕ, are denoted by $F(k,\phi)$, $E(k,\phi)$, $\Pi(n,k,\phi)$; ϕ is called the *amplitude*, k the *modulus*, and n the *parameter*. If the original integral is *real*, k can be taken to be a positive number less than 1, and n to be real; if the restriction to reality is removed, k, n may be any real or complex numbers, subject to the exceptions that if k^2 is 0 or 1 the integrals are elementary functions, and that if n is 0 the third integral reduces to the first. The integrals may be expressed in the equivalent algebraic forms

$$\int\frac{dx}{\sqrt{R_1}},\qquad\int\frac{\sqrt{(1-k^2x^2)}}{\sqrt{(1-x^2)}}dx,\qquad\int\frac{dx}{(1+nx^2)\sqrt{R_1}},$$

where $x=\sin\phi$ and $R_1=(1-x^2)(1-k^2x^2)$; R_1 may be called Legendre's *normal form* of the fundamental quartic.

The integrals in their algebraic forms have the functionally important properties that the first is finite for all real or complex values of x (including infinity), the second is simply-infinite (*i.e.* has a *pole* of order 1) for $x=\infty$, and the third is logarithmically-infinite for $x^2=-1/n$. If $\phi=\pi/2$, we have the corresponding *complete integrals*, sometimes denoted by F_1, E_1, Π_1; but the two former are more commonly called K and E respectively. If k is replaced by $k'=\sqrt{(1-k^2)}$, the corresponding complete integrals are denoted by K' and E'. It should be noticed that $F(k,\phi)$ and $E(k,\phi)$ are functions of two independent arguments k and ϕ, $\Pi(n,k,\phi)$ of three arguments; but k, n usually (though not invariably) remain constants throughout any particular investigation. Legendre gave extensive numerical tables of the integrals of the first and second kinds, which are the basis of nearly all modern tables (*see* bibliography).

Other standard forms of the integrals have been used by other writers; it is enough to give the important form of the integral of the first kind

$$\int_z^\infty\frac{dz}{\sqrt{(4z^3-g_2z-g_3)}}$$

(where g_2 and g_3 are constants), first systematically used at a much later date by Karl Theodor Wilhelm Weierstrass (1815–97). *See* sec. 6.

2. Inversion: Elliptic Functions.—Before Legendre's *Traité* was finished, the subject was revolutionized by Niels Henrik Abel (1802–29), working in close connection with Carl Gustav Jacob Jacobi (1804–51). In 1825 Abel *inverted* the relation between the integral of the first kind $F(k,\phi)$ and its amplitude ϕ, by treating ϕ as a function of the integral, instead of following Legendre in treating the integral as a function of ϕ. In Jacobi's notation, if $u=F(k,\phi)$ then

$$\phi=\mathrm{am}\,u,\quad\sin\phi=\sin\mathrm{am}\,u,\quad\cos\phi=\cos\mathrm{am}\,u,\quad\sqrt{(1-k^2\sin^2\phi)}=\Delta\mathrm{am}\,u.$$

The three latter functions so obtained, now more commonly written in the abbreviated forms sn u, cn u, dn u, or, if it is desirable to express the modulus k explicitly, sn(u,k) cn(u,k), dn(u,k), are called Jacobi's *elliptic functions*, as distinguished from Legendre's *elliptic integrals*, which, however, Legendre himself called *fonctions elliptiques*. Abel immediately recognized as a fundamental property the existence, in the case of each function, of two independent periods, which are respectively real and pure-imaginary in the standard case when $0<k^2<1$. In the particular degenerate case $k^2=0$, sn u, cn u become the trigonometrical functions sin u, cos u, with the real period 2π and dn u becomes 1; when $k^2=1$, sn u becomes the hyperbolic function tanh u, with the imaginary period $i\pi$, and each of cn u, dn u becomes sec u, with the period $2i\pi$. It is now known that many of the fundamental results of Abel and Jacobi had been anticipated, but not published, by Carl Friedrich Gauss (1777–1855).

It is by no means evident that the elliptic functions thus provisionally defined are definite functions of the argument u, still less that they are one-valued functions for complex as well as real values of u, as may be illustrated by the fact that in the next higher case, when the quartic is replaced by a quintic, the process of inversion breaks down completely. A satisfactory proof that the elliptic functions, as defined by inversion of an integral, are one-valued analytic functions only became possible after further development of the theory of functions of a complex variable. From one point of view the essential simplification due to inversion is that elliptic integrals, which are infinitely-many-valued functions, are replaced by one-valued functions; as in trigonometry it is obviously much simpler to work with the one-valued function $x=\sin\theta$ rather than with the many-valued inverse function $\theta=\arcsin x$.

3. Elementary Properties of Jacobi's Elliptic Functions.—Jacobi's book *Fundamenta nova theoriae functionum ellipticarum* (1829) contains, among other results, the main properties of the new functions and of some allied functions. The derivatives of sn u, cn u, dn u follow at once from the definitions. The very important formulae called *addition-theorems* express sn $(u+v)$, etc. as rational functions of sn u, cn u, dn u and sn v, cn v, dn v, and are analogous to the familiar trigonometrical formulae for sin $(A+B)$, etc. If u is increased by the complete integral K, it follows from the addition theorem that sn u is converted into a simple function of cn u, dn u, and if u is increased by $2K$, sn u merely changes sign, so that sn u is periodic in $4K$; if K' is the

complete integral corresponding to the complementary modulus k', iK' has similar properties and in particular sn u is periodic in $2iK'$; similarly for cn u, dn u. The transformations employed show that the three functions are infinite of order 1 (*i.e.*, have simple poles) when $u=iK'$, and, more generally, if u differs from iK' by any integral combination of $2K$, $2iK'$ of the form $2mK+2niK'$ where m and n are integers. A very large number of formulae of interest follow immediately from the addition theorems and the periodicity.

The integrals of the second and third kinds are now expressed in terms of the new variable u, the integral of the first kind. Modifying Legendre's choice of functions, Jacobi replaced $E(k, \phi)$ by $E(u, k)=\int_0^u dn^2u\,du$, and introduced an allied function $z(u)=E(u)-(E/K)u$, where E is Legendre's complete integral of the second kind; Legendre's $\Pi(n, k, \phi)$ is replaced by

$$\Pi(u, a, k) = \int_0^u \frac{k^2\text{sn}a \text{ cn}a \text{ dn}a \text{ sn}^2u\,du}{1-k^2\text{sn}^2 a \text{ sn}^2 u}.$$

4. Doubly-periodic Functions.—Jacobi's sn u, cn u, dn u are simple cases of a more general class of functions having the same or similar fundamental properties. We can take any two numbers 2ω, $2\omega'$ as periods, subject to the one restriction that $\tau\equiv\omega'/\omega$ is not real; then any one-valued analytical function $f(u)$, which is doubly periodic in 2ω, $2\omega'$, so that

$$f(u+2\omega)=f(u+2\omega')=f(u),$$

and has no singularities other than poles for any finite value of u, may be called an *elliptic function*. It is convenient to use the geometrical representation of complex numbers (*q.v.*) by points in a plane (the Argand diagram); any parallelogram with vertices at α, $\alpha+2\omega$, $\alpha+2\omega+2\omega'$, $\alpha+2\omega'$ (α arbitrary), is called a *parallelogram of the periods*; if we know the properties of $f(u)$ throughout any one parallelogram, then from the periodicity we know its properties everywhere, so that it is enough to study one parallelogram.

A number of important general properties of elliptic functions were established by Joseph Liouville (1809–82), mainly by the method of contour-integration; in particular

(i.) an elliptic function $f(u)$ which has no pole in a parallelogram of the periods is a constant;

(ii.) the sum of the *residues* of $f(u)$ at the poles in a parallelogram is zero;

(iii.) $f(u)$ has at least two poles, or a multiple pole, in a parallelogram;

(iv.) the number of poles in a parallelogram is equal to the number of zeros and is also equal to the number of points at which the function has any assigned value;

(v.) the sum of the values of u at the poles in a parallelogram is equal to the sum of the values of u at the zeros or differs from it by some period.

(These theorems require obvious modifications, if the poles, etc., are multiple, or if any of them lie on the boundary of the parallelogram, and in the trivial case when $f(u)$ is merely a constant). Liouville's theory gives simple proofs of important properties of the elliptic functions as well as of many elementary identities; *e.g.*, to prove the identity of two functions $f(u)$, $\phi(u)$, it is enough to prove (1) that the periods are the same, (2) that in any parallelogram they have the same poles and zeros (of the same order), so that by (i.) their quotient is a constant and (3) that the quotient is 1 for some particular value of u.

5. The Theta-Functions.—In the *Fundamenta Nova* Jacobi introduced four allied functions $\theta(u)$, $\theta(u+K)$, $H(u)$, $H(u+K)$, each of which is *holomorphic*, *i.e.*, is a one-valued analytic function with no singularity except at infinity; and showed that the quotients of $H(u)$, $H(u+K)$, $\theta(u+K)$ by $\theta(u)$ are constant multiples of sn u, cn u, dn u. He also showed that the integral of the third kind can be expressed in terms of these new functions.

In lectures (published posthumously) he used modifications of these functions as a basis for the whole theory. Taking one period arbitrarily to be π and the other to be $\pi\tau$ where τ is an arbitrary complex number $\alpha+i\beta$, subject only to the condition that β is positive, we define four functions $\theta_r(x)$, $(r=0, 1, 2, 3)$ as series of sines or cosines of multiples of a variable x, the coefficients being of the form $\pm 2\rho^{n^2}$, where $\rho=e^{\pi i\tau}$ and n is an integer or half an odd integer. From the condition imposed on $\tau_1|\rho|<1$ the series converge for all values of x, and, except when $|\rho|$ is near 1, with great rapidity. The addition of a half-period to x converts any θ into another θ multiplied by a simple factor, and the addition of a period merely multiplies any θ by a simple factor, in such a way that the quotient of any two θ's is doubly-periodic.

By multiplying four of the series together and rearranging, Jacobi obtains a remarkable system of *theta-product formulae*, which are, in the first instance, linear relations between products of four θ's of eight variables, four of which are independent. By specializing the variables, a great number of interesting and important relations between θ's of 4, 3, 2, 1 or 0 independent variables are obtained. Certain of these formulae yield algebraical addition theorems for quotients of two θ's, and differentiation follows by a simple limiting process; and finally there is constructed, in the form of a quotient of θ's, a function which satisfies the condition which defines sn u regarded as the inverse of the elliptic integral of the first kind. The process is entirely independent of any properties of the elliptic functions themselves, and is thus an independent method of solving the inversion problem (sec. 2), and incidentally gives most of the fundamental properties of Jacobi's elliptic functions.

The θ's are also expressible as singly-infinite products of trigonometrical factors, in forms from which the zeros are at once evident; sn u, cn u, dn u and various simple combinations of them, as well as $Z(u)$ are expressible as trigonometrical series, which unlike the θ's have only a limited range of convergence; and the constants k, k', K, etc. are expressible in a variety of forms as infinite products involving ρ, as ratios of series in ρ, or as series in ρ.

6. The Weierstrassian Theory.—By inverting the integral of the first kind in the Weierstrassian form (sec. 1), we obtain an elliptic function $\wp(u)$ which, unlike the Jacobian functions, has a single pole of order 2 in any parallelogram. The theory is however more simply developed if we define $\wp(u)$ not by inversion, but as a double-series, which converges everywhere except at the poles, has two periods chosen arbitrarily subject to the condition that their ratio is not real, and has a double pole in each parallelogram. An easy application of Liouville's method gives the formula

$$\wp'(u) = \sqrt{\{4\wp^3(u)-g_2\wp(u)-g_3\}},$$

where g_2, g_3 are defined as series involving only the periods, and a solution of the inversion problem follows. Closely connected with $\wp(u)$ are the functions $\zeta(u)$, defined as a doubly-infinite series with simple poles, and $\sigma(u)$ defined as a doubly-infinite product with no singularities. The three functions are connected by the equations

$$\zeta'(u)=-\wp(u), \quad \sigma'(u)/\sigma(u)=\zeta(u).$$

Neither ζ nor σ is periodic, but they undergo simple changes when u is increased by a period; ζ, which is closely allied to Jacobi's z, can be taken as the integral of the second kind, and the integral of the third kind is simply expressible in terms of $\sigma(u)$.

The Liouville theory and simple algebra lead very easily to the addition-theorem for $\wp(u)$, formulae for the addition of half-periods, and to many other results, the development being in general much more symmetrical and elegant than for the Jacobian functions. With $\sigma(u)$ are associated three other functions $\sigma_r(u)$, $(r=1, 2, 3)$, these four functions being closely related to the four θ's. The Weierstrassian and Jacobian functions are connected by equations of the form

$$\wp(u)=A+B/\text{sn}^2(bu),$$
$$\sigma(u)=Ce^{au^2}\theta_1(cu),$$

(with similar formulae for the other σ's), A, B, C, a, b, c, being

constants; and the properties of either set of functions can be derived from the others.

Any elliptic function $f(u)$ can be expressed in any one of three standard forms:—

(i.) as a product of σ's, divided by another product of σ's,
(ii.) as a linear combination of ζ's and their derivatives,
(iii.) as a rational function of $\wp(u)$ and $\wp'(u)$.

From the second form the integral of $f(u)$ is at once expressible in terms of σ and ζ.

7. **The Theory of Transformation,** which originated with Abel and Jacobi as the problem of algebraic transformation of one elliptic integral into another, has developed into a very extensive subject, intimately connected on one side with algebraic equations and *groups* (*q.v.*), on another with the theory of numbers (*see* NUMBERS, THEORY OF). It lies outside our present scope in this article.

8. **Applications.**—As elliptic integrals or functions are required for the integration of the square root of a cubic or quartic they necessarily occur in many mathematical problems. Among these problems are:

In differential equations: the integration of Lamé's equation, and of Briot and Bouquet's equation $f(y, dy/dx)=0$;

In geometry: the arc of an ellipse, hyperbola, lemniscate; the parametric representation of the coordinates of a point on a non-singular, plane, cubic curve, or more generally on any curve of genus 1; Poncelet's polygons inscribed in one conic, circumscribed to another; the surface of an oblique cone and of an ellipsoid; geodesics on a quadric of revolution and umbilical geodesics on a general quadric;

In physics: the elastica, the motion of a projectile under a resistance varying as the cube of the velocity, the simple and spherical pendulums, the motion of a rigid body under no forces, the symmetrical top; the potential of an ellipsoid; various potential problems in which occurs a rectangular boundary, or various other rectilinear boundaries.

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(A. BER.)

ELLIPTICITY, in astronomy, deviation from a circular or spherical form; applied to the elliptic orbits of heavenly bodies, or the spheroidal form of such bodies.

ELLIS (originally SHARPE), **ALEXANDER JOHN** (1814–1890), English philologist, mathematician, musician and writer on phonetics, was born at Hoxton, London, on June 14, 1814. He was educated at Shrewsbury, Eton and Trinity College, Cambridge, and took his degree in high mathematical honours. He was the first in England to reduce the study of phonetics to a science. His most important work, to which the greater part of his life was devoted, is *On Early English Pronunciation, with special reference to Shakespeare and Chaucer* (1869–89). He had long been associated with Isaac Pitman in his attempts to reform English spelling, and published *A Plea for Phonotypy and Phonography* (1845) and *A Plea for Phonetic Spelling* (1848); and contributed the articles on "Phonetics" and "Speech-sounds" to the 9th edition of the *Encyclopædia Britannica.* He died in London on Oct. 28, 1890.

ELLIS, GEORGE (1753–1815), English author, was educated at Westminster school and at Trinity college, Cambridge. He contributed to the *Rolliad* and the *Probationary Odes* satires against Pitt's administration. In 1797 he went to Lille as secretary to the embassy. He continued to write political satires in the *Anti-Jacobin,* which he founded with George Canning and William Gifford. For some years before the *Anti-Jacobin* was started Ellis had been studying Early English literature, in which he was one of the first to arouse interest. He rendered a very great service to English literature by his *Specimens of the Early English Poets* (1790) and his *Specimens of Early English Metrical Romances* (1805). He also edited G. L. Way's translation of select *Fabliaux* in 1796. Ellis was an intimate friend of Sir Walter Scott, who styled him "the first converser I ever saw." Some of the correspondence between them is to be found in Lockhart's *Life.*

ELLIS, SIR HENRY (1777–1869), English antiquary, was born in London on Nov. 29, 1777. Educated at Merchant Taylor's school, and at St. John's college, Oxford, he entered the British Museum in 1800. From 1827 to 1856 he was chief librarian. He died on Jan. 15, 1869. His principal works are: a new edition of Brand's *Popular Antiquities* (1813); *Introduction to Domesday Book* (1833); and *Original Letters Illustrative of English History* (first series, 1824; second series, 1827; third series, 1846) compiled chiefly from manuscripts in the British Museum and the State Paper office.

ELLIS, HENRY HAVELOCK (1859–), British psychologist, was born at Croydon, Surrey, on Feb. 2, 1859. Both his father and maternal grandfather were sea captains, and much of his childhood was spent on the Pacific. After teaching for four years in New South Wales, he qualified for the medical profession at St. Thomas's Hospital, London. For a short time he engaged in general practice but very soon abandoned it for literary and scientific work. The more popular researches of the Freudian school have to a considerable extent overshadowed the methods of Ellis, in which more emphasis is laid on biology and less on clinical experience. In the last century, moreover, the extension of his fame beyond medical circles was impeded by the repugnance aroused in the ordinary reader by the subject matter of his studies. Only of late has it become possible to adjudge his work without prejudicial heat.

Yet Ellis has the unusual advantage of being able to expound his scientific theories in a clear and often beautiful style. The patience of a Darwin is combined with the literary brilliance of a Huxley; even when he is unable to convince he is sure to amuse; and, especially in his occasional writings, he brings to the totality of human experience a generous sympathy, a sharp intelligence and a daring wit. Whatever his studies had been, he would certainly have won a reputation as a literary artist.

His works include: *Studies in Psychology of Sex* (6 vols., 1898–1910); *Affirmations* (1898); *The World of Dreams* (1911); *Impressions and Comments* (3 series, 1914–24); the *Dance of Life* (1923); *Germinal,* trans. from the Fr. of Emile Zola (1925); *Sonnets, with Folk Songs from the Spanish* (Boston, 1925); *Man and Woman* (6th ed., 1926); *The New Spirit* (4th ed., Boston, 1926); *A Study of British Genius* (1927). *See* also: D. Isaac Goldberg, *Havelock Ellis: a Biographical and Critical Survey* (1926).

ELLIS, ROBINSON (1834–1913), English classical scholar, was born at Barming, Kent. He was Latin reader at Oxford from 1883 till 1893 when he became professor. His most important work was his *Commentary on Catullus* (1876, new ed. 1889), which aroused much criticism. He also translated the poems (1871) in the metres of the originals. His other works include *Noctes Manilianae,* dissertations on the *Astronomica,* with emendations (1891); editions of Avianus (1887), Velleius Paterculus (1898) and the Christian poet Orientius (1888), vol. xvi. of the Vienna *Corpus Scriptorum Ecclesiasticorum,* the *Ibis* of Ovid (1881), the *Aetna* of the younger Lucilius (1901), *Appendix Vergiliana* (an edition of the minor poems) (1908), and Ovid's *Amores* (1912).

ELLIS, WILLIAM (1794–1872), English Nonconformist missionary, was born in London on Aug. 29, 1794. His boyhood and youth were spent at Wisbech, where he worked as a market-gardener. He was sent by the London Missionary Society to the South Sea Islands in Jan. 1816, and remained in Polynesia, occupying various stations in succession, until 1824. Ellis improved the condition of the people. He acclimatized many species of tropical fruits and plants, and set up and worked the first printing press in the South Seas. Ellis was for some years a travelling agent of the London Missionary Society and was its foreign secretary 1832–39. He paid three visits to Madagascar (1853–57), inquiring into the prospects for resuming the work that had been suspended by Queen Ranavolona's hostility. A further visit was paid in 1863. Ellis wrote accounts of all his travels, and Southey praised (in the *Quarterly Review*) his *Polynesian Researches* (2 vols., 1829). He died on June 25, 1872.

ELLISTON, ROBERT WILLIAM (1774–1831), English actor, was born in London on April 7, 1774, and died there on July 8, 1831. He played first of all at Bath, later at Drury Lane, of which he was lessee from 1819 to 1826. From that time to his death he was lessee of the Surrey theatre.

ELLORA, a village of India, in the native state of Hyderabad, near the city of Daulatabad, famous for its rock temples. The caves differ from those of Ajanta in being excavated in the sloping sides of a hill and not in a nearly perpendicular cliff. They extend along the face of the hill for a mile and a quarter, and are divided into three distinct series, the Buddhist, the Brahmanical and the Jain, and are arranged almost chronologically. The most splendid is the Kailas, which is not a mere interior chamber but a model of a complete Dravidian temple, the rock having been cut away externally as well as internally. First the great sunken court was hewn out of the solid trap-rock of the hillside, leaving the rock mass of the temple wholly detached in a cloistered court, save that a rock bridge once connected the upper storey of the temple with the upper row of galleried chambers surrounding three sides of the court. Colossal elephants and obelisks stand on either side of the open mandapam, or pavilion, containing the sacred bull; and beyond rises the monolithic Dravidian temple to Siva, 90 ft. in height, hollowed into vestibule, chamber and image-cells, all lavishly carved. The temple was made under Krishna I., Rashtrakuta, king of Malkhed in 760–783.

ELLORE, a town of British India, in the Kistna district of Madras, on the East Coast railway, 303 m. from Madras. Pop. (1921) 45,062. The canal systems of the Godavari and the Kistna deltas meet here. There are carpet and hosiery manufactures, cotton, rice, jute and oil mills, cotton ginning and pressing factories, a tannery, saltpetre works, and an extensive trade in grain and rice. There is an important high school. Ellore was formerly a military station, and the capital of the Northern Circars. At Pedda Vegi to the north of it are extensive ruins, believed to be remains of the Buddhist kingdom of Vengi. From these the Mohammedans, after the conquest of the district in 1470, obtained material for building a fort at Ellore.

ELLSWORTH, OLIVER (1745–1807), American statesman and jurist, was born at Windsor, Conn., on April 29, 1745. He studied at Yale and Princeton, graduating from the latter in 1766, studied theology for a year, then law, and began to practise at Hartford in 1771. He achieved extraordinary success at the bar, amassing what was for his day a large fortune. From 1773 to 1775 he represented the town of Windsor in the general assembly of Connecticut. In 1779 he again sat in the assembly, this time representing Hartford. From 1777 to 1783 he was a member of the Continental Congress. From 1780 to 1785 he was a member of the governor's council of Connecticut, and from 1785 to 1789 he was a judge of the State superior court. In 1787, with Roger Sherman and William Samuel Johnson, he was one of Connecticut's delegates to the Constitutional Convention at Philadelphia. When disagreement seemed inevitable on the question of representation, he, with Roger Sherman, proposed what is known as the "Connecticut compromise," by which the Federal legislature was made to consist of two houses, the upper having equal representation from each State, the lower being chosen on the basis of population. From 1789 to 1796 he was one of the first senators from Connecticut under the new constitution. In the Senate he was looked upon as President Washington's personal spokesman and as the leader of the Administration Party. His most important service to his country was in connection with the establishment of the Federal judiciary. As chairman of the committee having the matter in charge, he drafted the bill by the enactment of which the system of Federal courts, almost as it is to-day, was established. By President Washington's appointment he became chief justice of the Supreme Court of the United States in March, 1796, and in 1799 President John Adams sent him, with William Vans Murray (1762–1803) and William R. Davie (1756–1820), to negotiate a new treaty with France. It was largely through the influence of Ellsworth, who took the principal part in the negotiations, that Napoleon consented to a convention, Sept. 30, 1800, which provided for freedom of commerce between the two nations. Failing health compelled him in 1800 to resign the chief-justiceship. He died in Windsor on November 27, 1807.

See W. G. Brown's *Oliver Ellsworth* (1905), an excellent biography. There is also an appreciative account of Ellsworth's life and work in H. C. Lodge's *A Fighting Frigate and Other Essays and Addresses* (1902), which contains in an appendix an interesting letter by Senator George F. Hoar concerning Ellsworth's work in the Constitutional Convention.

ELLWANGEN, a town of Germany in the republic of Württemberg, on the Jagst. Pop. (1925) 5,653. The Benedictine abbey of Ellwangen is said to have been founded in 764, but there is no record of it before 814. In 1460 the abbey was converted, with the consent of Pope Pius II., into a *Ritterstift* (college or institution for noble pensioners) under a secular provost. The town of Ellwangen, which grew up round the abbey and received the status of a town about the middle of the 14th century, was until 1803 the capital of the provostship, when this passed to Württemberg. It is situated between two hills, one crowned by the castle of Hohen-Ellwangen, built in 1354 and now used as an agricultural college, and the other, the Schönenberg, by the pilgrimage church of Our Lady of Loreto. The Stiftskirche, the old abbey church, a Romanesque building dating from 1124 and the Gothic St. Wolfgangskirche are the chief churches. The industries include making of parchment covers, of envelopes, of wooden hafts and handles for tools, etc., and tanneries. There are also a wool-market and a horse-market which is famous.

ELLWOOD, THOMAS (1639–1714), English author, was born at Crowell, Oxfordshire. His family moved to London while he was still young, and he met a Quaker family named Pennington, and himself became a Quaker. They introduced him to Milton, to whom he went every afternoon as Latin reader, and about whom his autobiography contains much information. His visits to Milton were interrupted by imprisonments for Quakerism. His story that after reading the ms. of *Paradise Lost* he suggested the idea of *Paradise Regained* seems improbable (*see* the chapter on Milton in *Cambridge History of English Literature* vol. vii.). Ellwood wrote polemical works in defence of Quakerism such as *Forgery No Christianity* (1674) and *The Foundation of Tithes Shaken* (1678); also some poems, including a *Davideis* in five books.

See *The History of the Life of Thomas Ellwood; written by his own hand* (1714); F. A. Budge, *Thomas Ellwood and other Worthies* (1891); A. K. Brown, *Thomas Ellwood, the Friend of Milton* (1910).

ELLWOOD CITY, a borough of Lawrence county, Pa., U.S.A., on the Connequessing river, 36m. N.W. of Pittsburgh. It is served by the Baltimore and Ohio, the Buffalo, Rochester and Pittsburgh, the Pennsylvania and the Pittsburgh and Lake Erie railways. The population in 1920 was 8,958 (21% foreign-born white), and was estimated locally at 15,000 in 1928. It is a manufacturing centre, making steel, brass, bronze, brick and other products characteristic of the Pittsburgh industrial district. The town was founded in 1889 as a summer resort, and was incorporated as a borough in 1892.

ELM, the popular name for the trees and shrubs constituting the genus *Ulmus*, of the family Ulmaceae. The genus contains 18 species widely distributed throughout the north temperate zone and also found in the mountains of the tropics.

The common European elm, *U. campestris*, a doubtful native of England, is found throughout a great part of Europe, north Africa and Asia Minor, whence it ranges east to north Asia and Japan. It grows in woods and hedge-rows, especially in southern Britain, and on almost all soils, attaining a height of 60 to 100, and occasionally 150 ft. The branches are numerous, spreading and often pendulous at the extremities; the bark is rugged; the leaves ovate, rough, doubly serrate, and, as in other species of *Ulmus*, unequal at the base. The flowers are small, numerous, in purplish-brown tufts, and each with a fringed basal bract; the bell-shaped calyx surrounds four free stamens; the pistil bears two spreading hairy styles. They appear before the leaves in March and April. The seed-vessels are green, membranous, one-seeded and deeply cleft. The first 10 years the tree usually reaches a height of 25 to 30 ft. The wood, at first brownish white, becomes later brown with a greenish shade. It is close-grained, free from knots, without apparent medullary rays, hard and tough, but will not take a polish. All parts of the trunk, including the sapwood, are available in carpentry. The wood has considerable transverse strength, does not crack when once seasoned, and is remarkably durable under water, or if kept quite dry. Elm wood is used for keels and bilge-planks, the blocks and dead-eyes of rigging, ships' pumps, coffins, wheels, furniture, carved and turned articles, and for general carpenters' work. For ornamental purposes elm trees are frequently planted, and in avenues, are highly effective. In Italy, as in ancient times, it is still customary to train the vine upon the elm. The cork-barked elm, *U. campestris*, var. *suberosa*, is distinguished chiefly by the thick deeply fissured bark with which its branches are covered. There are numerous cultivated forms differing in size and shape of leaf, and manner of growth.

ENGLISH ELM, SHOWING TWIG BEARING FLOWERS; THESE COME OUT BEFORE THE LEAVES, WHICH ARE ASYMMETRICAL
A. Cluster of flowers
B. Single flower showing toothed external envelope, stamens and forked stigma
C. Cluster of fruits (achenes)

The Scotch or wych elm, *U. montana*, is indigenous to Great Britain and is the common elm in the north; it usually attains a height of about 50 ft., but among tall-growing trees may reach 120 ft. It has drooping branches, smoother and thinner bark, larger and more tapering leaves, and a far less deeply notched seed-vessel than *U. campestris*. The wood is tough and hard when properly seasoned, and, being very flexible when steamed, is well adapted for boat-building. Branches of the wych elm were formerly manufactured into bows, and if forked were employed as divining-rods. The weeping elm is a variety of this species. The Dutch or sand elm is very similar to the wych elm, but produces inferior timber.

In North America there are six native species of elm, all occurring east of the Rocky Mountains, and chiefly in the southern United States. Of these the most widely distributed is the American or white elm (*U. americana*), which ranges from Newfoundland to the Great Lakes and the eastern base of the Rocky Mountains in Alberta south to Florida and Texas. This handsome tree is the largest American elm, sometimes attaining a height of 100 ft. or 120 ft., with a trunk diameter of 6 ft. to 11 ft., often enlarged by great buttresses at the base. It sometimes rises as a straight undivided shaft, 60 ft. to 80 ft. in height, before dividing into short spreading branches. Usually it separates at a height of 30 ft. or less into numerous upright limbs which gradually spread to form an inversely conical rounded head of long, slender, graceful branches, frequently 100 ft. and occasionally 150 ft. in diameter. In size, vigor and gracefulness it is fully equal to the European elm (*U. campestris*) and, like it, is extensively planted for shade and ornament in the northern States and adjacent Canada, especially in New England where it is a characteristic tree of streets and parks. A famous elm on Boston common, supposed to have been in existence before the settlement of Massachusetts, measured 22 ft. in circumference at the time of its destruction by a storm in 1876.

The red or slippery elm (*U. fulva*) is common in rich soil from Quebec to South Dakota and south to Florida and Texas. It grows 60 ft. to 70 ft. high and 1 ft. to 2 ft. in trunk diameter, with stiff branches, rough leaves and thick, fragrant, mucilaginous bark, much used in spring for chewing by small boys and employed in medicine as a demulcent. Less common are the rock or cork elm (*U. racemosa*) of the northern States and adjacent Canada, a large tree with corky bark, and the much smaller winged or Wahoo elm (*U. alata*), likewise with corky bark, found in the southern States. The southern red elm (*U. serotina*) and the cedar elm (*U. crassifolia*), both of limited range in the southern States, differ from the other American elms in flowering in autumn instead of in spring. When of sufficient size, all American elms are of value as timber trees. The total cut of elm lumber, according to the U.S. census of 1925, was 190,630,000 bd.ft., mostly white elm, one-half of which was produced in the States of Michigan and Wisconsin.

ELMACIN, GEORGE (*c.* 1223–1274), author of a history of the Saracens, which extends from the time of Mohammed to the year 1118 of our era. He was a Christian of Egypt, where he was born; is known in the east as Ibn-Amid; and after holding an official position under the sultans of Egypt, died at Damascus. His history is principally occupied with the affairs of the Saracen empire, but it contains passages which relate to the Eastern Christians. It was published in Arabic and Latin at Leiden in 1625. The Latin version is a translation by Erpenius, under the title, *Historia saracenica*, and from this a French translation was made by Wattier as *L'Histoire mahométane* (Paris, 1657).

ELMALI ("apple-town"), a kaza in the vilayet of Adalia in Asia Minor, the present administrative centre of most of the ancient Lycia. It lies about 25 m. inland, at the head of a long upland valley (5,000 ft.) inhabited by direct descendants of the ancient Lycians, who have preserved a distinctive facial type. Pop. (1927) 16,126. The district is agricultural.

ELMAN, MISCHA (1891–   ), violinist, was born at Stalnoje, Russia, on Jan. 20, 1891, received his first musical teaching from his father, a schoolmaster, but subsequently studied under Fidelmann at Odessa, and later under Auer at St. Petersburg (Leningrad), where as a Jew he was enabled to reside only by virtue of a special dispensation granted by the Tsar. Recognition of his extraordinary talents was immediate, not only in Russia, but elsewhere throughout Europe. He paid his first visit to London in 1905 and to the United States in 1908. During the World War he was relieved of the obligation of military service to which as a Russian subject he would otherwise have been liable. During recent years he has practised his art chiefly in America, where he has made many tours, and after his marriage in San Francisco in 1925 he became a permanent resident of New York.

His first name is a diminutive of Michael.

ELMHAM, THOMAS (d. *c.* 1420), English chronicler, was probably born at North Elmham in Norfolk. He became a Benedictine monk at Canterbury, and then, joining the Cluniacs, was prior of Lenton Abbey, near Nottingham; he was chaplain

to Henry V., and was present at Agincourt. Elmham wrote a history of the monastery of St. Augustine at Canterbury (edit. C. Hardwick, Rolls Series, 1858); and a *Liber metricus de Henrico V.* (edit. C. A. Cole, in *Memorials of Henry V.* 1858). It is probable that he wrote the famous *Gesta Henrici Quinti*, which is the best authority for the life of Henry V. from his accession to 1416. This work, often referred to as the "chaplain's life," and thought by some to have been written by Jean de Bordin, has been published for the English Historical Society by B. Williams (1850). Elmham, however, did not write the *Vita et Gesta Henrici V.*, which was attributed to him by T. Hearne and others.

See C. L. Kingsford, *Henry V.* (1901).

ELMHURST, a city of Du Page county, Ill., U.S.A., 16m. W. of Chicago. It is served by the Chicago and North Western, the Chicago, Aurora and Elgin, the Chicago Great Western, and the Illinois Central railways, and has a commercial airport, Eagle field. The population was 4,594 in 1920, and was estimated locally at 15,000 in 1928. Stone quarries, woodworking and steel mills, brick-yards, and greenhouses constitute the leading industries of the city. It is the seat of Elmhurst college for men (Evangelical) established in 1871. Elmhurst was incorporated as a city in 1900.

ELMINA, a town on the Gold Coast, British West Africa, in 5° 4′ N., 1° 20′ W. and about 8 m. W. of Cape Coast. Pop. (1921) under 5,000. Facing the Atlantic on a rocky peninsula is Fort St. George, considered the finest fort on the Guinea coast. It is built square with high walls, and has accommodation for 200 soldiers. On the land side were formerly two moats, cut in the rock on which the castle stands. The houses in the native quarter are mostly built of stone, that material being plentiful in the vicinity.

Elmina was the first permanent European settlement on the Gold Coast. Diogo d'Azambuja was sent by John II. of Portugal to the coast for that purpose and he began, in 1481, the building of a fortress called São Jorge da Mina. One of the officers with d'Azambuja was Bartholemew Diaz. It was on this occasion or very soon afterward that Christopher Columbus visited the Guinea coast; his son records his father's statement "I have stayed in the Portuguese fortress of St. George of the Mine." It took 80 years before the fort was completed. Another defensive work is Fort St. Jago, built in 1666, which is behind the town and at some distance from the coast. (In the latter half of the 19th century it was converted into a prison.) Elmina was captured by the Dutch in 1637, and ceded to them by treaty in 1640. They made it the chief port for trade with Ashanti. With the other Dutch possessions on the Guinea coast, it was transferred to Great Britain in April 1872. The king of Ashanti, claiming to be ground landlord, objected to its transfer, and the result was the Ashanti war of 1873–1874. Up to the close of the 19th century the greatest output of gold from this coast came from Elmina. The annual export is said to have been nearly £3,000,000 in the early years of the 18th century, but the figure is probably exaggerated. The building of the railway from Sekondi to the gold mines took the trade away. Prempeh, the ex-king of Ashanti, was detained in the castle (1896) until his removal to the Seychelles. (*See* ASHANTI: *History,* and GOLD COAST: *History.*)

ELMIRA, a city of southern New York, U.S.A., on the Chemung river, at an altitude of 850ft.; the county seat of Chemung county. It is served by the Erie, the Lackawanna, the Lehigh Valley and the Pennsylvania railways. The population was 45,393 in 1920 (88% native white) and was estimated locally at over 54,000 in 1928. The city lies on both sides of the river, and is surrounded by wooded hills. The area is 7·4 sq.m. It is the seat of Elmira college for women (1853). The New York State reformatory for first offenders (men) 16–30 years of age, opened at Elmira in 1876 under the direction of Zebulon R. Brockway (1827–1920), has had a great influence on correctional methods in the United States and abroad. Its distinctive features are the indeterminate sentence; a strict regimen of physical training, work and academic instruction, and a marking system. Elmira is an important railway centre, and has extensive manufactures, including fire-engines, milk bottles, iron and steel bridges, valves and Bendix drives (for automobiles). The aggregate factory output in 1925 was valued at $35,107,555. Bank clearings in 1926 amounted to $52,400,000, and the assessed valuation of property was $47,093,426.

The site of Elmira was the intersection point of several important Indian trails, and there were several Indian villages in the vicinity. The first log cabin was built in 1778. The village was incorporated in 1815 as Newtown, and reincorporated in 1828 as Elmira. In 1832 the Chemung canal connected it with Lake Seneca, and in 1849 the first railroad (the Erie) reached it. It was chartered as a city in 1864, and by 1870 had a population of 15,863. Near the site of Elmira on Aug. 29, 1779, was fought the battle of Newtown, in which Gen. John Sullivan decisively defeated a force of Indians and Tories under Sir John Johnson and Joseph Brant. In 1861 a military camp was established here, and in 1864–65 there was a camp for Confederate prisoners. Mark Twain had a summer home ("Quarry Farm") near Elmira, and his grave is in Woodlawn Cemetery.

EL MORRO, a national reservation, technically known as a national monument, in the western part of Valencia county, New Mexico, U.S.A., and about 10 m. east of the Zuni Indian reservation. The reservation (240 ac. in area) was established to preserve an enormous sandstone rock eroded in the form of a castle, upon which inscriptions were placed by early Spanish explorers. It also contains cliff-dweller ruins of great historic, scenic and ethnologic interest.

ELMSHORN, a town of Germany, in the Prussian province of Schleswig-Holstein, on the Krückau, 19 m. by rail N.W. from Altona. Pop. (1925) 15,231. Its industries include weaving, dyeing, brewing, iron-founding and the manufacture of leather goods, boots and shoes, margarine, sugar and machines. There is a considerable shipping trade.

ELMSLEY, PETER (1773–1825), English classical scholar, was educated at Winchester and Christ Church, Oxford. He travelled extensively in France and Italy, and spent the winter of 1818 in examining the mss. in the Laurentian library at Florence. In 1823 he was appointed principal of St. Alban's Hall, Oxford, and Camden professor of ancient history. A man of extensive learning, Elmsley was considered the best ecclesiastical scholar in England; but he is chiefly famous for his work on the mss. of the Greek tragedians. He edited the *Acharnians* of Aristophanes and several of the plays and scholia of Sophocles and Euripides. He was the first to recognize the importance of the Laurentian mss. (*see* Sandys, *Hist. of Class. Schol.* iii., 1908).

ELNE, a town of south-western France in the department of Pyrénées-Orientales, 10 m. S.S.E. of Perpignan by rail. Pop. (1926) 3,172. The hill on which it stands, once washed by the sea, now over 3 m. distant, overlooks the plain of Roussillon. Elne, the ancient *Illiberis,* was named *Helena* by the emperor Constantine in memory of his mother. Hannibal encamped under its walls on his march to Rome in 218 B.C. The emperor Constans was assassinated there in A.D. 350. The town often changed hands between its capture by the Moors in the 8th century and its capitulation in 1641 to the troops of Louis XIII. From the 6th century till 1602 the town was the seat of a bishopric, which was transferred to Perpignan. The cathedral of St. Eulalie, early 12th century Romanesque, has a beautiful cloister in the same style, with interesting sculptures and three early Christian sarcophagi. There are remains of the ancient ramparts flanked by towers. Trade is in wine.

EL OBEID, chief town of the mudiria (province) of Kordofan, Anglo-Egyptian Sudan, and 230 m. S.W. by S. of Khartum; pop. about 17,000. It is situated about 2,000 ft. above the sea, at the northern foot of Jebel Kordofan, in 13° 11′ N. and 30° 14′ E. It is an important trade centre, and the southern terminus of the Sudan Government railway; the chief articles of commerce being gum, ivory, cattle and ostrich feathers. A considerable part of the trade of Darfur with Egypt passes through El Obeid.

El Obeid was garrisoned by the Egyptians on their conquest of Kordofan in 1821. In September 1882 the town was assaulted by the troops of the mahdi, to whom it capitulated on Jan. 17, 1883. During the Mahdia the city was destroyed and deserted, and when Kordofan passed, in 1899, into the possession of the Anglo-

Egyptian authorities nothing was left of El Obeid but a part of the old government offices. A new town was laid out in squares, the mudiria repaired and barracks built.

ELOI (Eligius), **SAINT** (588–659), bishop of Noyon and apostle of the Belgians and Frisians, was born at Cadillac, near Limoges. Trained as a goldsmith, he became coiner to Clotaire II., king of the Franks, and treasurer to his successor Dagobert. Both kings entrusted him with important artistic works, and though he was amassing great wealth, Eloi resolved to become a priest. He retired to a monastery, but in 640 was raised to the bishopric of Noyon. He made frequent missionary excursions to the Low Countries, where he founded many monasteries and churches. He died on Dec. 1, 659. St. Eloi is the patron saint of goldsmiths.

Migne's *Patrol. Lat.* vol. 87 contains his *Homilies* and his life written by his friend St. Ouen (Audoenus), French trans. Paris, 1626, 1847 and 1870. *See* also P. Parsy, *S. Eloi* (1907), and Potthast, *Bibliotheca hist. med. aevi* (Berlin, 1896).

ELONGATION, strictly, "lengthening"; in astronomy, the apparent angular distance of a heavenly body from its centre of motion, as seen from the earth; designating especially the angular distance of the planet Mercury or Venus from the sun, or the apparent angle between a satellite and its primary. The greatest elongation of Venus is about 45°; that of Mercury generally ranges between 18° and 27°.

EL PASO, a city in the extreme western corner of Texas, U.S.A., on the Rio Grande, opposite the Mexican city Juárez; a port of entry, the county seat of El Paso county and the largest city on the Mexican border. It is on Federal highways 80 and 366; and is served by the Santa Fe, the Southern Pacific, the Texas and Pacific and the Mexican North-western railways, and the National railways of Mexico. The population was 77,560 in 1920, of whom 30,769 were natives of Mexico; and was estimated by the census bureau at 113,500 in 1928. The city occupies 13 sq.m. on the mesas at the foot of Mt. Franklin, at an altitude of 3,752 ft., with the Organ, Hueco, Sacramento, Guadalupe and Sierra Madre ranges in the background. The climate is mild and dry, particularly beneficial in cases of pulmonary disease. In the architecture of both public and private buildings the early Spanish influence is apparent. The Mexican section is picturesque with gay shops and its adobe houses, many of which are over 100 years old. In 1916–17, following a survey of health and housing made for the chamber of commerce, 2,000 unsanitary *jacales* (community dwellings) in the Mexican quarter were razed by the health department. The court-house (completed 1917) contains a public auditorium seating 6,000, the county jail (on the top floor) and a roof garden. A fine high school and stadium was completed in 1915, at a cost of $1,000,000. The parks, covering 679 ac., include one of 43 ac. which is a memorial to the men who fell in the World War. A scenic driveway around Mt. Franklin (built in 1919) gives fine views of the city and the valley. A city plan is being developed in accordance with recommendations of a commission appointed in 1922. The assessed valuation of property in 1927 was $102,150,000.

Climate, cattle, copper and cotton are the chief foundations of El Paso's economic life. There are several large sanatoria in or near the city, including the William Beaumont general hospital of the U.S. army at Ft. Bliss; and it is estimated that 100,000 tourists visit the city annually for health or pleasure. The stockyards handle 400,000 head of live stock, and the trade in leather, hides, wool, mohair and fertilizers amounts to $70,000,000 annually. The principal manufacturing industry is the smelting of copper and lead ores from Mexico, New Mexico and Arizona, in one of the largest custom smelters of the world (just outside the city limits), which handles 500,000 tons of ore in a year. The output of the factories within the city was valued at $42,350,000 in 1927. There are extensive car shops, two meat-packing plants, a large cement plant, one of the largest wooden box factories in the country, many diversified smaller plants; and the introduction of cotton-growing in the valley has brought in the associated manufacturing industries—cotton gins and compresses, cotton-seed oil mills and a textile factory with over 5,000 spindles. El Paso is the centre of the Rio Grande reclamation project of 180,000 ac., for which water is supplied from the Elephant Butte reservoir (completed 1916). By 1927 about 138,000 ac. was under cultivation, producing crops valued at $12,000,000, of which about two-thirds was cotton. For this rapidly developing agricultural valley, and for the wide expanse of mining, grazing and lumbering regions within its trade territory, El Paso is the commercial and financial centre. A branch of the Federal Reserve Bank of Dallas is located here. Debits to individual accounts in the city's banks aggregated $387,393,501 in 1927. The foreign commerce of the El Paso customs district in 1927 amounted to $9,347,268 in imports and $11,572,709 in exports.

El Paso is the seat of the College of Mines of the University of Texas (established 1914), and of several private boarding-schools. Three miles north-east is Ft. Bliss, a cavalry post with a reservation of 2 sq.m., a garrison of 5,000 to 10,000 men, an Air Corps flying field (Biggs field), and a large base hospital. Juarez, across the river, is a colourful ancient city, with the oldest Spanish mission in this part of the country, Nuestra Señora de Guadalupe (established 1659). At Ysleta, 10 m. S.E., live the survivors of an ancient tribe of Pueblo Indians, and here is the second oldest mission of the region, Nuestra Señora del Carmen (established 1682).

The first European visitor of record to the site of El Paso was Cabeza de Vaca, in 1536. Other pioneers stopped here from time to time, and in 1659 the first permanent settlement was made. It was won from Mexico in the Texas War of Liberation in 1836. Before the Mexican War it was known as Ponce de Leon Ranch; afterwards, for a time, as Franklin. The name El Paso was adopted when the new town was plotted in 1858, perpetuating the Spanish phrase (*El paso del norte*) for the pass to the north formed here where the river breaks through the mountains. The city was incorporated in 1873, and in 1880 the population was 736. In 1881 four railroads rushed in their tracks in a race for the most favourable terminal site, and by 1890 the population was 10,338. In the next decade it increased 54%; between 1900 and 1910, 147%; between 1910 and 1920, 98%. A commission form of government was adopted in 1907.

ELPHINSTONE, MOUNTSTUART (1779–1859), Indian statesman and historian, fourth son of the 11th Baron Elphinstone in the peerage of Scotland, was born in 1779. Having received an appointment in the civil service of the East India Company, of which one of his uncles was a director, he reached Calcutta in the beginning of 1796. He was appointed in 1801 assistant to the British resident at Poona, at the court of the peshwa, the most powerful of the Mahratta princes. Here he obtained his first opportunity of distinction, being attached in the capacity of diplomatist to the mission of Sir Arthur Wellesley to the Mahrattas. When, on the failure of negotiations, war broke out, Elphinstone, though a civilian, acted as virtual aide-de-camp to General Wellesley and was present at the battle of Assaye. In 1804, when the war closed, he was appointed British resident at Nagpur. In 1808 he was appointed the first British envoy to the court of Kabul, with the object of securing a friendly alliance with the Afghans; but this proved of little value, because Shah Shuja was driven from the throne by his brother before it could be ratified. Elphinstone was appointed in 1810 to the difficult post of resident at Poona. The difficulty arose from the general complication of Mahratta politics, and especially from the weak and treacherous character of the peshwa. While the mask of friendship was kept up Elphinstone carried out a policy of vigilant quiescence with admirable tact and patience; in 1817 the mask was thrown aside and the peshwa ventured to declare war. The success of the British troops was chiefly owing to his assuming the command at an important crisis during the battle of Kirkee.

The peshwa being driven from his throne, his territories were annexed to the British dominions, and Elphinstone was nominated commissioner to administer them. He discharged the responsible task with rare judgment and ability. In 1819 he was appointed lieutenant-governor of Bombay and held this post till 1827, his principal achievement being the compilation of the "Elphinstone code." He may fairly be regarded as the founder

of the system of State education in India, and he did much towards the promotion of native education. His connection with the Bombay presidency was commemorated in the endowment of the Elphinstone college by the native communities, and in the erection of a marble statue by the European inhabitants.

Returning to England in 1829, after an interval of two years' travel, Elphinstone retained in his retirement an important influence on public affairs. He twice refused the offer of the governor-generalship of India. He wrote *Account of the Kingdom of Cabul and its Dependencies in Persia and India* (1815). His history of India (1841), embraces the Hindu and Mohammedan periods, and is still a work of high authority. He also published *The Rise of British Power in the East* (1858). He died on Nov. 20, 1859.

See J. S. Cotton, *Mountstuart Elphinstone* ("Rulers of India" series) (1892); T. E. Colebrooke, *Life of Mountstuart Elphinstone* (1884); and G. W. Forrest, *Official Writings of Mountstuart Elphinstone* (1884).

ELPHINSTONE, WILLIAM (1431–1514), Scottish statesman and prelate, founder of the University of Aberdeen, was born in Glasgow, and educated at the university. He was ordained priest, becoming rector of St. Michael's church, Trongate, Glasgow, in 1465. Four years later he went to continue his studies at the University of Paris, where he became reader in canon law, and then, proceeding to Orleans, became lecturer in the university there. Before 1474 he had returned to Scotland, and was made rector of the university, and official of the see of Glasgow. Elphinstone was made bishop of Ross in 1481. He was a member of the Scots parliament, and was sent by King James III. on diplomatic errands to Louis XI. of France, and to Edward IV. of England; in 1483 he was appointed bishop of Aberdeen, although his consecration was delayed for four years; and he was sent on missions to England, both before and after the death of Richard III. in 1485. Early in 1488 the bishop was made lord high chancellor, but on the king's death in the following June he vacated this office, and retired to Aberdeen. James IV. sent him on missions to the kings of England and France, and the German king, Maximilian I. He was made keeper of the privy seal in 1492.

The bishop's concluding years were mainly spent in the foundation of the University of Aberdeen. The papal bull for this purpose was obtained in 1494, and the royal charter which made old Aberdeen the seat of a university is dated 1498. A small endowment was provided by the king, and the university, modelled on that of Paris and intended principally to be a school of law, soon became the most famous and popular of the Scots seats of learning, a result which was largely due to the wide experience and ripe wisdom of Elphinstone and of his friend, Hector Boece, the first rector. The building of the college of the Holy Virgin in Nativity, now King's college, was completed in 1506, and the bishop also rebuilt the choir of his cathedral, and built a bridge over the Dee. Elphinstone opposed the policy of hostility towards England which led to the disaster at Flodden in Sept. 1513, and died in Edinburgh on Oct. 25, 1514. He was partly responsible for the introduction of printing into Scotland, and for the production of the *Breviarium Aberdonense*. He may have written some of the lives in this collection, and gathered together materials concerning the history of Scotland; but he did not, as some have thought, continue the *Scotichronicon*, nor did he write the *Lives of Scottish Saints*.

See Hector Boece, *Murthlacensium et Aberdonensium episcoporum vitae*, ed. and trans. J. Moir (Aberdeen, 1894); *Fasti Aberdonenses*, ed. C. Innes (Aberdeen, 1854); and A. Gardyne, *Theatre of Scottish Worthies and Lyf of W. Elphinston*, ed. D. Laing (Aberdeen, 1878).

EL RENO, a city of Oklahoma, U.S.A., near the North Fork of the Canadian river, 28m. W. by N. of Oklahoma City; the county seat of Canadian county. It is on Federal highways 66 and 81, and is served by the Oklahoma (electric) and the Rock Island railways. The population was 7,737 in 1920 (91% native white), and was estimated locally at 10,500 in 1928. It lies on a rolling prairie, 1,360ft. above sea-level, and is an important shipping point for poultry, cream and other farm products. Its industries include railroad shops, flour mills, washing machine and incubator factories. There is a Government boarding-school for Indians at Concho, 6m. north-west. Ft. Reno Remount Depot is 4m. north-west. A military post was established at Ft. Reno in 1876. The city was founded in 1889 and incorporated in 1892.

ELSFLETH, a maritime town of Germany, in the republic of Oldenburg, in a fertile district at the confluence of the Hunte with the Weser. Pop. (1925) 3,317. It is one of the centres of the North Sea herring fishery and has shipbuilding yards.

ELSHEIMER, ADAM (1579–1620), German painter, born in Frankfurt, son of Anthony Elsheimer, a well-to-do tailor. He studied under Phipp Uffenbach at Frankfurt. His early work betrays Flemish influence. The manner in which his figure subjects are staged in landscapes seems to suggest a connection with followers of Gillis van Coninxloo at Frankenthal. ("John the Baptist Preaching" in the Munich Pinakothek.) In 1598 Elsheimer worked under Johann Rottenhamer in Munich, and here first met with the classic tradition ("St. Paul at Lystra" in the Staedel at Frankfurt; and the "Fall of Troy" in Munich). He left for Italy soon afterwards, stayed in Venice, and in 1600 proceeded to Rome where he remained to the end of his life. He seems to have been successful for he enjoyed the patronage of church dignitaries and the friendship of Paul Brill and Rubens. His Italian pictures with landscapes, taken from the surroundings of Rome, were composed in the classic style, the colour being inspired by Venice. Pictures of this period are in most of the important museums of Europe. In his last works he seems to have followed Caravaggio both as regards the dark tonality and the treatment of figures. ("Ceres" at the Prado, Madrid.) At the end of his life he suffered from extreme dejection; but Sandrart's story of his debts is not altogether trustworthy.

He has been called one of the founders of modern landscape painting; for he broke away from tradition in his careful and minute study of nature. His pictures are small in size and are painted on copper. His backgrounds display distant views; the horizon is placed low in the picture. His interpretation is romantic. Moreover, in the rendering of light and atmosphere, he was a precursor of Rembrandt. ("Philemon and Baucis" at Dresden.) His influence on art was considerable. Many of his works were engraved by his friend and pupil, Hendrik Goudt. Pieter Lastman and Jan Pynas were among his followers. The Staedel at Frankfurt has a large collection of his drawings; he also executed some engravings.

See J. v. Sandrart, *Die Deutsche Akademie* (1768); David Passavant, "Adam Elsheimer," *Archiv für Frankfurts Geschichte und Kunst*, Heft 4, 8 (1847); W. v. Bode, "Adam Elsheimer," *Jahrbuch der Kgl. Pr. Kunstsammlungen I.* (1880).

ELSINORE (Dan. *Helsingør*), a seaport of Denmark on the east coast of the island of Zealand, 28 m. N. of Copenhagen. Pop. (1928) 15,100. It stands at the narrowest part of the Sound, opposite the Swedish town of Helsingborg, 3 m. distant. Railway communication is maintained by means of a train ferry. Helsingør received town privileges in 1425. In 1522 it was taken and burnt by Lübeck, but in 1535 was retaken by Christian II. It is celebrated as the Elsinore of Shakespeare's *Hamlet*. On a tongue of land east of the town stands the castle of Kronborg built by Frederick II. in Dutch Renaissance style and extensively restored by Christian IV. after a fire in 1637. It was taken by the Swedes in 1658, but returned to the Danes in 1660. It is now mainly used as a maritime museum. The town possesses also the Carmelite monastery St. Maria church, the old hospital, Marienlyst castle and the ruins of the castle of Eric of Pommern. Helsingør has an important shipyard, which, after the abolition of the Sound dues, has helped to bring prosperity to the town.

ELSSLER, FANNY (1810–1884), Austrian dancer, was born in Vienna on June 23, 1810. From her earliest years she was trained for the ballet, and made her appearance at the Kärntner-Thor theatre in Vienna before she was seven. She usually danced with her sister Theresa, who was two years her senior; and, after some years' experience together in Vienna, the two went in 1827 to Naples. Their success there—to which Fanny contributed most—led to an engagement in Berlin in 1830. This was the beginning of a series of triumphs for Fanny's personal beauty and

skill in dancing. After captivating all hearts in Berlin and Vienna, and inspiring the statesman Friedrich von Gentz (*q.v.*) with a remarkable passion, she visited London, where she received much kindness at the hands of Mr. and Mrs. Grote, who practically adopted the little girl who was born three months after the mother's arrival in England. In Sept. 1834 Fanny Elssler appeared at the Opera in Paris, a step to which she looked forward with much misgiving on account of Taglioni's supremacy there. The result was the temporary eclipse of Taglioni, who, although a finer artist, could not compete with the newcomer's personal charm. In her performance of the Spanish *cachucha* Fanny Elssler outshone all rivals. In 1845, having amassed a fortune from tours in America and in Europe, she retired from the stage and settled near Hamburg. Her sister Theresa contracted a morganatic marriage with Prince Adalbert of Prussia, and was ennobled under the title of Baroness von Barnim. Fanny Elssler died at Vienna on Nov. 27, 1884. Theresa was left a widow in 1873, and died on Nov. 19, 1878.

See A. Ehrharde, *Une vie de danseuse: Fanny Elssler* (1909).

ELSTER, the name of two rivers of Germany. (1) The Schwarze (Black) Elster rises in the Lausitz range, on the southern border of Saxony, flows north and north-west, and after a course of 112 m. enters the Elbe a little above Wittenberg. It is a sluggish stream, winding its way through sandy soil and frequently along a divided channel. (2) The Weisse (White) Elster rises in the north-western corner of Bohemia, a little north of Eger, cuts through the old hard rocks of the Vogtland in a deep and picturesque valley, passing Plauen and Greiz. Further downstream, round Gera and Zeitz, the scenery changes and for the rest of its course it meanders through lower and often sandy land. Above Leipzig it receives its chief tributary, the Pleisse. At Leipzig it divides, the main stream turning north-west and entering the Saale a little above Halle; the other arm, the Luppe, flowing parallel to the main stream and south of it enters the Saale below Merseburg. Total length, 121 m.; total descent, 1,286 ft.

ELSTER, a spa, in the republic of Saxony, on the Weisse Elster, close to the Bohemian frontier on the railway Plauen-Eger, and 20 m. S. of the former, has industries of lace-making and weaving, and a population of (1925) 3,368. The mineral springs, saline-chalybeate, have been supplemented by baths of various kinds, and these, together with natural attractions make the place a summer resort.

ELSWICK, ward, west parliamentary division, Newcastle-upon-Tyne, England. It contains the great ordnance and naval works of Sir W. G. Armstrong, Mitchell and Co., Elswick park.

EL TEB, a halting-place in the Anglo-Egyptian Sudan near the coast of the Red sea, 9 m. S.W. of the port of Trinkitat on the road to Tokar. There were two battles there in 1884. In the first, on Feb. 4, a heterogenous Egyptian force under Baker Pasha was destroyed by the Sudanese tribesmen under Osman Digna. In the second, on Feb. 29, a British force under General Graham partially avenged this disaster. For an account *see* EGYPT AND SUDAN CAMPAIGNS IN 1882–1899.

ELTON, CHARLES ISAAC (1839–1900), English lawyer and antiquary, was born at Southampton on Dec. 6, 1839. He was educated at Cheltenham and Balliol college, Oxford, and was called to the bar at Lincoln's inn in 1865. He had a large conveyancing practice, took silk in 1885, and was M.P. for West Somerset. He died at Whitestaunton on April 23, 1900. His literary work, like his practice, was mainly concerned with old English real property law and custom. His best-known works are *The Tenures of Kent* (1867); *Treatise on Commons and Waste Lands* (1868); *Law of Copyholds* (1874); *Origins of English History* (1882).

See a memoir by Andrew Lang, prefixed to Elton's *William Shakespeare, his Family and Friends* (1904).

ELTVILLE or **ELFELD,** town of Germany, in the Prussian province of Hesse-Nassau, on the right bank of the Rhine, 5 m. S.W. from Wiesbaden, on the railway Frankfort-on-Main-Cologne. Pop. (1925) 4,101. Eltville (originally *Adeldvile*, Lat. *Altavilla*), is first mentioned in a record of the year 882, was given by the emperor Otto I. to the archbishops of Mainz, and received town rights in 1331. In 1465 Gutenberg set up his press at Eltville, and several examples of printed books issued by this press survive, the earliest being the *Vocabularium Latino-Teutonicum*, first printed in 1467. Eltville was once capital of the Rheingau and has ruins of a feudal castle, and a monument to Gutenberg. It has a considerable trade in the wines of the district and two manufactories of sparkling wines.

ELTZ, a small river of Germany, a left bank tributary of the Mosel. It rises in the lower Devonian rocks of the Eifel range, and, after a swift course of 5 m., joins the latter river at Moselkern, nearly 20 m. S.W. of Coblenz. Just above its confluence stands the romantic castle of Eltz, crowning a rocky summit 900 ft. high, and famous as being one of the best preserved mediaeval strongholds of Germany. It is the ancestral seat of the counts of Eltz and contains numerous antiquities.

See Roth, *Geschichte der Herren und Grafen zu Eltz* (2 vols., 1889–90).

ELVAS, an episcopal city and frontier fortress of Portugal, 170 m. E. of Lisbon, and 10 m. W. of the Spanish fortress of Badajoz. Pop. (1920) 11,747. Elvas is finely situated on a hill 5 m. N.W. of the river Guadiana. It is defended by seven bastions and the two forts of Santa Luzia and Nossa Senhora da Graça. A fine aqueduct, 4 m. long, was begun early in the 15th century and completed in 1622. The surrounding lowlands are very fertile, and Elvas is celebrated for its excellent olives and plums. The fortress of Campo Maior, 10 m. N.E., is famous for its siege by the French and relief by the British under Marshal Beresford in 1811.

Elvas is the Roman *Alpesa* or *Helvas*, the Moorish *Balesh*, the Spanish *Yelves*. It was wrested from the Moors by Alphonso VIII. of Castile in 1166; but was temporarily recaptured before its final occupation by the Portuguese in 1226. It twice withstood sieges by the Spanish, in 1658 and 1711. The French under Marshal Junot took it in March 1808, but evacuated it in August, after the conclusion of the convention of Cintra (*see* PENINSULAR WAR).

ELVEY, SIR GEORGE JOB (1816–1893), English organist and composer, was born at Canterbury on March 27, 1816. He studied at the Royal Academy of Music under Cipriani Potter and Dr. Crotch. In 1834 he gained the Gresham prize medal for his anthem, "Bow down thine ear," and in 1835 was appointed organist of St. George's chapel, Windsor, a post which he filled for 47 years, retiring in 1882. He took the degree of Mus. B. at Oxford in 1838 and in 1840 that of Mus. D. Elvey, who was knighted in 1871, died at Windlesham in Surrey on Dec. 9, 1893. His works, which are nearly all for the Church, include two oratorios, a great number of anthems and services, and some pieces for the organ. A memoir of him, by his widow, was published in 1894.

ELVIRA, SYNOD OF, an ecclesiastical synod held in Spain, probably in 305 or 306, at Elvira, not far from or perhaps (Dale) identical with the modern Granada. There 19 bishops and 24 presbyters, from all parts of Spain, but chiefly from the south, assembled, probably at the instigation of Hosius of Córdova, with a view to restoring order and discipline in the Church. The 81 canons which were adopted reflect with considerable fulness the internal life and external relations of the Spanish Church of the 4th century. The social environment of Christians may be inferred from the canons prohibiting marriage and other intercourse with Jews, pagans and heretics, closing the offices of *flamen* and *duumvir* to Christians, forbidding all contact with idolatry and likewise participation in pagan festivals and public games. The state of morals is mirrored in the canons denouncing prevalent vices. The canons respecting the clergy exhibit the clergy as already a special class with peculiar privileges, a more exacting moral standard, heavier penalties for delinquency. The bishop has acquired control of the sacraments, presbyters and deacons acting only under his orders; the episcopate appears as a unit, bishops being bound to respect one another's disciplinary decrees. The following canons are worthy of special note: xxiii., enjoining celibacy upon all clerics and all who minister at the altar (the most ancient canon of

celibacy); xxxvi., forbidding pictures in churches; xxxviii., permitting lay baptism under certain conditions; and liii., forbidding one bishop to restore a person excommunicated by another.

See Dale, *The Synod of Elvira* (1882), an exhaustive monograph; Hennecke, art. "Elvira" in Herzog-Hauck, *Realencyklopädie;* Hefele, *History of Church Councils,* Eng. tr. vol. i., pp. 131 ff.; and the reference to the Spanish Church in the General Church Histories.

EL WAD, a town in the Southern region of Algeria, 125 m. in a straight line S.S.E. of Biskra, and 190 m. W. by S. of Gabes. Pop. 8,621. El Wad is one of the most interesting places in Algeria. It is surrounded by huge hollows containing noble palm groves (67,000 palms); and beyond these on every side stretches the limitless desert with its great billows of sand, the encroachments of which on the oasis are only held at bay by ceaseless toil. The town itself consists of a mass of one-storeyed stone houses, each surmounted by a little dome, clustering round the market-place with its mosque and minaret. El Wad oasis is one of a group known collectively as the Suf. Five miles N.W. is Kuinine (pop. 3,938) and 6 m. farther N.W. Guemar (pop. 6,798), an ancient fortified town noted for its manufacture of carpets with an important *Zaouïa* or convent of the order of Tidjaniya. Linen weaving is carried on extensively in the Suf. Administratively El Wad is the capital of an annex to the territory of Tuggurt.

ELWES, GERVASE CARY (1866–1921), English tenor singer, son of Valentine Cary Elwes, of Billing Hall, Northants., was born at Billing on Nov. 15, 1866, and educated at the Oratory school, Edgbaston, and Christ church, Oxford. In 1889 he married Lady Winefride Feilding, daughter of the 8th earl of Denbigh. In 1891 he was appointed to the diplomatic service, and became honorary attaché at Munich, and later at Vienna and Brussels. He studied music under Mandyczevski in Vienna, under Demest in Brussels, and under Bouhy in Paris. He entered the musical profession while still in the diplomatic service, which he finally abandoned in 1895. He made his first public appearances in 1903 at the Westmorland festival and at a concert of the Handel Society in London, subsequently achieving wide popularity at the hands of the most critical public. He took part in over 150 performances of *The Dream of Gerontius,* with which his name became indissolubly associated, while he excelled also in the interpretation of Bach. He was killed in an accident at Boston on Jan. 12, 1921, while on tour in the United States. The exceptional quality of the esteem which he enjoyed at the hands of the public was subsequently attested by the medallion erected to his memory in the Queen's hall, London.

ELWOOD, a city of Madison county, Ind., U.S.A., 48m. N.E. of Indianapolis. It is served by the Nickel Plate, the Union Traction of Indiana and the Pennsylvania railways. The population was 10,790 in 1920 (96% native white) and was estimated locally at 12,000 in 1928. It is an important shipping point for grain and live stock, and has large tinplate works, glass factories and various other manufacturing industries. The total factory output in 1925 was valued at $14,620,498. Elwood was settled in 1852 and was chartered as a city in 1891. Until 1869 it was known as Quincy. Between 1890 and 1900 the population grew from 2,284 to 12,950, following the discovery of natural gas. Failure of the supply in 1903 caused a temporary decline in the amount of manufacturing and consequently in the population.

ELY, a cathedral city and market-town, in the administrative and parliamentary county of the Isle of Ely, England, 14¾ m. N.N.E. of Cambridge by the L.N.E. railway. Pop. of urban district (1921) 7,690. Ely stands on a considerable eminence on the west bank of the Ouse, in the Isle which rises above the surrounding fens. The cathedral, towering above the town, is a landmark far over the surrounding level. It is at the junction of a network of railway branch lines (to Huntingdon, Peterborough, Norwich and Newmarket), and by means of the Ouse and the Cam has a wide inland navigation. The soil in the vicinity is fertile and market-gardening is carried on. A large beet sugar factory was erected in 1925. St. Mary's parish church ranges in style from Norman to Perpendicular, but in the main represents the Early English structure of Bishop Eustace (d. 1215). Holy Trinity church, formerly the Lady chapel of the cathedral (*see* below), on the north side of the choir, has served as a parish church since 1566. The public buildings include the shire hall and the corn exchange. The grammar school, known as The King's school, founded by Henry VIII. in 1541, and now enlarged and modernized, includes the old gatehouse of the monastery, known as the Porta, and the chapel built by Prior John de Cranden (1321–1341). Among the other educational institutions are Needham's school, founded in 1734, the Cathedral Choristers' school (1862) and a theological college founded in 1876 and opened in 1881.

History.—The architectural foundations of the present cathedral were laid by its first Norman abbot, Simeon (1081–94). But the reputation of Ely had been established long before, when Etheldreda (Aethelthryth), daughter of Anna, king of East Anglia, and wife to Ecgfrith, king of Northumbria, founded a religious house here, in all probability a mixed community, in 673, becoming its first abbess, and giving the whole Isle of Ely to the foundation. In 870 the monastery was destroyed by the Danes, as were also the neighbouring foundations at Soham, Thorney, Crowland and Peterborough. It remained in ruins till 970, when Aethelwold, bishop of Winchester, founded a new Benedictine monastery here. King Edgar in 970 endowed the monks with the former possessions of the convent, and also granted them the secular causes of certain lands within and without the marshes and certain other privileges and revenues in the province of Grantecestre. The wealth and importance of Ely rose, and its abbots held the post of chancellors of the king's court alternately with the abbots of Glastonbury and of St. Augustine's, Canterbury. In the struggle against William the Conqueror, of which Hereward "the Wake" was the hero, Ely again became a scene of contest. Finally, in 1071, the monks agreed to surrender the Isle of Ely to the king on condition of the confirmation of all the possessions and privileges held by them in the time of Edward the Confessor. Abbot Simeon, who now began the reconstruction of the church, was related to William and brother to Walkelin, first Norman bishop of Winchester. Under Abbot Richard (1100–07) the translation from the Saxon church of the bodies of St. Etheldreda and the two abbesses who had followed her, and their enshrinement in the new edifice, took place. The feast of St. Etheldreda, or St. Awdrey as she was generally called, was the occasion every year for a large fair at which "trifling objects" were sold to pilgrims by way of souvenirs; whence the word "tawdry," a contraction of St. Awdrey. In 1108–09 the Isle of Ely, most of Cambridgeshire and the abbeys of Thorney and Cetricht were separated from the diocese of Lincoln, and converted into a new diocese, Ely being the seat of the bishopric. After the Dissolution of the monasteries Henry VIII. converted the conventual church into a cathedral (1541), granting to the dean and chapter the cathedral with its revenues and precincts. The diocese was enlarged in 1837 and 1839, and until recently covered nearly the whole of Cambridgeshire, Huntingdonshire and Bedfordshire, part of Suffolk, and small portions of Essex, Norfolk, Northamptonshire, Hertfordshire and Buckinghamshire. But in 1913 Bedfordshire was transferred to St. Albans and West Suffolk to St. Edmundsbury and Ipswich, and the diocese now includes Cambridgeshire, Huntingdonshire and certain parishes in Norfolk.

Cathedral.—The cathedral is a cruciform structure, 537 ft. long and 190 ft. across the great transepts (exterior measurements). A relic of the Saxon foundation is preserved in the cross of St. Osyth (*c.* 670), and a pre-Norman window is preserved in the triforium, which was unearthed near the cathedral. The nave, which is Norman throughout, is 208 ft. in length, 72 ft. 9 in. to the top of the walls, and 77 ft. 3 in. broad, including the aisles. The great western tower and the transept, which are also Norman, were completed in the 12th century. The tower, which is 215 ft. high, is surmounted by a Decorated octagon with partly detached side turrets, and underwent alteration and strengthening in the Perpendicular period. The Galilee, or western porch, by which the cathedral is entered, is the work of Bishop Eustace, and is a perfect example of Early English style. In 1322 the Norman central tower, erected by Abbot Simeon, fell. Alan of Walsing-

ham, sacrist of the church, designed its restoration (1322–28) in the form of the present Decorated octagon, a beautiful and unique conception. Instead of the ordinary four-arched central crossing, an octagon is formed at the crossing, the arches of the nave aisles and choir aisles being set obliquely, while upon the ribbed vaulting of wood above it rose the lofty lantern, octagonal also, with its angles set opposite those of the octagon below. The total height is 170 ft. 7 in. Under Bishop John of Hotham (1316–37) the Lady chapel, a beautiful example of Decorated work, was also begun in 1321. It is attributed to John Wisbech, a monk, working under Alan de Walsingham, and was completed in 1349. Of the seven bays of the choir the four easternmost (as well as the two beyond forming the retrochoir) had been built by Bishop Hugh of Northwold (d. 1254), and the three western bays which were destroyed by the fall of the tower were now rebuilt by Bishop Hotham and completed by his successors. The earlier portion is a superb example of Early English work, while the later is perhaps the best example of pure Decorated in England; the elaborate choir stalls are attributed to Richard de Saxmundham (1338–46). The Perpendicular style is represented by the windows of the aisles and certain other details. There are also some splendid tombs, like that of Bishop John Redman (d. 1505), and the two chapels of Bishop John Alcock (d. 1500) and Bishop Nicolas West (d. 1534) in this style. Among earlier monuments the canopied tomb of Bishop William de Luda (1290–98) and the finely-carved effigy of Bishop Northwold (1254) are notable. Between 1845 and the end of the century, the cathedral underwent restoration. The work included the erection of the modern reredos and choir-screen, both designed by Sir G. Scott, and the painting of the nave roof by Styleman le Strange (d. 1862), who was succeeded by Gambier Parry. Parry also richly ornamented the octagon and lantern in the style of the 14th century.

Of the remains of the monastic buildings. mention has been made of the Ely "Porta" and of Prior John's beautiful chapel. But many of the remains, the bulk of which are incorporated in the deanery and canons' and other residences, are of much earlier date, such as the Norman undercroft of the prior's hall and the notable transitional Norman chancel of the infirmary chapel. The remnants of the cloisters show a 15th century reconstruction; but the prior's and monks' doorways from the cloisters into the cathedral are decorated late Norman. The bishop's palace has towers erected by Bishop Alcock. In the muniment room of the chapter is preserved the *liber Eliensis*, a history of the monastery by the monk known as Thomas of Ely (d. *c.* 1174), of which the first part, which extends to the year 960, contains a life of St. Etheldreda, while the second is continued to the year 1107.

Ely, which according to Bede (*Hist. eccl.* iv. 19) derives its name from the quantity of eels in the waters about it, was a borough by prescription at least as early as the reign of William the Conqueror. For a long time the abbot, and afterwards the bishop, had almost absolute power in the town. The bailiff who governed the town was chosen by the bishop until 1850, when a local board was appointed. Richard I. granted the bishop of Ely a fair there, and in 1319–20 Bishop Hotham received license to hold a fair. The markets are claimed by an undated charter by the bishop, who also continues to hold the fairs. In 1295 Ely sent two members to parliament, but was not represented thereafter. It was constituted an urban district under the Local Government act of 1894.

See C. W. Stubbs, *Ely Cathedral* (1897); *Victoria County History, Cambridgeshire.*

ELY, a city of St. Louis county, Minnesota, U.S.A., on Long lake, 117m. N. by E. of Duluth, at the entrance to the Superior national forest. It is served by the Duluth and Iron Range railroad, and is the northern terminus for motor travel in the "Arrowhead country." The population was 4,902 in 1920 (37% foreign-born white) and was estimated locally at 6,000 in 1928. There are five underground iron mines, employing 1,500 men the year round. The city is a centre for tourists and sportsmen, situated as it is in the midst of millions of acres of primeval wilderness and surrounded by a network of beautiful lakes. It is headquarters of the Superior national forest service. Ely was settled about 1886 and was incorporated in 1891.

ELYOT, SIR THOMAS (*c.* 1490–1546), English diplomat and scholar. His father was Sir Richard Elyot, judge of common pleas. The date and place of his birth are not known. Nor is the place of his education; both St. Mary Hall, Oxford and Jesus college, Cambridge, claim him, while he himself says in the preface to his *Dictionary* that he was educated at home, and from the age of 12 taught himself. In 1511 he accompanied his father as clerk of assize on the western circuit; later Wolsey made him clerk to the Privy Council. In 1530 he was displaced and knighted. He married Margaret Barrow, a student in the "school" of Sir Thomas More, and his known friendship with More was afterwards a bar to his advancement. In 1531 he produced the *Boke named the Governour,* dedicated to Henry VIII. The same year he was sent to the court of Charles V. to further Henry's divorce from Catherine of Aragon, and to attempt to catch William Tyndale. He served on the commission on the monasteries and on a second embassy to Charles V. in 1535. In 1542 he represented Cambridge in parliament. He died at Carleton in Cambridgeshire on March 26, 1546. The *Boke named the Governour* is a treatise on moral philosophy for the education of princes, and contains many classical quotations. It was very popular. He acknowledges his debt to Erasmus's *Institutio Principis Christiani,* but does not mention Patrizzi's *De regno et regis institutione,* on which his book was modelled. In 1534 he produced the *Castell of Helth,* a popular treatise on medicine, ridiculed by the doctors, but widely read. His *Latin Dictionary,* the first complete one in English, was finished in 1535, and edited and enlarged by Thomas Cooper, Bishop of Winchester, in 1548.

Elyot's translations include:—The *Doctrinal of Princes* (1534), from Isocrates; *Cyprianus, A Swete and Devoute Sermon of Holy Saynt Ciprian of the Mortalitie of Man* (1534); *Rules of a Christian Life* (1534), from Pico della Mirandola; *The Education or Bringing up of Children* (*c.* 1535), from Plutarch; and *Howe one may take Profite of his Enymes* (1535), from the same author is generally attributed to him. He also wrote: *The Knowledge which maketh a Wise Man* and *Pasquyll the Playne* (1533); *The Bankette of Sapience* (1534), a collection of moral sayings; *Preservative agaynste Deth* (1545), which contains many quotations from the Fathers; *Defence of Good Women* (1545). His *Image of Governance, compiled of the Actes and Sentences notable of the most noble Emperor Alexander Severus* (1540) professed to be a translation from a Greek MS. of the emperor's secretary Encolpius (or Eucolpius, as Elyot calls him), which had been lent him by a gentleman of Naples, called Pudericus, who asked to have it back before the translation was complete. In these circumstances Elyot, as he asserts in his preface, supplied the other maxims from different sources. He was violently assailed by Humphrey Hody and later by William Wotton for putting forward a pseudo-translation; but Mr. H. H. S. Croft has discovered that there was a Neapolitan gentleman at that time bearing the name of Poderico, or, Latinized, Pudericus, with whom Elyot may well have been acquainted. Roger Ascham mentions his *De rebus memorabilibus Angliae;* and Webbe quotes a few lines of a lost translation of the *Ars poëtica* of Horace.

A learned edition of the *Governour* (2 vols., 1880), by H. H. S. Croft, contains, besides copious notes, a valuable glossary of 16th century English words.

ELYRIA, a city of northern Ohio, U.S.A., on the Black river, 8m. S. of Lake Erie and 25m. W.S.W. of Cleveland; the county seat of Lorain county. It is on Federal highway 20, and is served by the Baltimore and Ohio and the New York Central railways, and by inter-urban trolley and motor bus lines. The population was 20,474 in 1920 (16% foreign-born white); was estimated locally at 27,000 in 1928, and 32,000 including immediate suburbs. The city has an altitude of 720ft., and lies at the junction of the east and west branches of the Black river, each of which falls about 40ft. here, in beautiful Cascade park. There are numerous and varied manufactures, including laces, furnaces and heaters, invalid chairs, alloys, hosiery, motors, fishing tackle, chemicals, portable cranes, golf balls, automobiles, cold rolled steel, seamless pipe, marine and stationary engines and radios. The aggregate output in 1925 was valued at $26,187,397. In 1816 Heman Ely of Massachusetts visited land owned by his father in the Connecticut Western Reserve, and contracted for the building of a grist-mill, a saw-mill and a cabin. He returned the next March with skilled workmen and labourers, took possession of the cabin, and called the town Elyria. It was selected for the county seat in 1823, and was chartered as a city in 1892.

ELYSIUM or the Elysian Plain, or Fields, the pre-Hellenic paradise, identified by the Greeks with their own Islands of the Blessed. In Homer (*Od.*, iv. 563) the Elysian Plain is a land of perfect happiness, ruled by Rhadamanthys, at the end of the earth, on the banks of the river Oceanus. Much the same description is given by Hesiod (*Works and Days*, 167) of the Islands of the Blessed. In Pindar (*Olymp.*, ii. 67 et seq., frags. 129, 130, von Christ) Rhadamanthys and Cronus (who is mentioned also in a doubtfully genuine line in Hesiod, *loc. cit.*) rule there. In the earlier authors, only those specially favoured of the gods enter; and, in Homer, they are carried there body and soul and made immortal. In Hesiod it is already a place for the blessed dead, and, from Pindar on, entrance is gained by a righteous life, a conception partly at least due to Orphism. In later authors, such as Virgil (*Aen.*, vi. 637 et seq.), Elysium is part of Hades; originally it has nothing to do with it.

For fuller discussion, *see* especially E. Rohde, *Psyche*, and A. Dieterich, *Nekyia*.

ELZE, KARL (1821–1889), German scholar and Shakespearian critic, was born at Dessau on May 22, 1821. He studied at Leipzig and in 1875 was appointed extraordinary, and in 1876 ordinary professor of English philology at the university of Halle, where he died on Jan. 21, 1889. Elze's most important works are: his biographies of Walter Scott, Byron and Shakespeare; *Abhandlungen zu Shakespeare* (Eng. trans. by D. Schmitz, *Essays on Shakespeare*, 1874), and the excellent treatise, *Notes on Elizabethan Dramatists with conjectural emendations of the text* (3 vols., Halle, 1880–86, new ed. 1889).

ELZEVIR, the name of a family of Dutch printers belonging to the 17th century. The original name was Elsevier, or Elzevier, and their French editions mostly retain this name; but in their Latin editions the name is spelt Elzeverius, gradually corrupted in English into Elzevir. Louis (1540–1617), who first made the name Elzevir famous, was born at Louvain. Compelled in 1580, on account of his Protestantism and his adherence to the cause of the insurgent provinces, to leave his native country, he established himself as bookbinder and bookseller in Leyden. The earliest Elzevir is now known to be *Drusii Ebraicarum quaestionum ac responsionum libri duo*, produced in 1583. In all he published about 150 works. Of his five sons, Matthieu, Louis, Gilles, Joost and Bonaventure, Bonaventure, who was born in 1583, is the most celebrated. He began business as a printer in 1608, and in 1626 took into partnership Abraham, a son of Matthieu. Both died in 1652. The fame of the Elzevir editions rests chiefly on the works issued by this firm. Their Greek and Hebrew impressions are inferior to those of the Aldi and the Estiennes, but their small editions in 12mo, 16mo and 24mo, for elegance of design, neatness, clearness and regularity of type and beauty of paper, cannot be surpassed. Especially may be mentioned the two editions of the New Testament in Greek, published in 1624 and 1633, of which the latter is the more beautiful and the more sought after; the *Psalterium Davidis*, 1653; *Virgilii opera*, 1636; *Terentii comediae*, 1635; but the works which gave their press its chief celebrity are their collection of French authors on history and politics in 24mo, known under the name of the *Petites Républiques*, and their series of Latin, French and Italian classics in small 12mo. Jean, son of Abraham, born in 1622, had since 1647 been in partnership with his father and uncle, and when they died Daniel, son of Bonaventure, born in 1626, joined him. Their partnership did not last more than two years, and after its dissolution Jean carried on the business alone till his death in 1661. In 1654 Daniel joined his cousin Louis (the third of that name), who had established a printing press at Amsterdam in 1638. From 1655 to 1666 they published a series of Latin classics in 8vo, *cum notis variorum; Cicero* in 4to; the *Etymologicon linguae Latinae;* and a magnificent *Corpus juris civilis* in folio, 2 vols., 1663. The last representatives of the Elzevir printers were Peter, grandson of Joost, and Abraham, son of the first Abraham, who from 1681 to 1712 was university printer at Leyden.

Some of the Elzevir editions bear no other typographical mark than simply the words *Apud Elzeverios*, or *Ex officina Elseveriana*, under the *rubrique* of the town. But the majority bear one of their special devices, four of which are recognized as in common use. Louis Elzevir, the founder of the family, usually adopted the arms of the United Provinces, an eagle on a cippus holding in its claws a sheaf of seven arrows, with the motto *Concordia res parvae crescunt*. About 1620 the Leyden Elzevirs adopted a device, known as "the solitary," and consisting of an elm tree, a fruitful vine and a man alone, with a motto *Non solus*. They also used another device, a palm tree with the motto, *Assurgo pressa*. The Elzevirs of Amsterdam used for their principal device a figure of Minerva with owl, shield and olive tree, and the motto, *Ne extra oleas*. The earliest productions of the Elzevir press are marked with an angel bearing a book and a scythe, and various other devices occur. When the Elzevirs did not wish to put their name to their works they generally marked them with a sphere, but the fact that a work printed in the 17th century bears this mark is no proof that it is theirs. The total number of works of all kinds which came from the presses of the Elzevirs is given by Willems as 1,608; there have also been many forgeries.

See Alphonse Willems, *Les Elzévier* (1880), with a history of the Elzevir family and their printing establishments, a chronological list and detailed description of all works printed by them, their various typographical marks, and a plate illustrating the types used by them; Kelchner, *Catalogus librorum officinae Elsevirianae* (1880); Frick, *Die Elzevirschen Republiken* (Halle, 1892); Berghman, *Etudes sur la bibliographie Elzévirienne* (Stockholm, 1885), and *Nouvelles études, etc.* (*ib.* 1897). *See* H. B. Copinger, *The Elzevier Press* (London, 1927).

EMANATION, in philosophy and theology, the name of one of the three chief theories of the relation between God and men—the One and the Many, the Universal and the Particular (Lat. *emanatio*, from *e-*, out, *manare*, to flow). This theory has been propounded in many forms, but the central idea is that the universe of individuals consists of the "outpourings" of the ultimate divine essence. That essence is not only all-inclusive, but absolutely perfect, while the "emanated" individuals degenerate in proportion to their distance from the essence. The existence of evil in opposition to the perfect goodness of God, as thus explained, need not be attributed to God's agency, inasmuch as the whole emanation-process is governed by necessary laws, which may be compared to those of the physical universe. The doctrine of emanation is thus to be distinguished from the cosmogonic theory of Judaism and Christianity, which explains human existence as due to a single creative act of a moral agent. The God of Judaism and Christianity is essentially a *person* in close *personal* relation to his creatures; emanation is the denial of personality both for God and for man. The emanation theory is to be contrasted, on the other hand, with the theory of evolution. The two theories are alike in so far as both recognize the existence of individuals as due to a necessary process of differentiation and a scale of existence. They differ, however, fundamentally in this respect, that, whereas evolution regards the process as from the lower towards the higher, emanation regards it as from the higher to the lower.

There is considerable superficial similarity between evolution and emanation, especially in their formal statements. The process of evolution from the indeterminate to the determinate is often expressed as a progress from the universal to the particular. Thus the primordial matter assumed by the early Greek physicists may be said to be the universal substance out of which particular things arise. The doctrine of emanation also regards the world as a process of particularization. Yet the resemblance is more apparent than real. The universal is, as Herbert Spencer remarked, a subjective idea, and the general forms, existing *ante res*, which play so prominent a part in Greek and mediaeval philosophy, do not in the least correspond to the homogeneous matter of the physical evolutionists. The one process is a logical operation, the other a physical. The theory of emanation, which had its source in certain moral and religious ideas, aims first of all at explaining the origin of mental or spiritual existence as an effluence from the divine and absolute spirit. In the next place, it seeks to account for the general laws of the world, for the universal forms of existence, as ideas which emanate from the Deity. By some it was developed into a complete philosophy

of the world, in which matter itself is viewed as the lowest emanation from the absolute. In this form it stands in sharp antithesis to the doctrine of evolution, both because the former views the world of particular things and events as essentially unreal and illusory, and because the latter, so far as it goes, looks on matter as eternal, and seeks to explain the general forms of things as we perceive them by help of simpler assumptions. In certain theories known as doctrines of emanation, only mental existence is referred to the absolute source, while matter is viewed as eternal and distinct from the divine nature. In this form the doctrine of emanation approaches certain forms of the evolution theory (*see* EVOLUTION).

The doctrine of emanation is correctly described as of oriental origin. It appears in various forms in Indian philosophy, and is the characteristically oriental element in syncretic systems like Neoplatonism and Gnosticism. None the less it is easy to find it in embryo in the speculations of the essentially European philosophers of Greece. Plato, whose philosophy was strongly opposed to the evolution theory, distinctly inclines to the emanation idea in his doctrine that each particular thing is what it is in virtue of a pre-existent idea, and that the particulars are the lowest in the scale of existence, at the head of, or above, which is the idea of the good. The view of Xenocrates is based on the same ideas. Or again, we may compare the Stoic doctrine of **ἀπόρροιαι** (literally "emanations") from the divine essence. It is, however, only in the last eclectic period of Greek philosophy that the emanation doctrine was definitely established in the doctrines, *e.g.*, of Plotinus.

See especially articles EVOLUTION, NEOPLATONISM, GNOSTICISM.

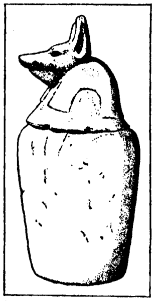
EMANUEL I. (Portuguese *Manoel*) (1469–1521), 14th king of Portugal, surnamed the "Great" and the "Happy" knight of the Garter and of the Golden Fleece, was the son of Duke Ferdinand of Vizeu and of Beatrice of Beja, grandchildren of John I. of Portugal. His reign (1495–1521) is noteworthy for Vasco da Gama's opening an all-sea route to India, Cabral's landing in Brazil, Corte-Real's voyage to Labrador, the exploration of the Indian seas and the opening of commercial relations with Persia and China. He also appointed Albuquerque viceroy of the Portuguese possessions in India. His intense religious zeal manifested itself in his persecutions of the Jews and in endeavours to promote a crusade against the Turks, in his missionary enterprise throughout his new possessions, and in his erection of 26 monasteries and two cathedrals, including the stately monastic church of the Jeronymos at Belem. He was married three times, to Isabella, daughter of Ferdinand and Isabella of Castile, to her sister Maria, and then to Leonora, sister of the emperor Charles V. By Maria he had two sons, John and Henry, both of whom became kings of Portugal.

The best authorities for the history of Emanuel's reign are the contemporary 16th century *Chronica d' el Rei D. Manoel,* by Damião de Goes, and *De rebus Emanuelis,* by J. Osorio. *El Rei D. Manoel,* by M. B. Branco (Lisbon, 1888), is a valuable but ill-arranged biography. *See* also the *Ordenações do S.R.D. Manoel* (Coimbra, 1797). For further bibliography *see* Barbosa Machado, *Bibliographica Lusitana,* vol. iii. pp. 161–166.

EMAUS, a borough of Lehigh county, Pa., U.S.A., on the Reading railroad, 6m. S. of Allentown. The population was 4,370 in 1920 (95% native white).

EMBALMING, the art of preserving dead bodies from decay. The custom of embalming had its origin in Egypt, probably as early as the 1st Dynasty. As practised by the Egyptians and other peoples of antiquity and by modern races of relatively low culture, embalming is usually spoken of as "mummification." The art was probably suggested by the natural preservation of bodies buried in predynastic times in the desert sands in Egypt. Bodies so inhumed survive to-day in a wonderful state of preservation owing to the total exclusion of air and moisture by contact with the sand. The adoption of more elaborate funerary offerings necessitated roomier graves, and bodies were thus no longer covered with sand but exposed to air and consequently decomposed. This led to the attempt to achieve by art that which unaided nature accomplished in simple sand-burials. Embalming in Egypt reached a high stage of development, its greatest elaboration being accomplished at the time of the 21st Dynasty (*see* MUMMY). The practice survived in Egypt until the Byzantine period, and throughout its long career the embalmers had two objects in view: the preservation of the body from decay and the perpetuation of the personal identity of the deceased. The motive was a belief in the physical survival of the dead.

Outside Egypt embalming has a wide geographical distribution, and in many places it has survived until recent times, although it is everywhere tending to disappear. The Guanches of the Canary Islands mummified their dead in a manner closely resembling that of the Egyptians, and there are traces of the custom, or debased survivals of it, in many parts of the African continent. In Indonesia, Australia, Melanesia, and Polynesia embalming in various forms has been practised principally for chiefs and persons of importance, the best preserved mummies being those of the Torres Straits Islands. In North, Central, and South America mummies have been found, many specimens having been discovered in ancient sites, particularly those of the Inca civilization.



BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

EGYPTIAN CANOPIC JAR IN WHICH INTESTINES OF EMBALMED WERE PLACED

References to embalming occasionally occur in classical literature. Herodotus (ii. 85–88), Diodorus Siculus (i. 91), Plutarch (*De carn. esu* and *Sept. Sap. Conv.* xvi.), Porphyry (*De Abst.* iv. 10), Plato (*Phaedo* xxix.), Lucian (*De Luctu*), Strabo (xvi. 2, 45), Cicero (*Tuscul. Disp.* i.), and others, mention Egyptian embalming. Herodotus also mentions methods practiced by the Persians (i. 140), the Ethiopians (iii. 24) and the Scythians (iv. 71). Tacitus (*Annals,* xvi. 6) states that Nero's wife was embalmed "according to the manner of foreign kings"; Statius (*Silv.* iii. 2, 117) affirms that the body of Alexander the Great was embalmed with honey, and the same material was employed to conserve the corpse of Agesipolis I. during its conveyance to Sparta for burial, according to Emilius Probus and Cornelius Nepos. The early Christian writers inveigh against the custom of embalming as a pagan usage (*e.g.,* Augustine, *De Diversis,* xii. Serm. 120).

Embalming was occasionally practised in Europe during the middle ages. Thus in 1135 the body of Henry I. was embalmed by a method recalling that of the Egyptians: incisions were made in the body, the viscera removed, and aromatic substances were introduced into the vacant body-cavity. Although in the meantime embalming was often practised, it was not until the end of the 17th century that any real scientific research into the matter had been made. The methods of embalming devised by Ruysch of Amsterdam (1665–1717) and others, arose out of experiments made to discover a satisfactory means of preserving anatomical preparations. Numerous methods, each claiming perfection, were propounded during the 18th and 19th centuries: the substances used included essential oils, alcohol, camphor, pitch, salt, and corrosive sublimate. Gypsum was also used as a dehydrating agent.

Embalming is declining mainly owing to the rapid growth of cremation. Modern embalming is accomplished by the injection of drugs into the vascular system without removing any organs (*see* MUMMY).

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EMBANKMENT. In engineering, generally, a mound or bank of earth, stone, or other material, usually narrow in comparison with its length, artificially raised above the prevailing level of the ground. Embankments may form parts of works or structures of varied character but usually serve for one or other of two main classes of purpose. On the one hand, they are used to preserve the level of railways (*q.v.*), roads, canals, and cause-

ways in cases where a valley or piece of low lying ground has to be crossed. In such circumstances they are commonly of earth suitably consolidated and drained. Embankments are also constructed for carrying railways and roads over marsh land or land liable to flooding, and, in some cases, over the shallow beds of lakes and seas: *e.g.*, the railway across the Great Salt Lake in Utah and that joining the mainland with the Florida Keys (*q.v.*). When formed on marsh land it is often necessary to make special provision to prevent or minimize sinking. A problem which frequently has to be considered by the railway engineer and the roadmaker is the relative economy of constructing an embankment or, its usual alternative, a viaduct.

On the other hand embankments are employed, in varied forms and circumstances, to stop or limit the flow of water, for instance: (a) For confining a river, canal, or other water course within fixed limits (*see* CANALS AND CANALIZED RIVERS; RIVER ENGINEERING; AQUEDUCT). (b) In fen or marsh lands to prevent flooding or to form the sides of drainage channels or ditches raised above the general level of the land. In the Fens (*q.v.*) they are known as "banks" and the men employed in constructing and maintaining them as "bankers." (c) On the sea coast or in estuaries for the purpose of coast protection (*q.v.*) and land reclamation, in some cases combined with a wall. Such embankments are sometimes referred to as sea-walls irrespective of their form. (d) For retaining water in a reservoir (*q.v.*) or for raising the water level of a lake when they are more usually described as "earth-dams" (*see* DAM).

Puddled clay, curtain walls of concrete, and steel sheet piling are frequently utilized in the construction of embankments when it is necessary to secure watertightness, and in most uses of embankments to limit or stop the flow of water some form of protection of the face of the work against erosion is required such as covering it with stone, slag, or concrete.

The word embankment has come to be used in particular instances for the mass of material, faced and supported by a stone or concrete wall, placed along the banks of a river where it passes through a city, whether to guard against floods or to gain additional space. Such is the Thames Embankment in London, which carries a broad roadway. In this sense an embankment is distinguished from a quay, though the structural form may be similar, the latter word being confined to places where ships are loaded and unloaded, thus differing from the French *quai* which is used both of embankments and quays, *e.g.*, the *Quais* along the Seine at Paris. In Holland (*q.v.*) the term *dike* is applied to any embankment designed to limit the flow of water. (N. G. G.)

EMBARGO may be either civil or hostile. Civil embargo is the restraint placed by a sovereign upon his own subjects, by prohibiting them or their vessels from leaving the realm. This measure was taken by the United States in retaliation for the Berlin and Milan Decrees of Napoleon of 1806 and 1807, and the British Orders in Council of 1807 and 1809, declaring interdiction of all intercourse with their respective subjects or the subjects of their allies on the part of neutrals. An embargo was consequently laid upon all American shipping by the president. Hostile embargo is the seizure and detention by the sovereign of one State of the subjects and property of another State with a view to obtain redress for some injury by exercising pressure on the latter State. If such seizure leads to war the embargo becomes retroactive, and the persons and property—usually merchant vessels and their crews—become tainted *ab initio* as enemy persons and property. In either case embargo is an act short of war. The seizure and detention of enemy ships lying in its ports by a belligerent on the outbreak of war is not within the meaning of the term.

See ANGARY; PACIFIC BLOCKADE; REPRISALS; RETORTION; WAR. (H. H. L. B.)

EMBASSY, the office of an ambassador, or, more generally, the mission on which an ambassador of one Power is sent to another, or the body of official personages attached to such a mission, whether temporary or permanent. The word is also used of the official residence of an ambassador. (*See* further AMBASSADOR, EXTERRITORIALITY, and DIPLOMACY.)

EMBER DAYS and **EMBER WEEKS,** the four seasons set apart by the Western Church for special prayer and fasting, and the ordination of clergy, known in the mediaeval Church as *quatuor tempora*, or *ieiunia quatuor temporum*. The Ember weeks are the complete weeks next following Holy Cross day (September 14), St. Lucy's day (December 13), the first Sunday in Lent and Whit Sunday. The Wednesdays, Fridays and Saturdays of these weeks are the Ember days distinctively, the following Sundays being the days of ordination. The derivation of the word from Anglo-Saxon *ymb-ren*, a circuit or revolution, is confirmed by the use of the word *imbren* in the acts of the Council of Aenham, A.D. 1009 ("ieiunia quatuor tempora quae *imbren* vocant"). It corresponds also with Pope Leo the Great's definition, "ieiunia ecclesiastica per totius anni circulum distributa."

The observance of the Ember days is confined to the Western Church, and had its origin as an ecclesiastical ordinance in Rome. They were probably at first merely the fasts preparatory to the three great festivals of Christmas, Easter and Pentecost. A fourth was subsequently added, for the sake of symmetry, to make them correspond with the four seasons, and they became known as the *ieiunium vernum, aestivum, autumnale* and *hiemale*. From Rome the Ember days gradually spread throughout Western Christendom, but neither in Gaul nor Spain do they seem to have been generally recognized much before the 8th century. Their introduction into Britain appears to have been earlier, dating from Augustine, A.D. 597, acting under the authority of Gregory the Great. Lack of uniformity led to the rule now observed being laid down under Pope Urban II. in A.D. 1095.

The present rule which fixes the ordination of clergy in the Ember weeks cannot be traced farther back than the time of Pope Gelasius, A.D. 492–496.

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EMBEZZLEMENT, in English law, a form of theft, which is distinguished from the ordinary crime of larceny in two points:—(1) It is committed by a person who is in the position of clerk or servant to the owner of the property stolen; and (2) the property when stolen has been received from a third person and has not reached the possession of the master, the owner. The definition of embezzlement as a special form of theft arose out of the difficulties caused by the legal doctrine that to constitute larceny the property must be taken out of the possession of the owner. Servants and others were thus able to steal with impunity goods entrusted to them for their masters. A statute of Henry VIII. (1529) was passed to meet this case, which was not covered by the common law.

Other statutes have been passed from time to time, but the law now in force is the Larceny Act 1916, which by ss. 16 to 19 deals with this offence.

By that act every person who being a clerk or servant or person employed in the capacity of a clerk or servant fraudulently embezzles the whole or any part of any chattel, money or valuable security delivered to or received or taken into possession by him for or in the name or on the account of his master or employer: or being employed in the public service of the sovereign or in the police of any place whatsoever embezzles or in any manner fraudulently applies or disposes of for any purpose whatsoever except for the public service any chattel, money or valuable security entrusted to or received or taken into possession by him by virtue of his employment: or being appointed to any office or service by or under a local marine board fraudulently applies or disposes of any chattel, money or valuable security received by him for or on account of any local marine board or for or on account of any other public board or department, for his own use or any use or purpose other than that for which the same was received by him; or fraudulently withholds, retains, or keeps back the same, or any part thereof, contrary to any lawful directions, is guilty of felony and on conviction thereof liable to penal servitude for 14 years, and in the case of a clerk or servant, if a male under the age of 16 years, to be once privately whipped in addition to any other

punishment.

Again every person who, being an officer of the Post Office, steals or embezzles a postal packet in course of transmission by post shall be guilty of felony and on conviction thereof liable, if the postal packet contains any chattel, money or valuable security, to penal servitude for life: in all other cases to penal servitude for seven years.

An officer or servant of the Bank of England or of the Bank of Ireland, who secretes, embezzles, or runs away with any bond, deed, note, bill, dividend warrant, warrant for the payment of any annuity, interest or money, security, money or other effects of or belonging to the Bank of England or Bank of Ireland and entrusted to him or lodged or deposited with the Bank of England or Bank of Ireland, or with him as such officer or servant, is guilty of felony and on conviction thereof liable to penal servitude for life.

The person charged must be one who is acting under and bound to obey the orders of the owner of the property, although his employment need not be permanent. A general deficiency in accounts is not sufficient, but it must be proved that a specific sum of money has been embezzled, just as in larceny proof of the theft of a specific article is necessary. Difficulties sometimes arose where the embezzler had an interest in the property taken, and this was first dealt with by the Larceny Act 1868; now, by s. 40 (4) of the act of 1916, if any person, who is a member of any co-partnership or is one of two or more beneficial owners of any property, embezzles any such property of or belonging to such co-partnership or to such beneficial owners he is liable to be punished as if he had not been or was not a member of such co-partnership or one of such beneficial owners. Again if on the trial of any indictment for embezzlement it is proved that the defendant stole the property in question, the jury may find him guilty of stealing, *i.e.*, larceny.

Under certain circumstances justices may deal summarily with some cases of embezzlement, *e.g.*, by a clerk, a servant or postal official (Criminal Justice Act 1925). *See* also CONVERSION and LARCENY.

Embezzlement, not having existed at the common law, is a crime as provided by the several States in the United States. Embezzlement differs from larceny in that the original taking was lawful or with the consent of the owner, misappropriation following such taking. In some States, the offence is designated as larceny with punishment as such.

EMBLEM, a word applied in Greek and Latin to a raised or inlaid ornament on vases, etc., or to mosaic or tessellated work. In English it is confined to a symbolical representation of some object, particularly to a badge or heraldic device.

EMBLEMENTS, a term applied in English law to the corn and other crops of the earth which are produced annually, not spontaneously but by labour and industry. Emblements belong therefore to the class of *fructus industriales,* or "industrial growing crops" (Sale of Goods Act, 1893, s. 62). They include not only corn and grain of all kinds, but everything of an artificial and annual profit that is produced by labour and manuring; *e.g.*, hemp, flax, hops, potatoes, artificial grasses and clover, but not fruit growing on trees, which come under the general rule *quicquid plantatur solo, solo cedit.* Emblements are included within the definition of goods in s. 62 of the Sale of Goods Act, 1893. Where an estate of uncertain duration terminates unexpectedly by the death of the tenant, or some other event due to no fault of his own, the law gives to the personal representative the profits of crops of this nature as compensation for the tilling, manuring and sowing of the land. If the estate, although of uncertain duration, is determined by the tenant's own acts, the right to emblements does not arise. The right to emblements became of less importance in England after the passing of the Landlord and Tenant Act, 1851. Under s. 1 of that statute as reproduced by s. 14 of the Agriculture Act, 1920, where the lease or tenancy of any farm or lands is held by a tenant at a rack-rent determined by the death or cesser of the estate of any landlord entitled for his life, or any other uncertain interest, the tenant shall continue to hold or occupy such farm or lands until the occupation is determined by a 12 months' notice to quit, expiring at the end of a year of the tenancy, paying a proportionate rent to the successive owner. The right to emblements still exists, however, in favour of (*a*) a tenant not within the Landlord and Tenant Act, 1851, whose estate determines by an event which could not be foreseen, (*b*) the executor, as against the heir of the owner in fee of land in his own occupation, (*c*) an execution creditor under a writ directing seizure of goods and chattels. A person entitled to emblements may enter upon the lands after the determination of the tenancy for the purpose of cutting and carrying away the crops. Emblements are liable to distress by the landlord for arrears of rent, or rent during the period of holding on under the act of 1851 (the Distress for Rent Act, 1737). (*See* DISTRESS.)

The term "emblements" is unknown in *Scots law,* but the heir or representative of a life-rent tenant, a life-renter of lands, has an analogous right to reap the crop (on paying a proportion of the rent) and a right to recompense for labour in tilling the ground. The Landlord and Tenant Act, 1851 (s. 1) was in force in Ireland till 1860, when it was replaced by the Land Act, 1860, which gave to the tenant an almost identical right to emblements (s. 34). (*See* also IRELAND; LANDLORD AND TENANT.)

In the United States the English common law of emblements has been generally preserved.

Under the French Code Civil, the outgoing tenant is entitled to convenient housing for the consumption of his fodder and for the harvests remaining to be got in (art. 1,777). The same rule is in force in Belgium (Code Civil, art. 1,777); and in Holland (Civil Code, art. 1,635); and Spain (art. 1,578). Similar rights are secured to the tenant under the German Civil Code (arts. 592, *et seq.*). French law is in force in Mauritius; the common law of England and the Landlord and Tenant Act, 1851 (14 and 15 Vict., c. 25, s. 1) in many of the British colonies acquired by settlement. In others they are recognized by statute.

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EMBOLISM: *see* THROMBOSIS AND EMBOLISM.

EMBOSSING, the art of producing raised portions or patterns on the surface of metal, leather, textile fabrics, cardboard, paper and similar substances. Strictly speaking, the term is applicable only to raised impressions produced by means of engraved dies or plates brought forcibly to bear on the material to be embossed, by various means, according to the nature of the substance acted on. Thus raised patterns produced by carving, chiselling, casting and chasing or hammering are excluded from the range of embossed work. Embossing supplies a convenient and expeditious medium for producing elegant ornamental effects in many distinct industries, and especially in its relations to paper and cardboard its applications are varied and important. Crests, monograms, addresses, etc., are embossed on paper and envelopes from dies set in small handscrew presses, a force or counter-die being prepared in leather faced with a coating of gutta-percha. The dies to be used for plain embossing are generally cut deeper than those intended to be used with colours. Colour embossing is done in two ways—the first and ordinary kind that in which the ink is applied to the raised portion of the design. The colour in this case is spread on the die with a brush and the whole surface is carefully cleaned, leaving only ink in the depressed parts of the engraving. In the second variety—called cameo embossing—the colour is applied to the flat parts of the design by means of a small printing roller, and the letters or design in relief is left uncoloured. In embossing large ornamental designs, engraved plates or electrotypes therefrom are employed, the force or counterpart being composed of mill-board faced with gutta-percha. In working these, powerful screw-presses, in principle like coining or medal-striking presses, are employed. Em-

bossing is also most extensively practised for ornamental purposes in the art of book-binding. The blocked ornaments on cloth covers for books, and the blocking or imitation tooling on the cheaper kinds of leather work, are effected by means of powerful embossing or arming presses. (*See* BOOK-BINDING.) For impressing embossed patterns on wall-papers, textiles of various kinds, and felt, cylinders of copper, engraved with the patterns to be raised, are employed, and these are mounted in calender frames, in which they press against rollers having a yielding surface, or so constructed that depressions in the engraved cylinders fit into corresponding elevations in those against which they press. The operations of embossing and colour printing are also sometimes effected together in a modification of the ordinary cylinder printing machine used in calico-printing, in which it is only necessary to introduce suitably engraved cylinders. For many purposes the embossing rollers must be maintained at a high temperature while in operation; and they are heated either by steam, by gas jets, or by the introduction of red-hot irons within them. The stamped or struck ornaments in sheet metal, used especially in connection with the brass and Britannia-metal trades, are obtained by a process of embossing—hard steel dies with forces or counterparts of soft metal being used in their production. A kind of embossed ornament is formed on the surface of soft wood by first compressing and consequently sinking the parts intended to be embossed, then planing the whole surface level, after which, when the wood is placed in water, the previously depressed portion swells up and rises to its original level. Thus an embossed pattern is produced which may be subsequently sharpened and finished by the ordinary process of carving (*see* WOOD-CARVING; REPOUSSÉ).

EMBOUCHURE: *see* MOUTHPIECE.

EMBRACERY, in law, the attempting to influence a juryman corruptly to give his verdict in favour of one side or the other in a trial, by promise, persuasions, entreaties, money, entertainments and the like. It is an offence, both at common law and by statute, and punishable by fine and imprisonment. As a statutory offence it dates back to 1360. The offence is complete, whether any verdict has been given or not, and whether the verdict is in accordance with the weight of evidence or otherwise. The person making the attempt, and any juryman who consents are equally punishable. The false verdict of a jury, whether occasioned by embracery or otherwise, was formerly considered criminal, and jurors were severely punished, being proceeded against by writ of attaint (*q.v.*). The Juries Act of 1825, in abolishing writs of attaint, made a special exemption as regards jurors guilty of embracery (s. 61).

EMBRASURE, the opening in a battlement between the two solid portions or merlons; a crenel; also the splay or reveal of a window.

EMBROIDERY: *see* TEXTILES.

EMBRUN, a town in the department of the Hautes Alpes in S.E. France. It stands 2,854 ft. above the right bank of the Durance. It is 27½ m. by rail from Briançon and 24 m. from Gap. Pop. (1926) 1,806. Embrun, the *Eburodunum* or *Ebredunum* of the Romans, was the chief town of the province of the Maritime Alps. The episcopal see was founded in the 4th century, and became an archbishopric about 800. In 1147 the archbishops obtained very extensive temporal rights, and the rank of princes of the Holy Roman Empire. In 1232 the county of the Embrunais passed by marriage to the dauphins of Viennois. In 1791 the archiepiscopal see was suppressed, the region being then transferred to the diocese of Gap. The town was sacked in 1585 by the Huguenots and in 1692 by the duke of Savoy. Henri Arnaud (1641–1721), the Waldensian pastor and general, was born at Embrun. Its ramparts were demolished in 1884. Besides the Tour Brune (11th century) and the old archiepiscopal palace, now government offices, barracks, etc., the chief object of interest in Embrun is its cathedral church, 12th century. Above its side door, called the *Réal*, there existed till 1585 (when it was destroyed by the Huguenots) a fresco, probably 13th century, of the Madonna, the object of a celebrated pilgrimage. Louis XI. habitually wore on his hat a leaden image of this Madonna, since between 1440 and 1461, he had been, as dauphin, the ruler of this province.

EMBRYO, the name applied to the developing young of an animal before birth or before hatching from the egg. (*See* EMBRYOLOGY.) The term is also used of that part of a seed (*q.v.*) which will develop into the new plant, in contradistinction to the endosperm of nutritive tissue. (X.)

In the present article a condensed summary is given of the development of the human embryo. Further details and a comparison of the development of man with that of other vertebrates are to be found in the anatomical articles on HEART, NERVOUS SYSTEM, LIVER, etc.

The human embryo, like that of all other vertebrate animals, arises from the union of two minute cells, the *ovum* and *spermatozoon.* This union ("fertilization") takes place in the oviduct, or Fallopian tube of the uterus (*see* REPRODUCTIVE SYSTEM), and results in the formation of a single cell, the *oösperm* or *zygote.* It is by means of these two minute cells, the larger of which is less than 1/100in. across, that hereditary characters are transmitted from parents to offspring. It is generally believed also that the sex of the new individual is determined at the time of fertilization, although it is not possible to distinguish the sex with certainty until the gonads or genital glands are sufficiently advanced in development to recognize the differences in microscopical structure between testis and ovary.

During the child-bearing period from the commencement of menstruation to its cessation about the 45th year, it is believed that a mature ovum is normally discharged from the surface of one of the two ovaries with each menstrual cycle. The ovum is received into the oviduct where it may become fertilized. If this does not take place, it perishes and is discharged.

The process of *ovulation*, or the shedding of a ripe ovum from a ruptured Graafian or ovarian follicle, is associated with menstruation in the following way: The uterus, stimulated by an internal secretion, perhaps derived from cells of the ruptured follicle, prepares for a possible pregnancy, its lining membrane thickens and becomes more vascular, but if fertilization does not take place the thickened lining is unnecessary and breaks down; slight haemorrhage takes place and blood and shreds of membrane are discharged with the degenerated ovum, the whole constituting the menstrual flow. If, however, ovum and spermatozoon have fused, and a zygote becomes imbedded in the mucous lining of the uterus, this discharge does not take place; in other words that cessation of menstruation occurs, which is the first recognizable sign of pregnancy.

Certain of the earlier stages of development have not as yet been completely followed out in the human subject, but those which have been observed confirm the general conclusions, based on the study of other mammalian embryos.

The following description is based partly on observations on segmentation of mammalian embryos other than that of man, but with the exception of these earliest stages the account has been drawn from human material.

During the passage of the fertilized ovum through the oviduct into the cavity of the uterus, it undergoes segmentation or division, and becomes a solid mass of rounded cells, the *morula.* This consists of smaller superficial cells, and larger central cells. The superficial layer, the *trophoblast,* has the important function of absorbing nutriment from the mucous lining of the uterus. The central cells give origin to the embryo. These central cells soon become massed at one pole of the morula, which now assumes an oval form, while at the other pole a cavity appears, so that the solid morula is converted into a hollow vesicle, the *blastula.* The outer wall of this is formed by the trophoblast, which encloses the eccentrically placed *embryonic cell mass,* and a cavity occupied by loose tissue containing fluid in its interstices. The embryonic cell mass is attached by a wide pedicle, the *body stalk* to the inner surface of the epithelial wall of the blastula. Two cavities soon appear within it: the *amniotic cavity,* and the cavity of the *yolk sac.* Between these is a disc shaped zone, where the walls of the two cavities are in contact; this is the embryonic area.

The membrane covering the embryonic area and enclosing the amniotic cavity is the *amnion,* one of the foetal membranes, and

the watery liquid contained within the cavity serves as a protection for the embryo. Later the developing child, now called the foetus, is suspended by the umbilical cord and floats freely in the amniotic fluid. The minute yolk sac of the human embryo is a mere remnant of the large yolk sac found in lower types of vertebrates such as birds and reptiles; in all of the higher mammals its function has been taken over by the *placenta* (*q.v.*). The embryonic area soon becomes oval in form and two axial grooves ("primitive," and "medullary") appear on its upper or dorsal surface. By a growing upward and coalescence of the edges of the anterior or medullary groove, it is converted into a closed tube, the *medullary canal*, which gives rise to the central nervous system and cerebrospinal nerves (*see* BRAIN). This takes place in embryos aged about 25 days and 2·3mm. in length.

Meanwhile the embryonic area becomes encircled by a groove, which by deepening separates the embryo from the amnion and yolk sac. The embryo now assumes a cylindrical form. One end of the hollow tube thus formed is enlarged to form the head and neck; the other, the tail end, becomes curved forward and tapers to a point. On each side of the neck appear four linear furrows, which represent the gill slits of fishes. Bounding these furrows in front and behind are the visceral arches, which correspond to the lower jaw, gill cover and branchial or gill arches of the fishes. At the sixth week the embryo has become nearly circular in outline, and measures about 10 mm. in its greatest diameter. At the head end are developed the mouth, eyes, ears and nasal cavities, and from each side two flattened buds grow outward, which are the rudiments of the upper and lower limbs.

Internally a portion of the yolk sac (archenteron) is separated off from the general cavity and enclosed within the embryo so as to form the alimentary canal. From the forepart of this, glands such as the salivary, thyroid, tonsils and thymus are developed, and as outgrowths from the canal further back, the lungs, liver and pancreas. The main tube gives rise to the pharynx, gullet, stomach and intestine. The heart and blood vessels are formed very early at the 3rd week; and the circulation at first resembles that of a fish, a single tubular heart propelling the blood through a branchial system of vessels.

Afterwards the primary heart and blood vessels are modified so as to form a general circulation for the blood supply of the body and a pulmonary circulation concerned in respiration. The primary branchial system adapted for respiration in water has thus been replaced by a pulmonary system, which enables the child from the time of birth, when the placental circulation is cut off, to breathe air by means of the lungs. During the later months of pregnancy the pulsations of the foetal heart may be heard with a stethoscope, and are a valuable sign of the life of the child.

Deposition of calcium salts to form the bones commences about the 6th week of intra-uterine life, and is accompanied by the formation of the muscles and joints. Development proceeds apace so that movements of the child, spoken of as "quickening," are first felt by the mother about the middle of the fourth month of pregnancy. It must be remembered, however, that although these are a most important sign of life of the child, the new life really commences at the time of fertilization of the ovum.

From the time of the "quickening" until birth, development consists almost entirely of an increase in size, though a recognizable human being has been in existence since about the 6th week of intra-uterine life, when the embryo was less than 12mm. in length. The sex of the future child becomes obvious about the 10th week, though it is possible to distinguish between the external genital organs of the two sexes at a much earlier age, namely about the 6th week. (R. J. G.)

EMBRYOLOGY is the science which treats of the development of an individual animal from its beginning as an egg to a period arbitrarily determined when it has attained or nearly reached its adult structure. With perhaps a very few exceptions all multicellular animals, both Parazoa and Metazoa, reproduce sexually, the new individual arising by a fusion of two cells, one, the spermatozoon, being produced by the male, the other, the ovum or egg, by the female parent. These two reproductive cells always differ greatly in size and appearance but have an equal influence on the characters of the animal arising from their fusion.

The spermatozoon is a small, actively moving cell, which, in the majority of animals, has a very characteristic structure consisting of a head, middle piece and tail. The head is almost entirely occupied by the nucleus, capped by a body called the acrosome and surrounded by a thin layer of cytoplasm. The middle piece is cytoplasmic in nature, containing certain granules, of which the most important are a centrosome which is responsible for the first division of the fertilized egg, and a basal granule which controls the activities of the long tail, a thread of protoplasm, which by its spiral lashing drives the whole forward.

The ovum differs from the spermatozoon in being relatively large and immobile. It is a cell containing a nucleus and much cytoplasm which includes a food store of greater or lesser amount. This food reserve has to supply all the needs of the developing embryo until it becomes capable of feeding. As this event occurs at very different times, the amount of yolk, and hence the size of the egg, varies greatly in different animals.

Fertilization (*q.v.*) is the act of fusion of a spermatozoon with an egg. It is followed immediately by a change of egg-surface which renders it impossible for any more spermatozoa to enter its substance. The entry of a spermatozoon begins a series of activities whose result is the formation from the apparently simple and uniform egg of the elaborately differentiated body of the adult. The first stages of this process are similar in essentials in all Metazoa, but the courses of development of the individuals of the different phyla of the animal kingdom part company at stages depending on the remoteness of their relationship.

After the spermatozoon has entered the egg, usually leaving its tail outside, its head swells up and the fertilized egg contains two very similar nuclei. These approach one another and finally fuse. Meanwhile the centrosome brought in by the sperm has divided into two parts, which separate, a spindle forming between them.

The originally single egg then divides itself into two new cells, the blastomeres of the two-celled stage. These are usually, but not always, exactly similar in appearance. In the case of the sea urchin, *Echinus esculentus*, this division, which is called the first cleavage, takes place about one hour and ten minutes after fertilization and occupies about half an hour.

Subsequently, in *Echinus*, an hour later each of these two blastomeres divides into two, giving rise to a four-celled embryo. The plane of this second cleavage is usually at right angles to that of the first, so that normally the four blastomeres lie in a ring, in contact with one another.

Each of these cells then divides again by a third cleavage, often at right angles to the two which have preceded it. The cleavage of the four cells takes place simultaneously. This process of cleavage is continued until there is built up a mass of some 128 cells, a morula. The morula, if formed at all, typically resolves itself into a blastula in which the cells are arranged in a layer, one cell thick, surrounding a cavity, the segmentation cavity or blastocoel. The blastula is usually larger than the egg from which it has arisen because it has imbibed water from its surroundings.

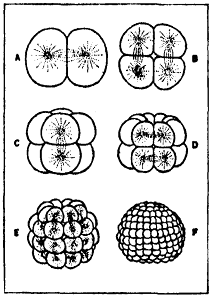
The next process in development is known as gastrulation. It has as its object the formation of a primitive food cavity, the archenteron, surrounded by a double cellular wall, an inner layer of cells, the endoderm or hypoblast, which actually forms the wall of the gut and is concerned with digestion and the absorption of food, and an outer ectoderm or epiblast, which is the part of the embryo which comes into contact with the outside world.

In relatively small eggs this transformation is brought about by the actual intucking of one pole of the blastula into the other. In larger and more yolky eggs so simple a mode of formation is impracticable, and various divergences are found which may be regarded as modifications of the primitive method. Thus, in a frog's egg an actual intucking takes place, but is restricted to one point on the surface of the blastula, and leads to the formation of a shallow pit, subsequently lengthened by a very active localized growth of the part turned in, and a spread of organization from it forward into a mass of cells, which fills most of what should be the blastocoel.

In such eggs as that of a bird the endoderm is formed by the

splitting off of a layer of cells from a comparatively thick mass formed by the cleavage divisions, by a process called delamination.

The gastrula formed by any of these processes corresponds in its fundamental architecture with the adult animals which compose the phylum Coelenterata (*q.v.*). In the development of the members of all higher phyla a third cell layer, the mesoderm, is established. This separates the ectoderm from the endoderm and from it are formed the majority, at any rate, of the muscles of the adult animal, its blood and blood vessels, and the gonads.



FROM E. SELENKA, "DIE KIEMBLATTER DER SCHINODERMEN: STUDIEN ÜBER ENTWICK"

CLEAVAGE OF THE OVUM OF SYNAPTA

A. Two-celled stage, from the side
B. Four-celled stage, from above
C. Eight-celled stage, from the side
D. 16-celled stage, from the side
E. 32-celled stage, from the side
F. 128-celled stage

The mesoderm may arise in many different ways, it may be entirely derived from special blastomeres very early set apart in cleavage, it may come from the endoderm, or from the ectoderm.

In all the higher phyla the mesoderm either is divided into two sheets from its first appearance, or becomes so later; one of these sheets lines the ectoderm and the other encloses the endoderm of the gut. The cavity which separates these mesodermal sheets is the coelom or body cavity. This space, which comes into existence to separate the gut from the body wall, is in most animals connected to the exterior by a canal or canals, the coelomoducts, whose primary function is to extrude the reproductive cells from the coelom in whose wall they have been formed, and into which they have been set free. Subsequently, in the evolution of many forms, these coelomoducts become modified so as to subserve the function of excretion of nitrogenous waste products.

Primitively the coelom with its walls, the primordium of the mesoderm, seems to have arisen as a pouch pushed out from the archenteron, but in the majority of animals this mode of origin has been lost, the mesoderm arising from as few as two cells, early set aside; from mesenchyme cells which have wandered out from the endoderm, or by "delamination" by being cut off as a sheet from the endoderm or even the ectoderm.

Subsequently a split, a schizocoel, appears in the originally solid mesoblast so formed. The embryo at this stage possesses a gut, the enteron, surrounded by the endoderm and communicating with the exterior by a single opening, the blastopore. The ectoderm forms the whole external surface, and from it arise the nervous system and sense organs; in certain embryos arising from eggs which are shed into water, the ectoderm also produces cilia which serve for locomotion and feeding.

At this stage the blastopore often closes completely, only to reopen as the anus, the mouth being formed as a result of the perforation of an area of contact between the endoderm and the ectoderm. When the mouth and anus are established the embryo can begin to feed and passes into the larval stage.

The term larva (*q.v.*) properly implies an animal at a stage in its development when it can feed and move about without having acquired the structure of an adult. The larva may have a very short free life, a few minutes or hours in the case of some molluscs and tunicates, or it may cover the greater part of the individual's existence as in the case of the caterpillars.

The larva may be adapted for a mode of life and even to a medium entirely different from that of the adult animal which it will eventually become; in which case the passage to the adult condition is usually carried out rapidly, by a process involving the destruction of the larval tissues by wandering phagocytic cells and the building up of their material into new adult tissues and organs. Such a transformation is known as a metamorphosis (*q.v.*). It is well illustrated by the mode in which a caterpillar becomes a pupa, all its tissues, except the nervous system and the gonads, becoming reduced to a structureless mass of cells, which are then built up into the body of the butterfly which will emerge from the chrysalis. The larval stage in a life history is thus designed to secure the possibility of growth, under favourable conditions, between the period when the food store originally laid down in the egg is exhausted and that when the adult form is reached.

In animals of very many groups the egg is fertilized within the body of the female which produced it (a process usually requiring special intromittent structures in the male) and may be retained there until development has gone on to some definite point. The new individuals are then expelled either as larvae or as small copies of the parent. This process is called viviparity.

In its early stages this condition implies no more than a retention of the egg inside the mother, but in its fully developed form it involves the provision of food for the growing embryo, either in a condition in which it can be eaten by what is essentially an unborn larva, as in certain fish, or by diffusion into the embryo from the mother's blood, usually through a special organ, the placenta, as in mammals. Viviparity has the advantage that the few young that are born make their appearance at a larger size and far more advanced in structure than would otherwise be possible, and hence have better chances of survival.

It is obvious that a period of development is a necessity for a metazoan: only in such a way can the elaborate body of one of the higher animals be built up from a single cell. It is not, however, clear that such a development must follow so similar a course in all the higher forms. The only explanation is that all these animals are blood relations which owe the differences which separate them to evolution, and that the courses of their development, originally identical, have come to differ by modification of the later stages, cleavage and gastrula remaining much the same in all.

The essentials of this conception were first stated by Carl Ernest von Baer in 1824. Much later Ernest Haekel made a more rigid generalization, his so-called biogenetic law, "that Ontogeny, the development of an individual animal, is a shortened recapitulation of Phylogeny, the evolutionary history of the species to which it belongs." Haekel compared the fertilized egg to a protozoon, the blastula to such a protozoan colony as *Volvox*, the gastrula to a coelenterate and so on. Belief in the general validity of Haekel's law led to an immense activity amongst zoologists in the last quarter of the 19th century. More and more refined methods of observation were elaborated and applied to representatives of all the phyla, and special efforts were made to work out the development of the more primitive members of each group, with the hope, seldom justified by results, that knowledge of it would make plain their phylogenetic relationships. This work, although it can scarcely be said to have succeeded in its original aim, established morphology as a discipline with an accepted technique and theory. It made it certain that development would afford most valuable evidence about the homologies of organs, controlling conclusions reached by comparative anatomy.

The most interesting of the later developments of observational embryology was the study of "cell lineages," which led to the remarkable discovery that the early development of a mollusc followed a most elaborate course, individual cells and small groups of cells being very early set apart for the production of definite structures in the larva and adult. Even more unexpected is the identity of this process in molluscs and annelids.

It must have been realized from the beginning of the study of embryology that there is present in the fertilized egg a mechanism which controls the subsequent development, and the actual course of that development, in such forms as molluscs, suggests that it may be possible to discover its nature.

The only possible method for such an investigation is an experimental one. The course of the development may be modifiable by altering the environment, the temperature, the chemical composition of the water in which it takes place, the space available for the growing embryo, and so on.

On the other hand materials may be removed from the egg or the embryo and any resulting defects noted. Two eggs may be caused to fuse and the history of the joint structure determined. The earliest stage of development, fertilization, may be demon-

strated by such methods to involve two separable processes. One of these, the modification of the egg surface and the beginning of cell division, can, in very many cases, be brought about by chemical means, or even by pricking with a glass needle smeared with blood serum. The other, the change in structure from the bringing in of paternal characters, can clearly not be copied artificially.

The embryo at the two-celled stage may be divided into two, and the subsequent history of the blastomeres traced. In different animals each may develop into a complete but half-sized larva, into a half larva, or one into a complete, the other an incomplete embryo.

Similar experiments may be performed on four- or eight-celled stages, or a blastula may be cut into pieces and their fate determined. The egg may be centrifuged so as to rearrange its constituent parts, subsequently fertilized and allowed to develop, or it may be held upside down so that gravity will disturb the normal orientation of its materials.

From such experiments the conclusion has been reached that the cytoplasm of the egg possesses a structure which determines the course of development, and that it gains this structure before its maturation, whilst the oocyte is growing. Experiments have been designed and carried out with the intention of investigating the period in the development when cells become committed to the formation of certain definite structures or types of structures.

Thus, small pieces of the developing larva of a newt have been transplanted into new regions in corresponding embryos of the same or some other species. They may grow up there, forming part of a complete animal, exactly as if they had been originally formed at that spot. (*See* EXPERIMENTAL EMBRYOLOGY, INVERTEBRATE EMBRYOLOGY, VERTEBRATE EMBRYOLOGY.)

(For embryology in plants, *see:* ANGIOSPERMS: *Embryology.*)

(D. M. S. W.)

EMDEN, a maritime town of Germany, in the Prussian province of Hanover, near the mouth of the Ems. Pop. (1925), 27,777. Emden (Emuden, Emetha) first mentioned in the 12th century, was sold in 1252 to the bishops of Münster, but the episcopal provosts and castellans soon established their practical independence. Towards the end of the 14th century the town gained a considerable trade owing to the permission given by the provost to the pirates known as "Viktualienbrüder" to make it their market, after they had been driven out of Gothland by the Teutonic Order. In 1402, after the defeat of the pirates off Heligoland by the fleet of Hamburg, Emden was besieged, but it was not reduced by Hamburg, with the aid of Edzard Cirksena of Greetsyl, until 1431. The town was held jointly by its captors till 1453, when Hamburg sold its rights to Ulrich Cirksena, who became count of East Friesland. In 1544 the Reformation was introduced, and in the following years numerous Protestant refugees from the Low Countries found their way to the town. In 1595 Emden became a free imperial city under the protection of Holland, and was occupied by a Dutch garrison until 1744 when, with East Friesland, it was transferred to Prussia. In 1810 Emden became the chief town of the French department of Ems Oriental; in 1815 it was assigned to Hanover, and in 1866 was annexed with that kingdom by Prussia. The Ems once flowed beneath its walls, but is now 2 m. distant, and connected with the town by a broad and deep canal, divided into the inner (or dock) harbour and the outer (or "free port") harbour. The latter since the construction of the Ems-Jade and Dortmund-Ems canals, has been deepened to 38 ft., thus allowing the largest sea-going vessels to approach its wharves, while canals bring the town into communication with most of East Friesland, of which it is the commercial capital. Its waterways and its gabled mediaeval houses give it the appearance of an old Dutch, rather than of a German, town. The Reformed "Great Church" (Grosse Kirche) is a large Gothic building completed in 1455 and the Gasthauskirche was formerly the church of a Franciscan friary founded in 1317. The Rathaus (town hall) was built in 1574–76, on the model of that of Antwerp, with a lofty tower, and contains an interesting collection of arms and armour. There are schools of commerce, navigation and telegraphy. Emden trades in agricultural produce and live-stock, horses, timber, coal, tea and wine. The deep-sea fishing industry of the town is important. Machinery, cement, cordage, wire ropes, tobacco, leather, chemicals, etc., are manufactured and shipbuilding is carried on. Emden is also of importance as the station of the submarine cables connecting Germany with England, North America and Spain.

EMERALD, a bright green variety of beryl, valued as a gem-stone. The name comes indirectly from the Gr. σμάραγδος (Arabic *zumurrud*), but seems to have been given to a number of stones having little in common except a green colour.

The properties of emerald are mostly the same as those of beryl. The crystals often show simply the hexagonal prism and basal plane. The prisms cleave, though imperfectly, at right angles to the geometrical axis; and hexagonal slices were formerly worn in the East. Compared with most gems, the emerald is rather soft, its hardness (7·5) being but slightly above that of quartz. The specific gravity is low, varying slightly in stones from different localities, but being for the Muzo emerald about 2·67. The refractive and dispersive powers are not high, so that cut stones show little "fire." The colour is probably due to chromium. F. Wöhler found 0·186% of Cr_2O_3 in the emerald of Muzo—a proportion sufficient to impart an emerald-green colour to glass.

The ancients appear to have obtained the emerald from Upper Egypt, where it is said to have been worked as early as 1650 B.C. It is known that Greek miners were at work in the time of Alexander the Great, and in later times the mines yielded their gems to Cleopatra. Remains of extensive workings were discovered in the northern Etbai by the French traveller, F. Cailliaud, in 1817, and the mines were re-opened for a short time under Mohammed Ali. "Cleopatra's Mines" are situated in Jebel Sikait and Jebel Zabara near the Red sea coast east of Aswan. They were visited in 1891 by E. A. Floyer, and the Sikait workings were explored in 1900 by D. A. MacAlister and others. The Egyptian emeralds occur in mica-schist and talc-schist.

On the Spanish conquest of South America vast quantities of emeralds were taken from the Peruvians, but the exact locality which yielded the stones was never discovered. The only South American emeralds now known occur near Bogotá, the capital of Colombia. The most famous mine is at Muzo, but workings are known also at Coscuez and Somondoco. The emerald occurs in nests of calcite in a black bituminous limestone containing ammonites of Lower Cretaceous age. The mineral is associated with quartz, dolomite, pyrites and the rare mineral parisite (*q.v.*), named after J. J. Paris, who worked the emeralds.

In 1830 emeralds were discovered in the Ural mountains and have been worked on the river Takovaya, about 60m. N.E. of Ekaterinburg, where they occur in mica-schist, associated with aquamarine, alexandrite, phenakite, etc. Emerald is found also in mica-schist in the Habachthal, in the Salzburg Alps, and in granite at Eidsvold in Norway. Emerald has been worked in a vein of pegmatite, piercing slaty rocks, near Emmaville, in New South Wales. The crystals occurred in association with topaz, fluorspar and cassiterite; but they were mostly of rather pale colour. In the United States, emerald has occasionally been found and fine crystals have been obtained from the workings for hiddenite at Stonypoint, Alexander county, N.C.

Many virtues were formerly ascribed to the emerald. When worn, it was held to be a preservative against epilepsy, it cured dysentery, it assisted women in childbirth, it drove away evil spirits, and preserved the chastity of the wearer. It was reputed to have medicinal value, and because of its colour was said to be good for the eyesight.

See AQUAMARINE; BERYL.

EMERGENCE. The difference between a mechanical mixture and a chemical compound was among the first things to which the attention of one who entered a laboratory more than half a century ago was directed. He was shown finely pulverized charcoal and sulphur where the relative proportions varied between the limits of 0 and 100% of sulphur. He was then shown the chemical compound labelled CS_2. He was bidden to note the very different effect this produces on the senses. He was taught more about it; the unvarying percentage of sulphur; how light waves behave as

they pass through it; what happens when it is heated; and so on. He learnt in picturesque and imaginative fashion something of its intimate structural organization. He was led to realize that in some way this structure is connected with certain properties and qualities; to realize also that carbon bisulphide comes into being pretty suddenly under certain conditions and not otherwise.

In the Second Series of *Problems of Life and Mind* (1875) George Henry Lewes suggested a new name—not a new concept. That which, under such conditions, springs into being he called "emergent." He held that the nature of an emergent cannot be foretold from the nature of its several constituents as they are in themselves prior to Emergence. Hence the nature of an emergent can be known only through observation and experiment when that emergent has come into being. He contrasted emergents with "resultants." The nature of a mixture of charcoal and sulphur, as resultant, can be foretold from the nature of the assembled particles. In such a resultant there is not a new and unforeseen mode of structural organization; nor is there a new and unforeseen set of properties.

If the word "Emergence" be taken over from Lewes it should be used in the sense he intended. He distinguished between an "empirical" treatment of nature and one that he called "metempirical" (1873) seeking thus to avoid the ambiguities of the word "metaphysical." What he meant by empirical treatment is one which is in accordance with the methods of inductive science. If, on the evidence of observation and experiment, there be Emergence, this is to be taken as it is given *in* nature, leaving others to discuss its alleged introduction *into* nature through some "metempirical" influx. On these terms, which are here accepted, Emergence is a hypothesis of inductive science to be weighed on the available evidence. There can be little doubt that Lewes would have regarded emergent evolution as empirical, and creative evolution as typically "metempirical."

When we apply the distinguishing analysis and synthesis of modern scientific thought to a crystal, that we may piece together its story, it comes, in brief, to this: The proximate constituents are crystal units. The crystal as a whole is, for our unaided vision, the visible and tangible expression of one of a limited number of ways in which these crystal units go together. Under further analysis (distinguishing not destructive) each crystal unit is made up of molecules which go together in a distinctive mode of structural organization; each molecule is made up of atoms which go together in a distinctive way; each atom is made up of electrical charges in proton and electrons; and they too go together in a distinctive manner.

Here we still keep in the neighbourhood of Lewes's starting-point. But we concentrate attention on structural organization, in the crystal unit, in the molecule, and in the atom. Now it may be that the distinctive plan of crystal-organization can be foretold from that of molecular organization, and this from the atomic plan. If this be so the crystal unit is interpretable as the outcome of resultant advance. Or it may be that the crystal unit cannot be foretold from the molecule, nor the molecule from the atom. If that be so each new mode of organization exemplifies Emergence. Of course in either case what actually happens can be generalized after the event under so-called "natural laws."

There seem, then, to be two alternative hypotheses. The alternatives are: (1) *All* events within the crystal are susceptible of resultant treatment (suitably defined); (2) *some* events within the crystal are emergent. In discussing the evidence in support of this hypothesis or that, one must get at the facts of observation and experiment as these facts are interpreted by the scientific expert on the lines of inductive procedure. But we must turn to the logician to say whether it is possible or impossible to foretell the organization of the crystal on the basis of our knowledge of the molecule. To carry the matter yet further, we may ask the experimentalist and the logician to combine forces and tell us whether the whole inorganic world can or cannot be deduced on the basis of our knowledge of, say, the Bohr-Rutherford atom.

The discussion is in progress in the light of present scientific knowledge. It may well be that the advance of knowledge will change the existing position of affairs. But to say that, though not yet, still some day, all events within the crystal, as a sample of the inorganic world, will be shown to be deducibly "resultant," is to anticipate the verdict of the future. We cannot foretell how matters may stand ten years hence. But whatever the verdict of the future may be, the concept of Emergence does here and now raise a crucial question.

But a question wholly different in kind may be raised. It may be asked: How is one *to account for* the sudden or very rapid appearance of new modes of structural organization with which are connected new properties and qualities? The only way in which the man of science professes "to account for" anything that happens is by describing in generalized terms the observed conditions under which it does happen. In this sense those who accept Emergence are bound to render the fullest possible account of these conditions in each instance of its alleged occurrence. It is in this sense that the words "account for" should be used in discussing Emergence as a scientific hypothesis. One does not in science account for the crystal by invoking an extraneous "somewhat" to be discussed in terms of "crystalism."

If we apply distinguishing analysis to the living organism, we come down, when we probe deep enough, to molecules and atoms. But some of the molecules—for example, those of the amino acid constituents of protein—are organized in a special many-linked way. If this distinctive plan of organization can be foreseen on the basis of our knowledge of simpler modes of molecular organization the amino acids, or more comprehensively the biochemical constituents of protoplasm, exemplify resultant advance. But if they cannot be foreseen they exemplify Emergence.

In this field of enquiry the man of science seeks to account for what happens by stating the observable conditions under which it does happen in the living organism or perhaps in the laboratory—not by invoking an extraneous "somewhat" to be discussed by philosophers in terms of "vitalism."

Closely connected with the structural organization and properties of protoplasm there are those processes in the living organism with which it is the task of physiology to deal. Here also for science the question is: Are *all* the events within the living organism susceptible of resultant treatment; or are *some* of these events such as to exemplify Emergence? This is a plain issue.

And when we pass to mental affairs the issue for science is like in kind. On the one hand we have such dim sentience and percipience as may be attributed to the amoeba; on the other hand we have such higher modes of mentality as we attribute to man. Distinguish, say, three stages: percipience, perception, reflective thought. Then ask: Is the mode of organization in reflective thought predictable from that in perception, and that in perception from amoebiform percipience? Or is Emergence exemplified in mental advance no less than in physiological advance and in the advance of events throughout nature? What we need, in the admittedly abstract domain of science, is an evaluation of the evidence in support of Emergence, and its treatment from the standpoint of logic.

Bibliography.—G. H. Lewes, *Problems of Life and Mind*, 2nd series (1875); S. Alexander, *Space, Time and Deity* (1920); C. Lloyd Morgan, *Emergent Evolution* (1923); C. D. Broad, *Mind and its Place in Nature* (1925). (C. Ll. M.)

EMERITUS, a term used of Roman soldiers and public officials who had earned their discharge from the service, applied, in modern times, to a university professor (*professor emeritus*) who has vacated his chair on account of long service, age, or infirmity, and, in the Presbyterian church, to a minister who has for like reason given up his charge.

EMERSON, RALPH WALDO (1803–1882), American poet and essayist, was born in Boston, Mass., May 25, 1803. Seven of his ancestors were ministers of New England churches. From them Emerson inherited qualities of self-reliance, love of liberty, strenuous virtue, sincerity, sobriety and fearless loyalty to ideals. The form of his ideals was modified by the metamorphic glow of Transcendentalism, but the spirit in which Emerson conceived the laws of life, reverenced them and lived them out, was the Puritan spirit, elevated, enlarged and beautified by the poetic temperament.

His father was the Rev. William Emerson, minister of the First Church (Unitarian) in Boston. Ralph Waldo was the fourth child in a family of eight, of whom at least three gave evidence of extraordinary mental powers. He was brought up in an atmosphere of hard work, of moral discipline, and of wholesome self-sacrifice. His aunt, Mary Moody Emerson, a brilliant and eccentric woman, was a potent factor in his education. In 1817 he entered Harvard college, and graduated in 1821. In scholarship he ranked about the middle of his class. In literature and oratory he was more distinguished, receiving a Boylston prize for declamation and two Bowdoin prizes for ethical dissertations. He was fond of reading and of writing verse, and was chosen as the poet for class day. His cheerful serenity of manner, his tranquil mirthfulness and the steady charm of his personality made him a favourite with his fellows, in spite of a certain reserve.

Immediately after graduation he became for three years an assistant in his brother William's school for young ladies, in Boston. The routine was distasteful; independence, sincerity, reality, grew more and more necessary to him. His aunt urged him to seek retirement, self-reliance, friendship with nature; to be no longer "the nursling of surrounding circumstances." The passion for spiritual leadership stirred within him. In 1825 he entered the divinity school at Cambridge, to prepare himself for the Unitarian pulpit. His studies, much interrupted by ill-health, were, however, far more philosophical and literary than theological.

In Oct. 1826 he was "approbated to preach" by the Middlesex Association of Ministers. The same year a threatened consumption compelled him to take a long journey in the South. Returning in 1827, he continued his studies and preached as a candidate in various churches. In 1829 he married a beautiful but delicate young woman, Ellen Tucker of Concord, and was installed as associate minister of the Second Church (Unitarian) in Boston. The retirement of his senior colleague soon left him the sole pastor. There was a homely elevation in Emerson's early sermons, a natural freshness in his piety, a quiet enthusiasm in his manner, that charmed thoughtful hearers. Early in 1832 he lost his wife, a sorrow that deeply depressed him in health and spirits. Following his passion for independence and sincerity, he arrived at the conviction that the Lord's Supper was not intended by Christ to be a permanent sacrament. He was willing to continue the service only if the use of the elements should be dropped and the rite made simply an act of spiritual remembrance. He found his congregation, not unnaturally, reluctant to agree with him, and therefore retired, not without some disappointment, from the pastoral office. He never again took charge of a parish; but he continued to preach, as opportunity offered, until 1847. In fact, he was always a preacher, his supreme task being to befriend and guide the inner life of man.

The strongest influences in his development about this time were the liberating philosophy of Coleridge, the mystical visions of Swedenborg, the intimate poetry of Wordsworth and the stimulating essays of Carlyle. On Christmas Day 1832 he started on a trip abroad, during which he met Landor, Coleridge, Carlyle and Wordsworth. His visit to Carlyle, in the lonely farmhouse at Craigenputtock, was the memorable beginning of a lifelong friendship. Emerson published Carlyle's first books in America; Carlyle introduced Emerson's essays into England. The two men were bound together by a mutual respect deeper than a sympathy of tastes and a community of spirit stronger than a similarity of opinions. Emerson was a sweet-tempered Carlyle, living in the sunshine. Carlyle was a militant Emerson, moving amid thunderclouds. The things that each most admired in the other were self-reliance, directness, moral courage. A passage in Emerson's diary, written on his homeward voyage, strikes the keynote of his remaining life. "A man contains all that is needful to his government within himself. . . . All real good or evil that can befall him must be from himself. . . . There is a correspondence between the human soul and everything that exists in the world; more properly, everything that is known to man. Instead of studying things without, the principles of them all may be penetrated into within him. . . . The purpose of life seems to be to acquaint man with himself. . . . The highest revelation is that God is in every man." Here is the essence of that intuitional philosophy commonly called Transcendentalism. Nevertheless, Emerson disclaimed allegiance to that philosophy. All through his life he navigated the Transcendental sea, piloted by a clear moral sense, warned off the rocks by the saving grace of humour, and kept from capsizing by a good ballast of New England prudence.

After his return from England in 1833 he went to live with his mother at the old manse in Concord, Mass., and began his career as a lecturer in Boston. His first discourses, delivered before the Society of Natural History and the Mechanics' Institute, were chiefly on scientific subjects, approached in a poetic spirit. In the autumn of 1835 he married Lydia Jackson of Plymouth, having previously purchased a spacious old house and garden at Concord. There he spent the remainder of his life, a devoted husband, a wise and tender father, a careful householder, a virtuous villager, a friendly neighbour, and, spite of all his disclaimers, the central and luminous figure among the Transcendentalists. Some mild departures from established routine he tranquilly tested and as tranquilly abandoned. His theory that manual labour should form part of the scholar's life was checked by the personal discovery that hard labour in the fields meant poor work in the study. "The writer shall not dig," was his practical conclusion. Intellectual independence was what he chiefly desired; and this, he found, could be attained in a manner of living not outwardly different from that of the average college professor or country minister. And yet it was to this property-holding, debt-paying, law-abiding, well-dressed, courteous-mannered citizen of Concord that the ardent and enthusiastic turned as the prophet of the new idealism. The influence of other Transcendental teachers was narrow and parochial compared with that of Emerson. Something in his imperturbable, kindly presence, his commanding style of thought and speech, announced him as the possessor of the great secret which many were seeking—the secret of a freer, deeper, more harmonious life. More and more, as his fame spread, those who "would live in the spirit" came to listen to the voice, and to sit at the feet, of the Sage of Concord.

It was on the lecture platform that he found his power and won his fame. The courses of lectures that he delivered at the Masonic Temple in Boston, during the winters of 1835 and 1836, were well attended and admired. They were followed by two discourses which commanded for him immediate recognition as a new and potent personality. His Phi Beta Kappa oration at Harvard college in August 1837, on "The American Scholar," was an eloquent appeal for independence, sincerity, realism, in the intellectual life of America. His address before the graduating class of the divinity school at Cambridge, in 1838, was an impassioned protest against what he called "the defects of historical Christianity" and a daring plea for absolute self-reliance and a new inspiration of religion. "In the soul," he said, "let redemption be sought. . . . Cast conformity behind you, and acquaint men at first hand with Deity." A blaze of controversy sprang up at once. Emerson made no reply. But amid this somewhat fierce illumination he went forward steadily as a public lecturer. It was not his negations that made him popular; it was the eloquence with which he presented the positive side of his doctrine. Whatever the titles of his discourses, "Literary Ethics," "The Present Age," "The Conduct of Life," their theme was always the same, namely, "the infinitude of the private man." Those who thought him astray on the subject of religion listened to him with delight when he poeticized the commonplaces of art, politics, literature or the household. The simplicity and symmetry of his sentences, the modulations of his thrilling voice, the radiance of his fine face, even his slight hesitations and pauses over his manuscript, lent a strange charm to his speech. For more than a generation he went about the country lecturing, and there was no man on the platform in America who excelled him in distinction, in authority, or in stimulating eloquence.

In 1847 Emerson visited Great Britain for the second time, was welcomed by Carlyle, lectured to appreciative audiences in Manchester, Liverpool, Edinburgh and London, made many new

friends in England and Scotland, paid a brief visit to Paris, and returned home in July 1848. The impressions of this journey were embodied in *English Traits* (1856). The book might be called "English Traits and American Confessions," for nowhere does Emerson's Americanism come out more strongly. But the America that he loved and admired was the ideal, the potential America. For the actual conditions of social and political life in his own time he had a fine scorn. He was an intellectual Brahmin. His principles were democratic, his tastes aristocratic. He loved man, but he was not fond of men. He had grave doubts about universal suffrage. He took a sincere interest in social and political reform, but towards specific "reforms" his attitude was somewhat remote and visionary. He was a believer in woman's rights, but he was lukewarm towards conventions in favour of woman suffrage. For a long time he refused to be identified with the Abolitionists. But as the irrepressible conflict drew to a head, Emerson's hesitation vanished. He said in 1856, "I think we must get rid of slavery, or we must get rid of freedom"; and with the outbreak of the Civil War he became an ardent and powerful advocate of the cause of the Union.

Emerson the essayist was a condensation of Emerson the lecturer. His prose works, with the exception of the slender volume entitled *Nature* (1836), were collected and arranged from the manuscripts of his lectures. His method of writing was characteristic. He planted a subject in his mind, and waited for thoughts and illustrations to come to it, as birds or insects to a plant or flower. When an idea appeared he followed it, "as a boy might hunt a butterfly"; when it was captured he pinned it in his "thought-book." The writings of other men he used more for stimulus than for guidance. "I value them," he said, "to make my top spin." His favourite reading was poetry and mystical philosophy, Shakespeare, Dante, George Herbert, Goethe, Berkeley, Coleridge, Swedenborg, Jakob Boehme, Plato, the new Platonists, and the religious books of the East (in translation). Next to these he valued books of biography and anecdote: Plutarch, Grimm, St. Simon, Varnhagen von Ense. Novels he seldom read. He was a follower of none, an original borrower from all. His illustrations were drawn from near and far. On his pages, close beside the Parthenon, the Sphinx, Etna and Vesuvius, you will find the White mountains, Monadnock, Katahdin, the pickerel weed in bloom, the wild geese honking through the sky, Wall street, cotton mills and Quincy granite. For an abstract thinker, he was strangely in love with the concrete facts of life. From the pages of his teeming notebooks he took the material for his lectures, arranging and rearranging it under such titles as "School," "Genius," "Beauty and Manners," "Self-Possession," "Duty," "The Superlative," "Truth." When the lectures had served their purpose he rearranged the material in essays and published them. Thus appeared in succession the following volumes: *Essays* (1st ser. 1841, 2nd ser. 1844); *Representative Men* (1850); *English Traits* (1856); *The Conduct of Life* (1860); *Society and Solitude* (1870); *Letters and Social Aims* (1876). Besides these, many other lectures were printed in separate form and in various combinations.

Emerson's style is brilliant, epigrammatic, gemlike; clear in sentences, obscure in paragraphs. He was a sporadic observer. He saw by flashes. The coherence of his writing lies in his personality. His work is fused by a steady glow of optimism. Yet he states this optimism moderately. "The genius which preserves and guides the human race indicates itself by a small excess of good, a small balance in brute facts always favourable to the side of reason."

His verse, though in form inferior to his prose, was perhaps a truer expression of his genius. He said, "I am born a poet"; and again, writing to Carlyle, he called himself "half a bard." He had "the vision," but not "the faculty divine" which translates the vision into music. In his two volumes of verse (*Poems*, 1847; *May Day and Other Pieces*, 1867) there are many passages of beautiful insight and profound feeling, some lines of surprising splendour, and a few poems, like "The Rhodora," "The Snow-Storm," "Ode to Beauty," "Terminus," "The Concord Ode," and the marvellous "Threnody" on the death of his first-born boy, of beauty unmarred and penetrating truth. But the total value of his poetical work is discounted by the imperfection of metrical form, the presence of incongruous images, the predominance of the intellectual over the emotional element, and the lack of flow. It is the material of poetry not thoroughly worked out. But the genius from which it came—the swift faculty of perception, the lofty imagination, the idealizing spirit enamoured of reality—was the secret source of all Emerson's greatness as a speaker and as a writer. Whatever verdict time may pass upon the bulk of his poetry, Emerson himself must be recognized as an original and true poet of a high order.

His later years were passed in peaceful honour at Concord. In 1866 Harvard college conferred upon him the degree of LL.D., and in 1867 he was elected an overseer. In 1870 he delivered a course of lectures before the university on "The Natural History of the Intellect." In 1872 his house was burned down, and was rebuilt by popular subscription. In the same year he went on his third foreign journey, going as far as Egypt. About this time began a failure in his powers, especially in his memory. But his character remained serene and unshaken in dignity. Steadily, tranquilly, cheerfully, he finished the voyage of life.

> I trim myself to the storm of time,
> I man the rudder, reef the sail,
> Obey the voice at eve obeyed at prime;
> "Lowly faithful, banish fear,
> Right onward drive unharmed;
> The port, well worth the cruise, is near,
> And every wave is charmed."

Emerson died April 27, 1882, and his body was laid to rest in the peaceful cemetery of Sleepy Hollow, on the edge of Concord.

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EMERY (Ger. *Smirgel*), an impure variety of corundum, much used as an abrasive or polishing substance, and occurring as a granular or massive, dark-coloured, dense substance, having much the appearance of an iron-ore. Its specific gravity varies with its composition from 3·7 to 4·3. Under the microscope, it is seen to be a mechanical aggregate of corundum, usually in grains or minute crystals of a bluish colour, with magnetite, which also is granular and crystalline. Other iron oxides, like haematite and limonite, may be present as alteration-products of the magnetite. Some of the alumina and iron oxide may occasionally be chemically combined, so as to form an iron spinel,

or hercynite. In addition to these minerals emery sometimes contains diaspore, gibbsite, margarite, chloritoid and sillimanite. Indeed emery must be regarded as a rock rather than a definite mineral species.

The hardness of emery is about 8, whereas that of pure corundum is 9. Its "abrasive power," or "effective hardness," is by no means proportional to the amount of alumina which it contains, but seems rather to depend on its physical condition. Thus, taking the effective hardness of sapphire as 100, J. Lawrence Smith found that the corresponding hardness of the emery of Samos with 70·10% of alumina was 56, that of Naxos, with 68·53 of Al_2O_3, 46, and that of Gumach with 77·82 of Al_2O_3, 47.

Emery has been worked from a very remote period in the Isle of Naxos, one of the Cyclades, whence the stone was called *naxium* by Pliny and other Roman writers. The mineral occurs as loose blocks and as lenticular masses or irregular beds in granular limestone, associated with crystalline schists, and has been found to contain 52·4% of corundum, 32·1 of magnetite, 11·5 of tourmaline, 2 of muscovite and 2 of margarite.

Important deposits of corundum were discovered in Asia Minor by J. Lawrence Smith, when investigating Turkish mineral resources about 1847. The chief sources of emery there are Gumach Dagh, a mountain about 12m. E. of Ephesus; Kula, near Alashehr; and the mines in the hills between Thyra and Cosbonnar, south of Smyrna. The occurrence is similar to that in Naxos. The emery is found as detached blocks in a reddish soil, and as rounded masses embedded in a crystalline limestone associated with mica-schist, gneiss and granite. It is believed to have originated by regional or contact metamorphism of bauxite deposits. The proportion of corundum in this emery is said to vary from 37 to 57%. Emery is worked at several localities in the United States, especially near Chester, Mass., where it is associated with peridotites.

The hardness and toughness of emery render it difficult to work, but it may be extracted from the rock by blasting in holes bored with diamond drills. In the East fire-setting is employed. The emery after being broken up is carefully picked by hand, and then ground or stamped and separated into grades by wire sieves. The higher grades are prepared by washing and elutriation, the finest being known as "flour of emery." A very fine emery dust is collected in the stamping room, where it is deposited after floating in the air, and is used by lapidaries and plate-glass manufacturers. Emery-wheels are made by consolidating the powdered mineral with an agglutinating medium like shellac or silicate of soda or vulcanized india-rubber, and are used not only by dentists and lapidaries but also, on a large scale, in mechanical workshops for grinding, shaping and polishing steel. Emery-sticks, emery-cloth and emery-paper are made by coating the several materials with powdered emery mixed with an adhesive medium. (*See* Corundum.)

EMETICS are substances given for the purpose of producing vomiting. It is customary to divide emetics into central, those which act on the vomiting centre in the medulla, and gastric, those which act directly on the stomach itself. The gastric emetics in common use are alum, ammonium carbonate, zinc sulphate, sodium chloride (common salt), mustard, and warm water. The central emetics are apomorphine, tartar emetic, ipecacuanha, senega, and squill. Of these, tartar emetic and ipecacuanha come under both heads; when taken by the mouth they act as gastric emetics before absorption into the blood, and later produce a further and more vigorous effect by stimulation of the medullary centre. Their action is accompanied by intense depression.

Emetics have two main uses: that of emptying the stomach, especially in cases of poisoning, and that of clearing the air passages, more especially in children. Where possible the first of these is nearly always replaced by use of the stomach pump, whereby depression is avoided. Emetics still have their place, however, in the treatment of bronchitis, laryngitis, and diphtheria in children. Occasionally also they are administered when a foreign body has entered the larynx.

EMIGRANTS' INFORMATION OFFICE: *see* Overseas Settlement Committee.

EMIGRATION, the movement of population out of one country into another. (*See* Migration.)

EMILIA, a territorial division (*compartimento*) of Italy, bounded by Venetia and Lombardy on the N., Liguria on the W., Tuscany on the S., the Marches on the S.E., and the Adriatic Sea on the E. It has an area of 7,967 sq.m., and a population of 2,477,690 (1901), which had grown to 3,033,113 (1921), embracing the provinces of Bologna, Ferrara, Forli, Modena, Parma, Piacenza, Ravenna and Reggio nell' Emilia.

The northern portion is a great plain from the Via Aemilia to the Po; its highest point is not more than 200 ft. above sea-level, while along the east coast are lagoons at the mouth of the Po and those called the Valli di Comacchio to the south of them, and to the south again the plain round Ravenna (10 ft.), which continues as far as Rimini, where the mountains come down to the coast.

Immediately to the south-east of the Via Aemilia the mountains begin to rise, culminating in the central chain of the Ligurian and Tuscan Apennines. The boundary follows the summits of the chain in the provinces of Parma, Reggio and Modena, passing over the Monte Bue (5,915 ft.) and the Monte Cimone (7,103 ft.), while in the provinces of Bologna and Forli it keeps along the N.E. slopes of the chain. With the exception of the Po, the main rivers of Emilia descend from this portion of the Apennines, the majority of them being tributaries of the Po; the Trebbia (which rises in the province of Genoa), Taro, Secchia and Panaro are the most important. Even the Reno, Ronco and Montone, which now flow directly into the Adriatic, were, in Roman times, tributaries of the Po, and the Savio and Rubicon seem to be the only streams of any importance from these slopes of the Tuscan Apennines which ran directly into the sea in Roman times. A considerable amount of electric power is derived from these rivers, and the stations are connected with the Alpine plants, so that interchange at different seasons is possible.

Railway communication in the plain of Emilia is mainly afforded by the line from Piacenza to Rimini. This, as far as Bologna, forms part of the main route from Milan to Florence and Rome, while beyond Rimini it follows the S.E. coast of Italy past Ancona as far as Brindisi and Lecce. The description follows this main line in a south-east direction. Piacenza, being immediately south of a bridge over the Po, is an important centre; a line runs to the west to Voghera, through which it communicates with the lines of west Lombardy and Piedmont, and immediately north of the Po a line goes off to Cremona. A new bridge over the Po carries a direct line from Cremona to Fidenza, and thence to Fornovo, on the line from Parma to Spezia. From Parma starts a main line, which crosses the Apennines to Spezia (and Sarzana, for Pisa and Rome), tunnelling under the pass of La Cisa, while lines run north and north-east to Brescia and Suzzara. From Reggio branch lines run to Guastalla, Carpi and Sassuolo, there being also a line from Sassuolo to Modena. At Modena the line to Verona through Suzzara and Mantua diverges to the north; there is also a branch north-north-east to Mirandola, and another south to Vignola. Bologna is, however, the most important railway centre; besides the line south to Pistoia and Florence over the Apennines (soon to be superseded by a direct line to Prato), and due north to Verona and the line south-east to Rimini, Ancona and Brindisi, there is the main line N.N.E. to Ferrara, Padua and Venice, and there are branches to Budrio and Portomaggiore to the north-east, and to S. Felice sul Panaro and Poggio Rusco to the north which connect the main lines of the district.

At Castel Bolognese, 5 m. N.W. of Faenza, a branch goes off to Lugo, whence there are connections with Budrio, Lavezzola (on the line between Ravenna and Ferrara) and Ravenna, and at Faenza a line goes across the Apennines to Florence. Rimini is connected by a direct line with Ravenna and Ferrara; and Ferrara, besides the main line S.S.W. to Bologna and N. by E. to Padua, has a branch to Poggio Rusco, on the main line between Bologna and Verona. The main products of the plain are cereals, vegetables (tomatoes), wine, and, in the marshy districts near the Po, rice; the system prevailing is that of the mezzadria—half the produce to the owner and half to the cultivator. Beet sugar is produced, the combined production of Emilia and Veneto being 78% of the

total for Italy. Still more, however, might be done with the aid of irrigation and reclamation: the latter is proceeding perhaps more successfully than the former. The ancient Roman divisions of the fields are still preserved in some places. There are also considerable pastures, and cheese is produced, especially Parmesan. Flax, hemp and silkworms are also cultivated, and a considerable quantity of poultry kept. The hill districts produce cereals, vines, olives and fruit; while on the mountains are considerable chestnut and other forests, and extensive summer pastures, the flocks going in part to the Maremma in summer, and in part to the pastures of the plain of the Emilia.

The name Emilia comes from the Via Aemilia (*q.v.*), the Roman road from Ariminum to Placentia, which traversed the entire district from S.E. to N.W., its line being closely followed by the modern railway. The name was transferred to the district (which formed the eighth Augustan region of Italy) as early as the time of Martial, in popular usage, and in the 2nd and 3rd centuries it is frequently named as a district under imperial judges, generally in combination with Flaminia or Liguria and Tuscia. The district of Ravenna was, as a rule, from the 3rd to the 5th century, not treated as part of Aemilia, the chief town of the latter being Placentia. In the 4th century Aemilia and Liguria were joined to form a consular province; after that Aemilia stood alone, Ravenna being sometimes temporarily added to it. The boundaries of the ancient district correspond approximately with those of the modern.

History.—In the Byzantine period Ravenna became the seat of an exarch; and after the Lombards had for two centuries attempted to subdue the Pentapolis (Ravenna, Bologna, Forli, Faenza, Rimini), Pippin took these cities from Aistulf and gave them, with the March of Ancona, to the papacy in 755, to which, under the name of Romagna, they continued to belong. The other chief cities of Emilia—Ferrara, Modena, Reggio, Parma, Piacenza—were independent, and each, whether belonging to Romagna or not, had a history of its own; and, notwithstanding the feuds of Guelphs and Ghibellines, prospered considerably. Pope Nicholas III. obtained control of the Romagna in 1278, but the papal dominion during the Avignon period was only maintained by the efforts of Cardinal Albornoz, a Spaniard sent to Italy by Innocent VI. in 1353. Even so, however, the papal supremacy was little more than a name; and this state of things only ceased when Caesar Borgia, the natural son of Alexander VI., crushed most of the petty princes of Romagna, intending to found there a dynasty of his own; but on the death of Alexander VI. it was his successors in the papacy who profited by what Caesar Borgia had begun. The majority of the towns were thenceforth subject to the church and administered by cardinal legates. In 1796–1814, Emilia was first incorporated in the Italian republic and then in the Napoleonic Italian kingdom; after 1815 Romagna returned to the papacy and its ecclesiastical government, the duchy of Parma was given to Marie Louise, wife of the deposed Napoleon, and Modena to the archduke Francis of Austria, the heir of the last Este. In Romagna and Modena the government was oppressive, arbitrary, corrupt and unprogressive, but in Parma things were better. In 1821 and 1831 there were unsuccessful attempts at revolt in Emilia, which were sternly and cruelly repressed; chronic discontent continued and the people joined again in the movement of 1848–49, which was crushed by Austrian troops. In 1859 the struggle for independence was finally successful, Emilia passing to the Italian kingdom almost without resistance.

EMINENCE, a title of honour now confined to the cardinals of the church of Rome. It was originally given as a complimentary title to emperors, kings, and then to less conspicuous persons. It passed into the Latin of the middle ages as a flattering epithet, and was applied in the church and by the popes to the dignified clergy at large, and sometimes as a form of civility to churchmen of modest rank. On June 10, 1630 Urban VIII. confined the use of the titles *Eminentiae* and *Eminentissimi* to the cardinals, to imperial electors, and to the master of the Hospital of St. John of Jerusalem (order of the Knights of Malta). Since the dissolution of the holy Roman empire, and the entire change, if not actual destruction, of the order of St. John, the title "eminence" has become strictly confined to the cardinals. Before 1630 the members of the sacred college were "illustrissimi" and "reverendissimi."

See du Cange, *Glossarium mediae et infimae latinitatis* (Niort and London, 1884), *s.v.* "Eminentia."

EMINENT DOMAIN, a term applied in law to the sovereign right of a State to appropriate private property to public uses, whether the owner consents or not. It is repeatedly employed by Grotius (*e.g.*, *De jure belli*, bk. iii. c. 20, s. 7), Bynkershoek (*Quaest. jur. pub.*, bk. 2, c. 15), and Puffendorf (*De jure naturae et gentium*, bk. i. c. 1, s. 19)—the two latter, however, preferring the word *imperium* to *dominium;* and by other Dutch jurists. But in modern times it is chiefly in the United States of America that the doctrine of eminent domain has received its application, and it is chiefly to American law that the following remarks refer. Eminent domain is distinguishable alike from the *police power,* by which restrictions are imposed on private property in the public interest, *e.g.*, in connection with the liquor traffic or public health (see *re Haff* [1904], 197 U.S. 488); from the *power of taxation,* by which the owner of private property is compelled to contribute a portion of it for public purposes; and from the *war-power,* involving the destruction of private property in the course of military operations. The police power fetters rights of property; eminent domain takes them away. The power of taxation is analogous to eminent domain as regards the purposes to which the contribution of the taxpayer is to be applied; but, unlike eminent domain, it does not necessarily involve a taking of specific property for those purposes. The destruction of property in military operations, or in the discharge of Government or other duties in cases of necessity, *e.g.*, in order to check the progress of a fire in a city, clearly cannot be said to be an exercise of the power of eminent domain. The question whether the element of compensation is necessarily involved in the idea of eminent domain has in modern times aroused much controversy. According to one school of thought (*see* Lewis, *Eminent Domain,* s. 10), this question must be answered in the negative. According to a second, whose view has the support of the civilians (*see* Randolph, *Eminent Domain,* s. 227; Mills, *Eminent Domain,* s. 1) compensation is an inherent attribute of the power. An intermediate view is advocated by Professor Thayer (*Cases on Constitutional Law,* vol. i. 953), according to which eminent domain springs from the necessities of government, while the obligation to reimburse rests upon the natural right of individuals. The right to compensation is thus not a component part of the power to take, but arises at the same time and the latter cannot exist without it. The relation between the two is that of substance and shadow. The matter is not, however, of great practical importance, for the Federal Constitution prohibits the exercise of the power "without just compensation" (5th Amendment), while in most of the States the State constitution or other legislation has imposed upon it a similar limitation; and the tendency of modern judicial decisions is in favour of the view that the absence of such a limitation will make an enactment so far unconstitutional and invalid.

In order to justify the exercise of the power of eminent domain, the purposes to which the property taken is to be applied must be "public," *i.e.*, primarily public, and not primarily of private interest and merely incidentally beneficial to the public (*Madisonville Traction Co. v. Mining Co.*, 1904, 196 U.S. 239). Subject to this definition, the term "public" receives a wide interpretation. All kinds of property may be taken; and the procedure indicated by the different legislatures must be followed. *See* COMPENSATION. (A. W. R.)

EMINESCU, MICHAIL (1849–1889), the greatest Rumanian poet of the 19th century, was born on Dec. 20, 1849 in Ipateshti near Botoshani, Moldavia. He was of Turco-Tatar origin, and his surname was originally Emin. He studied at Czernowitz, and joined a roving theatrical company where he played in turn the rôles of actor, prompter and stage-manager. After a few years spent in this way, he went to Vienna, Jena and Berlin, where he attended lectures, especially on philosophy. In 1874 he was appointed school inspector and librarian at the university of Jassy, but was soon turned out through the change of govern-

ment, and took charge, as editor-in-chief, of the Conservative paper *Timpul* (Times). In 1883 he had the first attack of the insanity hereditary in his family, and in 1889 he died in Bucharest. In 1870 his great poetical talent was revealed by two contributions to the *Convorbiri literare*, the organ of the Junimist party in Jassy; these were the poems "Venera şi Madona" and "Epigonii." Other poems followed and he was recognized as the first among the modern poets of his country. Mystically inclined and himself of a melancholy disposition, he lived in the glory of the mediaeval Rumanian past; he rebelled against the conventionality of society and his surroundings. Over all his poetry hangs a cloud of sadness, the sense of coming doom. Simplicity of language, masterly handling of rhyme and verse, deep thought and plastic expression made Eminescu the creator of a school of poetry which dominated the thought of Rumania and the expression of Rumanian writers and poets at the end of the 19th century and the beginning of the 20th.

Five editions of his collected poems appeared after 1890. Some of them were translated into German by "Carmen Sylva" and Mite Kremnitz, and others have also been translated into several other languages. Eminescu also wrote two short novels, real poems in prose (Jassy, 1890).

EMIN PASHA (Eduard Schnitzer) (1840–1892), German traveller, was born at Oppeln, Silesia, on March 28, 1840. He graduated M.D. at Berlin, and in 1865 became quarantine medical officer under the Turkish Government at Antivari. From 1870 to 1874 he was in the service of the governor of northern Albania, and adopted a Turkish name. In 1875 he went to Cairo, and next year was invited by Gen. Gordon to join him at Lado on the Upper Nile as medical officer. Gordon sent Schnitzer, now known as Emin Effendi, on missions to Uganda and Unyoro, and in 1878 Emin became governor of the equatorial province of the Sudan, a position which he retained after Gordon's departure. After the abandonment of the Sudan by the Egyptian Government in 1884 Emin Pasha (as he was now styled) was obliged to surrender various posts before the Mahdist advance, and eventually found himself isolated at Wadelai, whither he had removed his capital. There he was relieved by Stanley in April 1888. He does not seem to have welcomed the idea of leaving the province, but eventually he decided to leave with Stanley for the coast.

The German Government now asked him to undertake a new expedition in equatorial Africa with a commission "to secure on behalf of Germany the territories situated south of and along Victoria Nyanza up to Albert Nyanza." But soon after Emin's expedition started the Anglo-German agreement delimitating the British and German spheres of influence and excluding the Albert Nyanza from the German sphere was signed (July 1, 1890), and the political object of Emin's mission was thereby modified. Emin had difficulties with the German authorities in Tanganyika, epidemics among his force and he himself fell ill. In May 1891 he crossed into the Congo Free State; in December he sent the greater part of his caravan, under Dr. Stuhlmann, to the coast, while he himself remained behind with the sick. He encountered the hostility of the Arab traders in slaves and ivory, and was murdered at the instigation of one of these on Oct. 23 or 24, 1892, at Kinena, a place 80m. E.S.E. of Stanley Falls.

See *Emin Pasha in Central Africa* (1888), a collection of Emin's papers contributed to scientific journals; Major G. Casati (1838–1902), an Italian officer who spent several years with Emin, and accompanied him and Stanley to the coast, narrated his experiences in *Dieci anni in Equatoria* (Eng. ed., *Ten Years in Equatoria and the Return with Emin Pasha*, 1891); F. Stuhlmann, *Mit Emin Pascha ins Herz von Afrika* (1894); G. Schweitzer, *Emin Pasha, his Life and Work*, with introduction by R. W. Felkin (1898); A. Kettner, in *Deutsch. Rundschau für Geog.* 26 (1903), 13–17.

EMLYN, THOMAS (1663–1741), English nonconformist divine, was born at Stamford, Lincolnshire. He served as chaplain to the presbyterian Letitia, countess of Donegal, and then to Sir Robert Rich, afterwards (1691) becoming colleague to Joseph Boyse, presbyterian minister in Dublin. From this office he was virtually dismissed on his own confession of unitarianism, and for publishing *An Humble Inquiry into the Scripture Account of Jesus Christ* (1702) was sentenced to a year's imprisonment and a fine of £1,000. Thanks to the intervention of Boyse he was released in 1705 on payment of £90. He is said to have been the first English preacher definitely to describe himself as "unitarian." Emlyn preached a good deal in Paul's Alley, Barbican, in his later years, and died in London in 1741.

EMMANUEL or **IMMANUEL**, a Hebrew symbolical proper name meaning "God (is) with us." At a critical juncture the young King Ahaz of Judah was threatened in 734–733 B.C. by a coalition of north Israel and Syria which aimed at forcing him into an anti-Assyrian alliance. Isaiah, knowing of the King's intention to appeal to Assyria, dramatically intervened to dissuade him, and offered him a sign from Yahweh (Is. vii. 14–16). The actual character and significance of the sign have been variously interpreted (*see* G. B. Gray *ad loc.*). Two main interpretations have emerged: (*a*) any young woman who should within the year bear a son, might call his name Immanuel in token of the divine protection accorded to Judah (a variation of this interprets the mother to be the community of Sion); (*b*) a very attractive view was put forward by Gressmann (*Ursprung*, 1905) who interpreted the passage in the light of ancient eschatological ideas. There was a widespread belief among the people that a wonderful child should be born in the hour of the nation's need who would act as a divine redeemer; the expectation was vague and undefined but well-known, and the prophet makes this idea definite by announcing the advent of the Deliverer. The name, which occurs also in Is. viii. 8, is applied to Christ in Matthew i. 23.

EMMANUEL PHILIBERT (1528–1580), duke of Savoy, son of Charles III. and Beatrice of Portugal, was born on July 8, 1528. Charles, after trying in vain to remain neutral in the wars between France and the emperor Charles V., had been forced to side with the latter, whereupon his duchy was overrun with foreign soldiery and became the battlefield of the rival armies. Prince Emmanuel took service with the emperor in 1545 and distinguished himself in Germany, France and the Low Countries. On the death of his father in 1553 he succeeded to the title. He tried in vain to negotiate a separate peace with France; but in 1556 France and Spain concluded a five years' truce, by which each was to retain what it then occupied. This would have been the end of Savoy, but within a year the two powers were again at war. The chief events of the campaign were the successful resistance of Cuneo, held for the duke by Count Luserna, and the victory of St. Quentin (1557), won by Emmanuel Philibert himself against the French. At last in 1558 the powers agreed to an armistice, and in 1559, under the peace of Cateau-Cambrésis, Emmanuel regained his duchy, but on onerous terms, for France was to occupy several Piedmontese fortresses, including Turin and Pinerolo, for not more than three years, and a marriage was arranged between the duke and Margaret, duchess of Berry, sister of the French king; while Spain was to garrison Asti and Vercelli (afterwards exchanged for Santhià) until France evacuated the above-mentioned fortresses. The duke's marriage took place in Paris a few months later, and he re-entered his dominions. The condition of Piedmont at that time was deplorable, for wars, the exactions and devastations of the foreign soldiery and religious antagonism between Catholics and Protestants had wrought terrible havoc. The duke inaugurated a series of useful reforms, ably assisted by his minister, Niccolò Balbo. But progress was slow, and was accompanied by measures which abolished the states general, the last survival of feudal liberties. Savoy, following the tendency of the other states of Europe at that time, became thenceforth an absolute monarchy.

He had to deal with the vexed question of the Waldenses (*q.v.*) and, though he initiated repressive measures against them, he ended by allowing them a measure of religious liberty in their valleys (1561). He recommenced persecution some years later, but was dissuaded by his duchess and some of the German princes. He next turned his attention to getting rid of the foreign garrisons. In December 1562 the French departed on payment of 100,000 scudi, retaining only Pinerolo and Savigliano, and Turin became the capital once more. There remained the Bernese, who had occupied some of the duke's territories in Savoy and Vaud, and in Geneva, over which he claimed certain rights. With Bern he

made a compromise, regaining Gex, the Chablais, and the Génévois, on condition that Protestantism should be tolerated there, but he renounced Vaud and some other districts (1566). Disagreements with the Valais were settled in a similar way in 1569; but the Genevans refused to recognize Savoyard suzerainty.

Emmanuel reformed the currency, reorganized justice, prepared the way for the emancipation of the serfs, raised the standing army to 25,000 men, and fortified the frontiers, ostensibly against Huguenot raids, but in reality from fear of France. From Henry III., Emmanuel obtained in 1574 the evacuation of Pinerolo and Savigliano. Philip of Spain was likewise induced to evacuate Asti and Santhià in 1575. The duke rounded off his dominions by the purchase of Tenda and Oneglia, which increased his seaboard, and the last years of his life were spent in fruitless negotiations to obtain Monferrato, held by the Gonzagas under Spanish protection, and Saluzzo, which was a French fief. He died on Aug. 30, 1580, and was succeeded by his son Charles Emmanuel I. During the reign of Emmanuel Philibert the duchy, which had been more than half French, became predominantly Italian. He converted it from a ruined and divided land into a respectable independent power of the second rank, and, after Venice, the best-governed state in Italy.

See E. Ricotti, *Storia della monarchia Piemontese,* vol. ii. (Florence, 1861); Claretta, *La Successione di Emanuele Filiberto* (Turin, 1884).

EMMAUS, the name of two, or perhaps three, places in ancient Palestine. (1). Emmaus-Nicopolis (mod. 'Amwās), a town of the maritime plain about 20 m. from Jerusalem, on the road to Ramleh. Here Judas Maccabeus defeated Georgias (166 B.C.) and here, too, Vespasian established a fortified camp (A.D. 69). The name Nicopolis it received from Heliogabalus.

(2). The Emmaus of Luke. St. Luke (xxiv.) makes mention of Emmaus as being 60 stadia (*Codex Sinaiticus* and other mss. have 160) from Jerusalem, but with no indication of direction. Consequently, its location has been sought in all likely places at the shorter or longer radius. Thus Emmaus-Nicopolis (*see* above—176 stadia), Karyet el-'Anab (66), Kuloniyeh (36), El-Kubeibeh (63), 'Urtas (60), and Khirbet el-Khamasa (86), have been separately advocated. Emmaus-Nicopolis has much support. It has the name and a tradition in its favour, but its great distance from Jerusalem makes it difficult, if not impossible, to reconcile it with the details of Luke's narrative. Of the others, El-Kabeibeh and Kuloniyeh have most in their favour. Josephus (*Wars,* vii. 6, 6) speaks of an Emmaus at 30 stadia from Jerusalem, where Vespasian settled 800 veterans, making clear by his manner of reference that he knows of the existence of another Emmaus, presumably that of the Plain. Both the town and its name apparently disappeared, with so many others, in the widespread destruction during the revolt of 132 to 135. The Emmaus of Josephus would seem to accord well with Kuloniyeh (Colonia). Others who rely on mss. reading 60 instead of 30 stadia in Josephus' account, find his Emmaus at El-Kabeibeh, where the ruins of an early church and a tradition in existence in crusading times, place it. El-Kabeibeh, as Emmaus, would satisfy the Josephus account according to some mss., as well as the Lucan according to most mss.

(3). Emmaus (the Hamath of the Old Testament, mod. Hummām) was the name given by the Greeks to the hot springs that lie on the shore of the Sea of Galilee, a mile to the south of Tiberias.

EMMENDINGEN, a town of Germany, in the republic of Baden, close to the Black Forest, on the Elz. Pop. (1925) 8,835. It was formerly the seat of the counts of Hochberg, a cadet branch of the margraves of Baden. In 1418 it received market rights from the emperor, and in 1590 was raised to the status of a town, and walled, by Margrave Jacob III.

Emmendingen has spinning mills, tanneries and manufactories of paper, machinery and cigars. There is also trade in wine.

EMMERICH (the ancient *Embrica*), a town of Germany, in the Prussian Rhine province, on the right bank of the Rhine and the railway from Cologne to Amsterdam, 5m. N.E. of Cleves. Pop. (1925) 13,563. Emmerich, formerly called Embrika and Emrik, originally a Roman colony, is mentioned in records in the 7th century. St. Willibrord founded a monastery and church here. In 1233 the place came into the possession of the dukes of Gelderland and received the status of a town in 1247. In 1371 it fell to the duchy of Cleves, and passed with it in 1609 to Brandenburg. The town joined the Hanseatic League in 1407. It passed into the possession of Prussia in 1815.

It has some shipping trade, and manufactories of tobacco and cigars, chocolate, margarine, oil and sugar. There are also iron foundries and machine factories. The old minster church dates from the middle of the 11th century.

EMMET, ROBERT (1778–1803), Irish rebel, youngest son of Robert Emmet, physician to the lord-lieutenant of Ireland, was born in Dublin in 1778, and entered Trinity college, Dublin, in October 1793 where he had a distinguished academic career, showing special aptitude for mathematics and chemistry and acquiring a reputation as an orator. Without taking a degree he removed his name from the college books in April 1798, as a protest against the inquisitorial examination of the political views of the students conducted by Lord Clare as chancellor of the university. He then turned to political intrigue, being already to some extent in the secrets of the United Irishmen, of whom his elder brother Thomas Addis Emmet (*see* below) was one of the most prominent. In April 1799 a warrant was issued for his arrest, but was not executed; and in 1800 and the following year he travelled on the continent of Europe, where he entered into relations with the leaders of the United Irishmen, exiled since the rebellion of 1798, who were planning a fresh outbreak in Ireland in expectation of support from France. Emmet went to Paris in Oct. 1802, where he had an interview with Bonaparte which convinced him that the peace of Amiens would be of short duration and that a French invasion of England might be looked for in Aug. 1803. The councils of the conspirators were weakened by divided opinions as to the ultimate aim of their policy; and no clearly thought-out scheme of operations appears to have been arrived at when Emmet left Paris for Ireland in Oct. 1802. Those in his confidence afterwards denied that Emmet was himself the originator of the plan on which he acted; and several of the ablest of the United Irishmen held aloof, believing the project to be impracticable. Among the latter was Lord Cloncurry, at one time on the executive of the United Irishmen, with whom Emmet dined the night before he left Paris, and to whom he spoke of his plans with intense enthusiasm and excitement. Emmet's lack of discretion was shown by his revealing his intentions in detail to an Englishman named Lawrence, resident near Honfleur, with whom he sought shelter when travelling on foot on his way to Ireland. Arriving in Dublin at the end of October he received information to the effect that 17 counties were ready to take up arms if a successful effort were made in Dublin. For some time he remained concealed in his father's house near Miltown, making his preparations. A large number of pikes were collected and stored in Dublin during the spring of 1803, but fire-arms and ammunition were not plentiful.

The probability of a French invasion in August was increased by the renewal of the war in May, Emmet's brother Thomas being then in Paris in communication with Talleyrand and Bonaparte. But a discovery by the government of concealed arms, and an explosion at one of Emmet's depots in Patrick Street, necessitated immediate action, and July 23 was accordingly fixed for the projected rising. A plan of operations had been prepared by Emmet, the leading feature of which was a simultaneous attack on the castle, the Pigeon House and the artillery barracks at Island bridge; while bodies of insurgents from the neighbouring counties were to march on the capital. But the whole scheme miscarried. Some of Emmet's proposals, such as a plan for capturing the commander-in-chief, were vetoed by the timidity of his associates. On July 23, all was confusion at the depots, and the leaders were divided as to the course to be pursued; orders were not obeyed; a trusted messenger despatched for arms absconded with the money committed to him to pay for them; treachery, quite unsuspected by Emmet, honeycombed the conspiracy; the Wicklow contingent failed to appear; the Kildare men turned back on hearing that the rising had been postponed; a signal expected by a contingent at the Broadstone was never given. A false report

reached Emmet at one of his depots at nine o'clock in the evening that the military were approaching. Emmet put on a green and white uniform, and placed himself at the head of some 80 men, who marched towards the castle, being joined in the streets by a second body of about equal strength. Lord Kilwarden, proceeding to a hastily summoned meeting of the privy council, was dragged from his carriage by this rabble and murdered, together with his nephew Richard Wolfe; his daughter, who accompanied him, being conveyed to safety by Emmet himself. Emmet, now seeing that the rising had become a mere street brawl, made his escape; a detachment of soldiers quickly dispersed his followers.

After hiding for some days in the Wicklow mountains Emmet repaired to the house of a Mrs. Palmer at Harold's Cross, in order to be near the residence of John Philpot Curran (*q.v.*), to whose daughter Sarah he had for some time been secretly attached. In the hope of persuading this lady to fly with him to America, Emmet lingered in the neighbourhood till Aug. 25, when he was captured. At his trial he was defended and betrayed by the infamous Leonard MacNally (*q.v.*), and was convicted of treason; and after delivering an eloquent speech from the dock, was hanged on Sept. 20, 1803.

Robert Emmet was a youth of modest character, pure motives and winning personality. Thomas Moore, who warmly eulogizes Emmet, with whom he was a student at Trinity college, records that one day when he was playing on the piano the melody "Let Erin remember," Emmet started up exclaiming passionately, "Oh, that I were at the head of 20,000 men marching to that air!" He had no knowledge of the world or of men; he trusted every one with child-like simplicity; except personal courage he had none of the qualities essential to leadership in such an enterprise as armed rebellion. His love affair with Sarah Curran inspired Thomas Moore's well known songs, "She is far from the land where her young hero sleeps," and "Oh, breathe not his name"; it is also the subject of Washington Irving's "The Broken Heart." Emmet was short and slight in figure; his face was marked by smallpox, and he was described in 1803 for the purpose of identification as being "of an ugly, sour countenance and dirty brown complexion." A few poems by Emmet, of little merit, are appended to Madden's biography.

See R. R. Madden, *The United Irishmen, their Lives and Times* (2nd ed. 4 vols., Dublin, 1858–60); Charles Phillips, *Recollections of Curran and Some of his Contemporaries* (2nd ed. 1822); Henry Grattan, *Memoirs of the Life and Times of the Right Hon. H. Grattan* (5 vols. 1839–46); W. H. Maxwell, *History of the Irish Rebellion in 1798; with Memoirs of the Union and Emmet's Insurrection in 1803* (1845); W. H. Curran, *Life of J. P. Curran* (2 vols., Edinburgh, 1822); Thomas Moore, *Life and Death of Lord Edward Fitzgerald* (2 vols. 3rd ed., 1832); and *Memoirs, Journals and Correspondence of Thomas Moore,* edited by Lord John Russell (8 vols., 1853–56).

EMMET, THOMAS ADDIS (1764–1827), Irish lawyer and politician, elder brother of Robert Emmet (*q.v.*), the rebel, was born at Cork on April 24, 1764, and was educated at Trinity college, Dublin, and at Edinburgh University where he studied medicine. After visiting the chief medical schools on the continent, he returned to Ireland in 1788; but the sudden death of his older brother, Christopher Temple Emmet, a barrister of some distinction, induced him to follow the advice of Sir James Mackintosh to forsake medicine for the law as a profession. He was called to the Irish bar in 1790 and quickly obtained a practice, principally as counsel for prisoners charged with political offenses, and he became the legal adviser of the leading United Irishmen. When the Dublin corporation issued a declaration of Protestant ascendancy in 1792, the counter-manifesto of the United Irishmen was drawn up by Emmet; and in 1795 he took the oath of the society in open court, becoming secretary in the same year and a member of the executive in 1797. Emmet was among the more prudent of the United Irishmen on the eve of the rebellion; he engaged in conspiracy with reluctance, and in opposition to bolder spirits like Lord Edward Fitzgerald, he discountenanced the taking up of arms until help should be obtained from France. After the rebellion he was imprisoned with the other leaders at Fort George till 1802. On his release, he went to Brussels, and was involved in the attempt to raise a fresh insurrection with Napoleon's assistance. On the failure of Robert Emmet's rising in 1803, he emigrated to the United States. Joining the New York bar he obtained a lucrative practice and in 1812–13 was attorney-general of New York; his abilities and success being such that Judge Story declared him to be "by universal consent in the first rank of American advocates." He died while conducting a case in court on Nov. 14, 1827. Thomas Emmet married, in 1791, Jane, daughter of the Rev. John Patten, of Clonmel.

See authorities under EMMET, ROBERT; also Alfred Webb, *Compendium of Irish Biography* (Dublin, 1878); C. S. Haynes, *Memoirs of Thomas Addis Emmet* (1829); Theobald Wolfe Tone, *Memoirs,* ed. W. T. W. Tone (2 vols., 1827); W. E. H. Lecky, *Hist. of Ireland in the 18th Century,* vol. iv., 5 vols. (1892).

EMMETT, DANIEL DECATUR (1815–1904), American song-writer, was born at Mount Vernon, Ohio. He started the "negro minstrel" performances, which from 1842 onwards became so popular in America and England, but is remembered particularly as the writer of the famous Southern war-song "Dixie," which he composed in 1859.

EMMITSBURG, a town of Frederick county, Md., U.S.A., 60m. N.W. of Baltimore, near the northern boundary of the State, served by the Emmitsburg railroad. The population was 940 in 1920. Near by are Mount St. Mary's college and Ecclesiastical seminary (Roman Catholic; founded 1808), which has trained many leaders of the Church; and St. Joseph's college for women (incorporated 1816). The town was settled about 1773 and was incorporated in 1824. It was here that the order of the Sisters of Charity was introduced into the United States by Mrs. Elizabeth Ann Seton in 1809.

EMMIUS, UBBO (1547–1625), Dutch historian and geographer, was born at Gretha, East Friesland, on Dec. 5, 1547. After studying at Rostock, he spent two years in Geneva, where he became intimate with Theodore Beza; and returning to the Netherlands was appointed the principal of a college at Norden, a position which he lost in 1587 because, as a Calvinist, he would not subscribe to the Confession of Augsburg. Subsequently he was head of the College at Groningen and when in 1614 this college became a university he was chosen principal and professor of history and Greek at the new university of Groningen and by his wise guidance and his learning speedily raised the new university to a position of eminence. He was on friendly terms with Louis, count of Nassau; corresponded with many of the learned men of his time; and died at Groningen on Dec. 9, 1625. The chief works of Emmius are: *Rerum Frisiarum historiae decades* in six parts, a complete edition of which was published at Leiden in 1616; *Opus chronologicum* (Groningen, 1619); *Vetus Graecia illustrata* (Leiden, 1626); and *Historia temporis nostri* (Groningen, 1732). An account of his life, written by Nicholas Mulerius, was published, with the lives of other professors of Groningen, at Groningen, in 1638.

See his correspondence (2 vols., 1911–22), ed. Brugmans and Wachter.

EMMONS, EBENEZER (1800–1863), American geologist, was born at Middlefield, Mass., May 16, 1800. He studied medicine at Albany, and after taking his degree practised for some years in Berkshire county. His interest in geology was kindled in early life, and in 1824 he had assisted Prof. Chester Dewey (1784–1867) in preparing a geological map of Berkshire county, in which the first attempt was made to classify the rocks of the Taconic area. While undertaking professional work in natural history and geology in Williams college, he also accepted the professorship of chemistry and afterwards of obstetrics in the Albany medical college. The chief work of his life was, however, in geology, and he has been designated by Jules Marcou as "the founder of American palaeozoic stratigraphy, and the first discoverer of the primordial fauna in any country." In 1836 he became attached to the geological survey of the State of New York, and after lengthened study he grouped the local strata (1842) into the Taconic and overlying New York systems. The latter system was subdivided into several groups that were by no means well defined. Emmons had previously described the Potsdam sandstone (1838), and this was placed at the base of the New York system. It is now regarded as Upper Cambrian. In

1844 Emmons for the first time obtained fossils in his Taconic system: a notable discovery because the species obtained were found to differ from all palaeozoic fossils then known, and they were regarded as representing the primordial group. Marcou was thus led to advocate that the term Taconic be generally adopted in place of Cambrian. Nevertheless, the Taconic fauna of Emmons has proved to include only the lower part of Sedgwick's Cambrian. Considerable discussion has taken place on the question of the Taconic system, and whether the term should be adopted; and the general opinion has been adverse. Emmons made contributions on agriculture and geology to a series of volumes on the natural history of New York. He also issued a work entitled *American Geology; containing a statement of the principles of the Science, with full illustrations of the characteristic American Fossils* (1855–57). From 1851 to 1860 he was State geologist of North Carolina. He died at Brunswick, N.C., Oct. 1, 1863.

See the "Biographical Notice of Ebenezer Emmons," by J. Marcou; *Amer. Geologist,* vol. vii. (Jan. 1891), p. 1 with portrait and list of publications.

EMOTION, a vivid feeling and state of excitement induced by the apprehension of some object which arouses an instinctive reaction; *e.g.,* the perception, memory or imagination of any object that threatens danger, and so arouses the instinct of self-preservation, induces an emotion of fear. Similarly with the other emotions. (*See* FEELING, PSYCHOLOGY OF; JAMES-LANGE THEORY OF EMOTIONS; EXPRESSION OF THE EMOTIONS; PSYCHOLOGY.)

EMOTIONS, ANALYSIS OF. The analysis of emotions has two most important aspects. First, attempts are being made to determine the nature of emotion. Second, theoretical and experimental efforts are being undertaken to determine the elementary emotions and to analyze the more complex emotional states into such elements.

There is much dispute among leading authorities as to the nature of emotion. Five principal views are upheld and at present are under experimental investigation.

First, the James-Lange theory, with modifications, is defended by some psychologists (*see* Allport, *Social Psychology*). That theory maintains that all emotions consist ultimately of sensations. James emphasized sensations resulting from skeletal movements caused by the exciting object, and sensations caused directly by the exciting object itself. Lange emphasized visceral sensations, caused by movements of the viscera resulting from perception of the exciting object. Some writers follow James' emphasis, some follow Lange's, and some give approximately equal weight to both types of sensation as components of emotion.

Three lines of experimental evidence weigh against acceptance of any version of the James-Lange theory. First, Lenander, Sherrington, Goltz, Cannon and others have produced much physiological evidence against the theory. Visceral sensations have been shown to be very sparse, with a small number of receptor organs for sensation located in the viscera. Dogs have been shown to retain their former emotions unimpaired and even to experience emotions never felt before, when nearly all visceral change has been prevented by appropriate spinal transection. On the other hand, when a sufficient portion of the central nervous system (brain) has been removed, only the emotion of rage persists. Another line of evidence, advanced by Cannon and others, shows that visceral changes must be virtually identical during many different emotions. Second, experimenters (Marañon) have shown that administration of adrenalin, which produces the very visceral sensations said to compose emotion, does not in fact cause emotion in human subjects, unless the appropriate emotional *idea* is also supplied by suggestion or previous experience. Third, psychological experiments (Blatz, Marston, Brunswick) indicate that the emotion occurs more quickly than the visceral changes, does not run parallel with the visceral changes, and can be distinguished introspectively from sensations which may or may not accompany it (Nafe, Conklin and Dimmick, Titchener, Cornell Laboratory). The James-Lange theory, though still under experimental investigation, seems quite definitely disproved.

Second, some behaviourists hold a view closely akin to Lange's theory but much more radical in that the bodily changes themselves, and not their sensations, are regarded as constituting the emotion. These behaviourists, of course, deny the existence of consciousness of any sort, their emotion theory being but a corollary of this general position. (For evidence on this issue *see* the article on CONSCIOUSNESS.) The behaviourists distinguish between emotional and other responses simply by defining all visceral changes as emotional. Therefore, the same evidence cited against the James-Lange theory likewise weighs against their contention.

Third, those psychologists who still uphold the concept of instinct regard emotion as one aspect of the consciousness accompanying instinctive behaviour patterns. This view has been carried still further by regarding emotion as the "inner" or "subjective" or "self" aspect of all action. Another slightly different version holds that emotion occurs only when the basic instincts or "drives" are blocked by some obstacle in the environment, or are thwarted by malfunctioning of the individual organism. The number of instincts, with corresponding emotions, varies considerably in different theories. McDougall gives 13 major and 7 minor instincts; Colvin 30; Kirkpatrick 30; James originally described 52; and Woodworth seems to accept about 110. These large and varying numbers of ultimately different emotions accepted by the instinctivists appear to offer little hope of finding any common factor upon which all would agree as the true nature of emotion. Experimental proof of this view of emotion depends upon proof or disproof of instinct. Experiments in animal psychology are best adapted to this problem.

Fourth, the tenets of leading psycho-analysts assume a libido, with either one or two fundamental departments, sex, or sex and ego. This view is really very close to that of the instinctivists, as McDougall points out (*Body and Mind*); since both sex and ego can be thought of as little else than basic instincts with corresponding and accompanying emotions. The physiological basis of the libido and its emotions is hazy, to say the least. Experimental testing of this view of the ultimate nature of emotion is therefore impossible. But social and group-analysis studies (Trigant Burrow) are seeking to amass evidence that the libido's dynamic drives and emotions underlie all human conduct.

Fifth, there are psychological and physiological theories which regard emotion and feeling as distinctive consciousness products of certain portions of the brain or nervous system (Cannon). A recent (1927) integrative theory of this type maintains that affection is motor consciousness generated by integration of nervous impulses in the motor centres, just as sensation is sensory consciousness generated by integration of impulses in the sensory centres (Marston). According to this view some affective awareness must accompany all bodily action brought about by activity of the central nervous system. In this respect the theory agrees with the essential point of both the instinctive and psychoanalytical views, and with James's original assertion that awareness of bodily changes as they occur is the emotion. Some experimental verification of this theory has been found, but adequate technique for a crucial test of the theory has not yet been perfected. It is, however, clearly subject to experimental proof or disproof.

The second important aspect of analysis of emotions concerns various attempts to discover primary or elementary emotions, from which all other emotions are built up. One view of this problem, maintained by some behaviouristic experimenters, holds that there is no such thing as a discreet, individual emotion, qualitatively distinct from all others, but that "general emotionality" (Landis) only exists. This theory is based upon a failure to find distinctive emotional expressions in the form of invariable bodily changes for any of the emotions (fear, rage, etc.) experimentally evoked, and thus presumes, without investigation, that fear, rage, etc., are ultimately simple emotion elements, and also that simple emotion elements must produce uniform bodily changes.

Other theories which postulate more or less specific primary emotions, or emotion elements, are those of the instinctivists and

psychoanalysts, already discussed. The selection by the psychoanalysts of love (sex) and appetite (ego-emotion) as emotion elements is based upon a great deal of clinical data; but the concepts of sex and ego thus arrived at clearly depict compound and not simple emotion elements.

Recent psychological findings suggest a definite neurological basis for love and appetite as the two basic compound emotions, and further present evidence for the existence of two simpler emotion elements in each compound (Marston). Appetite is composed of compliance and dominance, and love is composed of inducement and submission. Fear results from over-compliance, rage from over-dominance, and other destructive emotions from conflicts and maladjustments between the four emotion elements.

Watson's findings with regard to emotion elements in young infants closely accord with those just given. Watson finds only three emotions in children, but one of those three, love, includes descriptions of both inducement and submission emotions. Watson terms all compliance emotion fear, and all dominance rage. The classifications of emotion elements by Watson and Marston are in close agreement.

The only basis for emotional analysis of human beings in need of personality readjustment has been introspective reports, with reports of dreams and free associations therefrom. These have furnished an extremely indefinite and subjective basis for psychoanalytical procedures, which have nevertheless accomplished surprisingly effective practical results. When emotion elements are identified objectively, by observing the subject's behaviour, personality analysis and readjustment is placed upon a scientific basis, with promise of greater success.

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EMPATHY, a term used as the equivalent of the German *Einfühlung,* which is very difficult to translate. It is modelled on the word sympathy. The term is used with special (but not exclusive) reference to aesthetic experience. The most obvious example perhaps is that of the actor or singer when he *feels* the part he is performing or (better perhaps) reading or studying. Similarly with other works of art. One may, by a kind of introjection, "feel oneself into" what one observes or contemplates. Whereas in empathy proper the observer assimilates himself to his aesthetic object, in animism he assimilates an inanimate object to himself. This latter process is much easier than the former; and no doubt it happens often enough in aesthetic experience that the subject assimilates the aesthetic object to himself, though he may mean to assimilate himself for the time being to his object, to be sympathetic with it. *See* AESTHETICS.

See also T. Lipps, *Aesthetik* (1903); J. Volkelt, *System der Aesthetik* (1905, etc.); D. W. H. Parker, *The Analysis of Art* (1927).

EMPEDOCLES (*c.* 490–430 B.C.), Greek philosopher and statesman, a citizen of Akragas in Sicily. It seems that he carried on the democratic tradition of his distinguished family by helping to overthrow an oligarchic government which succeeded the tyranny in Agrigentum, but refused the invitation of the citizens to become their king. Later he left the city, and died in the Peloponnese in 430.

Of his poem on nature (φύσις) there are left about 400 lines in unequal fragments out of the original 5,000; of the hymns of purification (καθαρμοί) less than 100 verses remain; of the other works, improbably assigned to him, nothing is known. His grand but obscure hexameters, after the example of Parmenides, delighted Lucretius. Aristotle, it is said, called him the father of rhetoric, and Galen regarded him as the founder of the Italian medical school. To his contemporaries he seemed more than a mere man, and the people of Agrigentum have never ceased to honour his name; even in modern times he has been celebrated by followers of Mazzini as the democrat of antiquity *par excellence.*

As his history is uncertain, so are his doctrines. He is at once a believer in Orphic mysteries, and a scientific thinker. There are, he holds, four ultimate unchangeable elements, four primal divinities, of which are made all structures in the world—fire, air, water, earth. These four roots of all things are eternally brought into union, and eternally parted by two active corporeal forces, love and strife—forces which can be seen working amongst men, but which really pervade the whole world. Nothing new comes or can come into being; the only change that can occur is a change in the juxtaposition of element with element.

Empedocles seems to have conceived a period when love was predominant, and all the elements formed one great sphere. Since that period discord gained more sway; the actual world was full of contrasts and oppositions, due to the combined action of both principles. His theory attempted to explain the separation of elements by strife, the formation of earth and sea, of sun and moon, of atmosphere. His most interesting views dealt with the origin of plants and animals, and with the physiology of man. As the elements combined through the work of love, there appeared quaint results—heads without necks, arms without shoulders. Then as these structures met, there were seen horned heads on human bodies, bodies of oxen with men's heads, and figures of double sex. But most of these disappeared as suddenly as they arose; only in those rare cases where the several parts were adapted to each other did the complex structures last. Soon various influences reduced the creatures of double sex to a male and a female, and the world was replenished with organic life. This theory seems a crude anticipation of the modern "survival of the fittest" theory.

As man, animal and plant are composed of the same elements in different proportion they have an identity of nature. They all have sense and understanding, mind in man being always dependent upon the body. Hence the precepts of morality are with Empedocles largely dietetic. Knowledge is explained by the principle that the several elements in things are perceived by the corresponding elements in ourselves. Like is known by like. The organs of sense are specially adapted to receive the effluxes from bodies around us; and in this way arises perception which is not merely passive. The heart, not the brain, is the organ of consciousness. According to Aristotle, Empedocles made no distinction between perception and thought.

It is not easy to harmonize these theories with the Pythagorean theory of transmigration of souls which Empedocles seems to expound. Probably the doctrine that the divinity (δαίμων) passes from element to element, nowhere finding a home, is a mystical way of teaching the continued identity of the principles which are at the bottom of every phase of development from inorganic nature to man. At the top of the scale are the prophet and the physician, those who have best learned the secret of life; they are next to the divine. It is the business of the philosopher to lay bare the fundamental difference of elements, and to display the identity between what seem unconnected parts of the universe.

See Diog. Laërt. viii. 51–77; Sext. Empiric. *Adv. math.* vii. 123; Simplicius, *Phys.* f. 24, f. 76. For text S. Karsten, "Empedoclis Agrigenti carminum reliquiae," in *Reliq. phil. vet.* (Amsterdam, 1838); F. W. A. Mullach, *Frag. philos. Graec.* vol. i.; H. Stein, *Empedoclis Agrigenti fragmenta* (Bonn, 1882); Diels, *Die Frgm. der Vorsokratiker* vol. i. (4th ed., 1922); Ritter and Preller, *Historia philosophiae* (4th ed., Gotha, 1869); verse translation, W. E. Leonard (1908). For criticism E. Zeller, *Phil. der Griechen* (Eng. trans., 1881); A. W. Beun, *Greek Philosophers* (1882); J. A. Symonds, *Studies of the Greek Poets* (3rd ed., 1893); Millerd, *On the Interpretation of Empedocles* (1908); T. Gomperz, *Greek Thinkers,* vol. i. (Eng. trans., 1901); J. Burnett, *Early Greek Philosophy* (1920) giving trans. of the fragments in Diels; W. Windelband, *Gesch. der abendl. Phil. im altertum* (4th ed., 1923); Überweg, *Grund. der gesch. der phil.* pt. 1. (1926). (W. WAL.; X.)

EMPEROR, a title formerly borne by the sovereigns of the Roman empire (*see* EMPIRE), and since their time, partly by derivation, partly by imitation, used by a variety of other sovereigns. Under the republic, the term *imperator* applied in theory to any magistrate vested with *imperium;* but in practice it was only used of a magistrate who was acting abroad (*militiae*) and was thus in command of troops. The term *imperator* was the natural and regular designation employed by his troops in addressing such a magistrate; but it was specially employed by them to salute him after a victory; and when he had been thus saluted he could use the title of *imperator* in public till the day of his triumph

at Rome, after which it would lapse along with his *imperium*. The senate itself might, in the later republic, invite a victorious general to assume the title; and in these two customs—the salutation of the troops and the invitation of the senate—we see in the germ the two methods by which under the empire the *princeps* was designated; while in the military connotation attaching to the name even under the republic we can detect in advance the military character by which the emperor and the empire were afterwards distinguished. Julius Caesar was the first who used the title continuously (from 58 B.C. to his death in 44 B.C.), as well *domi* as *militiae;* and his nephew Augustus took a further step when he made the term *imperator* a *praenomen*, a practice which after the time of Nero becomes regular. But apart from this amalgamation of the term with his regular name, and the private right to its use which that bestowed, every emperor had an additional and double right to the title on public grounds, possessed as he was of an *imperium infinitum maius*, and commanding all the troops of the empire. The title *imperator* was conferred by the senate; and an emperor normally dates his reign from the day of his salutation by the senate. But the troops were also regarded as still retaining the right of saluting an *imperator;* and there were emperors who regarded themselves as created by such salutation and dated their rights accordingly. The military associations of the term thus resulted, only too often, in making the emperor the nominee of a turbulent soldiery.

Augustus had been designated (not indeed officially, but none the less regularly) as *princeps*—the first citizen of the State. The designation suited the early years of the empire, in which a dyarchy of *princeps* and senate had been maintained. But by the 2nd century the dyarchy is passing into a monarchy: the title of *princeps* recedes, and the title of *imperator* comes into prominence to designate not merely the possessor of a certain *imperium*, or the general of troops, but the simple monarch in the fullness of his power as head of the State. From the days of Diocletian there are occasionally two emperors, but not, at any rate in theory, two empires; the two emperors are the dual sovereigns of a single realm. But from the time of Arcadius and Honorius (A.D. 395) there are in reality (though not in theory) two empires as well as two emperors, one of the East and one of the West.

On the revival of the Roman empire in the West by Charlemagne in 800, the title (at first in the form *imperator*, or *imperator augustus*, afterwards *Romanorum imperator augustus*) was taken by him and by his Frankish, Italian and German successors, heads of the Holy Roman empire, down to the abdication of the Emperor Francis II. in 1806. The doctrine had, however, grown up in the earlier middle ages (about the time of the Emperor Henry II., 1002–24) that although the emperor was chosen in Germany (at first by the nation, afterwards by a small body of electors), and entitled from the moment of his election to be crowned in Rome by the pope, he could not use the title of emperor until that coronation had actually taken place. The German sovereign, therefore, though he exercised, as soon as chosen, full imperial powers both in Germany and Italy, called himself merely "king of the Romans" (*Romanorum rex semper augustus*) until he had received the sacred crown in the sacred city.

In mediaeval times the emperor, conceived as vicegerent of God and co-regent with the pope in government of the Christian people committed to his charge, might almost be regarded as an ecclesiastical officer. Not only was his function regarded as consisting in the defence and extension of true religion; he was himself arrayed in ecclesiastical vestments at his coronation; he was ordained a subdeacon; and, assisting the pope in the celebration of the Eucharist, he communicated in both kinds as a clerk. The same sort of ecclesiastical character came also to be attached to the tsars[1] of Russia, who—especially in their relations with the Orthodox Eastern Church—might have vindicated for themselves (though the sultans of Turkey have disputed the claim) the succession to the East Roman emperors (*see* EMPIRE). But the title of emperor was also used in the middle ages, and is still used, in a loose and vague sense, without any ecclesiastical connotation or hint of connection with Rome (the two attributes which should properly distinguish an emperor), and merely in order to designate a non-European ruler with a large extent of territory. It was thus applied to the rulers of China and Japan; it was attributed to the Mogul sovereigns of India; and since 1876 it has been used by British monarchs in their capacity of sovereigns of India (*Kaiser-i-Hind*).[1]

Since the French Revolution and during the course of the 19th century the term emperor has had an eventful history. In 1804 Napoleon took the title of "Emperor of the French," and posed as the reviver of the empire of Charlemagne. Afraid that Napoleon would next proceed to deprive him of his title of Holy Roman emperor, Francis II., in 1804, invested himself with a new title, that of "Hereditary Emperor of Austria," and then, in 1806, abdicated his old, historical title and dissolved the Holy Roman empire. Thus the old and true sense of the term emperor —the sense in which it was connected with the Church in the present and with Rome in the past—finally perished; and the term became partly an apanage of Bonapartism (Louis Napoleon resuscitated it as Napoleon III. in 1853), and partly a personal title of the Hapsburgs as rulers of their various family territories. In 1870, however, a new use of the title was begun, when the union of Germany was achieved, and the Prussian king, who became the head of united Germany, received in that capacity the title of German emperor. Here the title of emperor designated the president of a federal State; and here the Holy Roman emperor of the 17th and 18th centuries, the president of a loose confederation of German States, may be said to have found his successor. But the term has been widely and loosely used in the course of the 19th century. It was the style from 1821 to 1889 of the princes of the house of Braganza who ruled in Brazil; it has been assumed by usurpers in Haiti, and in Mexico it was borne by Augustin Iturbide in 1822 and 1823, and by the ill-fated Archduke Maximilian of Austria from 1864 to 1867.

See J. Selden, *Titles of Honour* (1672); Sir E. Colebrooke, "On Imperial and Other Titles" in the *Journal of the Royal Asiatic Society* (1877); J. Bryce, *Holy Roman Empire* (1904). *See* also the articles on "Imperator" and "Princeps" in Smith's *Dictionary of Greek and Roman Antiquities.*

EMPEROR-FISH (*Holocanthus imperator*), a large and gorgeously coloured coral fish of the family *Chaetondontidae* (butterfly fishes, *q.v.*), reaching a length of 15 in. and found from East Africa to Malaya. It is an excellent table-fish.

EMPETRACEAE, a family of dicotyledonous plants the best known member of which is the crowberry (*q.v.*) There are only four species, in three genera, confined to the northern hemisphere and the Andes. The parts of the flowers are in threes and the fruit is a drupe.

EMPHYSEMA, a medical term applied to two conditions—"pulmonary emphysema" (the word "pulmonary" is frequently omitted) and "surgical emphysema." Of pulmonary emphysema there are two forms, vesicular and interstitial (or interlobular). In vesicular emphysema there is enlargement of air-vesicles, from excessive distension and destruction of the septa between contiguous vesicles (*see* RESPIRATORY SYSTEM). In interstitial emphysema air is present in the connective tissue beneath the pleura and between the pulmonary air-cells.

The former variety is by far the more common and generally is caused by forced expiration against a closed glottis, as in coughing. Hence emphysema is most evident over relatively

[1]The word *Tsar*, like the German *Kaiser*, is derived from Caesar (*see* TSAR). Peter the Great introduced the use of the style "Imperator," and the official designation afterwards became "Emperor of all the Russias, Tsar of Poland, and Grand Duke of Finland," though the term tsar was still popularly used in Russia.

[1]For the titles of βασιλεύς, *Imperator Augustus*, etc., applied in the 10th century to the Anglo-Saxon kings, *see* EMPIRE (note). The claim to the style of emperor, as a badge of equal rank, played a considerable part in the diplomatic relations between the sultan and certain European sovereigns. Thus, at a time when this style (padishah) was refused by the sultan to the tsars of Russia, and even to the Holy Roman emperor himself, it was allowed to the French kings, who in diplomatic correspondence and treaties with Turkey called themselves "emperor of France" (*empereur de France*).—(ED.)

unsupported parts of the lungs, *e.g.*, above the collar bone and between the ribs. Probably an impaired nutritive condition of the lung tissue conduces towards the change. Emphysema is a progressive condition, since the distended air vesicles have lost their elasticity. Moreover, many of the pulmonary capillary blood vessels which run in the inter-vesicular septa have been destroyed and the rest are elongated and narrowed. Hence an increased strain is thrown on the right ventricle, with a consequent dilatation leading on to heart failure and all its attendant troubles. The chief symptom in this complaint is shortness of breath, more or less constant, but greatly aggravated by exertion and by attacks of bronchitis, to which persons suffering from emphysema appear to be specially liable. The respiratory rhythm is altered, the expiratory portion being far longer than the inspiratory. In severe forms of the disease the patient has a puffy cyanosed appearance and the chest becomes barrel-shaped.

Interstitial emphysema, arising from the rupture of air-cells in the immediate neighbourhood of the pleura, may occur as a complication of the vesicular form, or separately as the result of some sudden expulsive effort, such as a fit of coughing, or, as has frequently happened, in parturition. Gangrene or post-mortem decomposition may lead to the presence of air in the interstitial tissue of the lung. Occasionally the air infiltrates the cellular tissue of the posterior mediastinum, and distends the whole surface of the body.

Surgical emphysema signifies the effusion of air into the general connective tissues of the body. The commonest causes are a wound of some air-passage, or a penetrating wound of the chest wall without injury to the lung. Its severity varies, from a little crepitation felt under the skin to extreme cases where the whole body is blown up and death is imminent from impeded respiration and failure of the action of the heart. In mild cases no treatment is necessary, as the air gradually becomes absorbed; but in severe cases incisions must be made in the swollen cellular tissues to allow the air to escape. The condition must be distinguished from those in which gas is formed in the tissues during the growth of pathogenic bacteria (*e.g.*, gas gangrene).

EMPIRE, a term used to denote a state of large size and also (as a rule) of composite character, often, but not necessarily, ruled by an emperor—a state which may be a federation, like the German empire from 1870 to 1918, or a unitary state, like the Russian empire before its collapse, or even, like the British empire, a loose commonwealth of free states united to a number of subordinate dependencies. For many centuries the writers of the church, basing themselves on the Apocalyptic writings, conceived of a cycle of four empires, generally explained—though there was no absolute unanimity with regard to the members of the cycle—as the Assyrian, the Persian, the Macedonian and the Roman. But in reality the conception of empire, like the term itself (Lat. *imperium*), is of Roman origin. The empire of Alexander had indeed in many ways anticipated the empire of Rome. "In his later years," Bury writes, "Alexander formed the notion of an empire, both European and Asiatic, in which the Asiatics should not be dominated by the European invaders, but Europeans and Asiatics alike should be ruled on an equality by a monarch, indifferent to the distinction of Greek and barbarian, and looked upon as their own king by Persians as well as by Macedonians." The contemporary Cynic philosophy of cosmopolitanism harmonized with this notion, just as Stoicism did later with the practice of the Roman empire: Alexander, like Diocletian and Constantine afterwards, accustomed a Western people to the forms of an Oriental court; and he anticipated the Roman Caesars in claiming and receiving the recognition of his own divinity. But when he died in 323, his empire, which had barely lasted ten years, died with him; and it was divided among Diadochi who, if in some other respects (as, for instance, the Hellenization of the East) they were heirs of their master's policy, were destitute of any general conception of empire. The work of Alexander was rather that of the forerunner than the founder. He prepared the way for the world-empire of Rome; he made possible the rise of a universal religion. And these are the two factors which, throughout the middle ages, went together to make the thing which men called empire.

The Roman Empire.—At Rome the term *imperium* signified generally, in its earlier use, the sovereignty of the state over the individual, a sovereignty which the Romans had disengaged with singular clearness from all other kinds of authority. Each of the higher magistrates at Rome was vested, by a *lex curiata,* passed by the people (for power was distinctly conceived as resident in, and delegated by, the community), with an *imperium* both civil and military, which varied in degree with the magnitude of his office. In the later days of the republic such *imperium* was enjoyed, partly in Rome by the resident consuls and praetors, partly in the provinces by the various proconsuls or propraetors. There was thus a certain *morcellement* of *imperium,* delegated as it was by the people to a number of magistrates: and the coming of the empire meant the reintegration of this *imperium,* and its unification, by a gradual process, in the hands of the *princeps,* or emperor. The means by which this process was achieved had already been anticipated under the republic. Already in the days of Pompey it had been found convenient to grant to an extraordinary officer an *imperium aequum* or *majus* over a large area, and that officer thus received powers, within that area, equal to, or greater than, the *imperium* of the resident governors. This precedent was followed by Augustus in the year 27 B.C., when he acquired for himself sole *imperium* in a certain number of provinces (the imperial provinces), and an *infinitum imperium maius* in the remaining provinces (which were termed senatorial). As a result, Augustus enjoyed an *imperium* coextensive indeed with the whole of the Roman world, but concurrent, in part of that world, with the *imperium* of the senatorial proconsuls; and the early empire may thus be described as a dyarchy. But the distinction between imperial and senatorial provinces finally disappeared: by the time of Constantine the emperor enjoyed sole *imperium;* and an absolute monarchy had been established. We shall not, however, fully understand the significance of the Roman empire unless we take also into account the importance of its military aspect. All the soldiers of Rome had from the first to swear *in verba Caesaris Augusti;* and thus the whole of the Roman army was his army, regiments of which he might indeed lend, but of which he was sole *Imperator* (*see* under EMPEROR). Thus regarded as a permanent commander-in-chief, the emperor enjoyed the privileges, and suffered from the weaknesses of his position. He had the power of the sword behind him; but he became more and more liable to be deposed, and to be replaced by a new commander, at the will of those who bore the sword in his service.

The period which is marked by the reigns of Diocletian and Constantine (A.D. 284–337) marks a great transformation in the character of the empire. The old dyarchy, under which the emperor might still be regarded as an official of the *respublica Romana,* passed into a new monarchy, in which all political power became, as it were, the private property of the monarch. There was now no distinction of provinces. The old public aerarium which had survived the republic, became merely a municipal treasury: the *fiscus* of the emperor became the exchequer of the empire. The officers of the emperor's *praetorium,* or bodyguard, are made the great officers of state; his private council becomes the public consistory, or supreme court of appeal; and the *comites* of his court are also the administrators of his empire. "All is in him, and all comes from him," as our own year-books say of the mediaeval king: his household, for instance, is not only a household, but also an administration. On the other hand, this unification seems to be accompanied by a new bifurcation. The exigencies of frontier defence had long been drawing the empire towards the troubled East; and this tendency reached its culmination when a new Rome arose by the Bosporus, and Constantinople became the centre of what seemed a second empire in the East (A.D. 324). Particularly after the division of the empire between Arcadius and Honorius in 395 does this bifurcation appear to be marked; and one naturally speaks of the two empires of the West and the East. Yet it cannot be too much emphasized that in reality such language is utterly inexact. The Roman empire was, and always continued to be, ideally one and indivisible. There were two emperors, but one empire—two persons, but one power. The point

is of great importance for the understanding of the whole of the middle ages: there only is, and can be, one empire, though it may, for convenience, be ruled conjointly by two emperors, resident, again for convenience, in two separate capitals. As a matter of fact, the beginning of the residence of an emperor in the East not only did not spell bifurcation actually fostered, but to some extent, the tendency towards unification.[1] It helped forward the transformation of the empire into an absolute and quasi-Asiatic monarchy which reduced all its subjects to a single level of loyal submission: it helped to give the emperor a gorgeous court, marked by all the ceremony and the servility of the East. The deification of the emperor himself dates from the days of Augustus; by the time of Constantine it has infected the court and the government, which are now regarded as in some sense "divine." Each emperor, again, had from the first enjoyed the sacrosanct position which was attached to the tribunate; but now his palace, his chamber, his charities, his letters, are all "sacred," and one might almost speak in advance of a "Holy Roman empire."

Influence of Christianity.—But there is one factor, the greatest of all, which still remains to be added, before we have counted the sum of the forces that made the world think in terms of empire for centuries to come; and that is the reception of Christianity into the Roman empire by Constantine. That reception added a new sanction to the existence of the empire and the position of the emperor. The empire, already one and indivisible in its aspect of a political society, was welded still more firmly together when it was informed and permeated by a common Christianity, and unified by the force of a spiritual bond. The empire was now the church; it was now indeed indestructible, for, if it perished as an empire, it would live as a church. But the church made it certain that it would not perish, even as an empire, for many centuries to come. On the one hand the church thought in terms of empire, and taught the millions of its disciples (including the barbarians themselves) to think in the same terms. No other political conception—no conception of a πόλις or of a nation—was any longer possible. When the church gained its hold of the Roman world, the empire, as it has been well said, was already "not only a government, but a fashion of conceiving the world": it had stood for three centuries; and no man could think of any other form of political association. Moreover, the gospel of St. Paul—that there is *one* church, whereof Christ is the Head, and we are all members—could not but reinforce, in the minds of all Christians, the conception of a necessary political unity of all the world under a single head. *Una Chiesa in uno Stato*—such, then, was the theory of the church. But not only did the church perpetuate the conception of empire by making it a part of its own theory of the world: it perpetuated that conception equally by materializing it in its own organization of itself. Growing up under the shadow of the empire, the church too became an empire, as the empire had become a church. As it took over something of the old pagan ceremonial, so it took over much of the old secular organization. The pope borrowed his title of *pontifex maximus* from the emperor: what is far more, he made himself gradually, and in the course of centuries, the caesar and imperator of the church. The offices and the dioceses of the church are parallel to the offices and dioceses of the Diocletian empire: the whole spirit of orderly hierarchy and regular organization, which breathes in the Roman Church, is the heritage of ancient Rome. The Donation of Constantine is a forgery; but it expresses a great truth when it represents Constantine as giving to the pope the imperial palace and insignia, and to the clergy the ornaments of the imperial army (*see* DONATION OF CONSTANTINE).

Barbarian Invasions.—Upon this world, informed by these ideas, there finally descended, in the 5th century, the avalanche of barbaric invasion. Its impact seemed to split the empire into fragmentary kingdoms; yet it left the Universal Church intact, and with it the conception of empire. With that conception, indeed, the barbarians had already been for centuries familiar: service in Roman armies, and settlement in Roman territories, had made the Roman empire for them, as much as for the civilized provincial, part of the order of the world. One of the barbarian invaders, Odoacer (Odovakar), might seem, in 476, to have swept away the empire from the West, when he commanded the abdication of Romulus Augustulus; and the date 476 has indeed been generally emphasized as marking "the fall of the Western empire." Other invaders, again, men like the Frank Clovis or the great Ostrogoth Theodoric, might seem, in succeeding years, to have completed the work of Odoacer, and to have shattered the sorry scheme of the later empire by remoulding it into national kingdoms. *De facto,* there is some truth in such a view: *de jure,* there is none. All that Odoacer did was to abolish one of the two joint rulers of the indivisible empire, and to make the remaining ruler at Constantinople sole emperor from the Bosporus to the pillars of Hercules. He abolished the dual sovereignty which had been inaugurated by Diocletian, and returned to the unity of the empire in the days of Marcus Aurelius. He did not abolish the Roman empire in the West: he only abolished its separate ruler, and, leaving the empire itself subsisting, under the sway (nominal, it is true, but none the less acknowledged) of the emperor resident at Constantinople, he claimed to act as his vicar, under the name of patrician, in the administration of the Italian provinces (*see* Bryce, *Holy Roman Empire,* p. 25, note *u,* in the edition of 1904). As Odoacer thus fitted himself into the scheme of empire, so did both Clovis and Theodoric. They did not claim to be emperors (that was reserved for Charlemagne): they claimed to be the vicars and lieutenants of the empire. Theodoric spoke of himself to Zeno as *imperio vestro famulans;* he left justice and administration in Roman hands, and maintained two annual consuls in Rome. Clovis received the title of consul from Anastasius; the Visigothic kings of Spain (like the kings of the savage Lombards) styled themselves Flavii, and permitted the cities of their eastern coast to send tribute to Constantinople. Yet it must be admitted that, as a matter of fact, this adhesion of the new barbaric kings to the empire was little more than a form. The empire maintained its ideal unity by treating them as its vicars; but they themselves were forming separate and independent kingdoms within its borders. The Italy of the Ostrogoths cannot have belonged, in any real sense, to the empire; otherwise Justinian would never have needed to attempt its reconquest. And in the 7th and 8th centuries the form of adhesion itself decayed: the emperor was retiring upon the Greek world of the East, and the German conquerors, settled within their kingdoms, lost the width of outlook of their old migratory days.

The Church and the Empire.—It is here that the action of the church becomes of supreme importance. The church had not ceased to believe in the continuous life of the empire. The fathers had taught that when the cycle of empires was finally ended by the disappearance of the empire of Rome, the days of Antichrist would dawn; and, since Antichrist was not yet come, the church believed that the empire still lived, and would continue to live till his coming. Meanwhile the Eastern emperor, ever since Justinian's reconquest of Italy, had been able to maintain some hold on the centre of Italy; and Rome itself, the seat of the head of the church, still ranked as one of the cities under his sway. The imperialist theory of the church found its satisfaction in this connection of its head with Constantinople; and as long as this connection continued to satisfy the church, there was little prospect of any change. For many years after their invasion of 568, the pressure which the Lombards maintained on central Italy, from their kingdom in the valley of the Po, kept the popes steadily faithful to the emperor of the East and his representative in Italy, the exarch of Ravenna. But it was not in the nature of things that such fidelity should continue unimpaired. The development of the East and the West could not but proceed along constantly diverging lines, until the point was reached when their connection must snap. On the one hand, the development of the West set towards the increase of the powers of the bishop of

[1] Bryce points out, with much subtlety and truth, that the rise of a second Rome in the East not only helped to perpetuate the empire by providing a new centre which would take the place of Rome when Rome fell, but also tended to make it more universal; "for, having lost its local centre, it subsisted no longer by historic right only, but, so to speak, naturally, as a part of an order of things which a change in external conditions seemed incapable of disturbing." (*Holy Roman Empire,* p. 8 of the edition of 1904.)

Rome until he reached a height at which subjection to the emperor at Constantinople became impossible. Residence in Rome, the old seat of empire, had in itself given him a great prestige; and to this prestige St. Gregory (pope from 590 to 604) had added in a number of ways. He was one of the fathers of the church, and turned its theology into the channels in which it was to flow for centuries; he had acquired for his church the great spiritual colony of England by the mission of St. Augustine; he had been the protector of Italy against the Lombards. As the popes thus became more and more spiritual emperors of the West, they found themselves less and less able to remain the subjects of the lay emperor of the East. Meanwhile the emperors of the East were led to interfere in ecclesiastical affairs in a manner which the popes and the Western church refused to tolerate. Brought into contact with the pure monotheism of Mohammedanism, Leo the Isaurian (718–741) was stimulated into a crusade against image-worship, in order to remove from the Christian Church the charge of idolatry. The West clung to its images: the popes revolted against Leo's decrees; and the breach rapidly became irreparable. As the hold of the Eastern emperor on central Italy began to be shaken, the popes may have begun to cherish the hope of becoming their successors and of founding a temporal dominion; and that hope can only have contributed to the final dissolution of their connection with the Eastern empire.

Thus, in the course of the 8th century, the empire, *as represented by the emperors at Constantinople*, had begun to fade utterly out of the West. It had been forgotten by lay sovereigns; it was being abandoned by the pope, who had been its chosen apostle. But it did not follow that, because the Eastern emperor ceased to be the representative of the empire for the West, the conception of empire itself had also passed away from it. The popes abandoned only the representative; they did not abandon the conception. If they had abandoned the conception, they would have abandoned the idea that there was an order of the world; they would have committed themselves to a belief in the coming of Antichrist. The conception of the world as a single empire-church remained; and what had to be found was a new representative of one of the two sides of that conception. For a brief time, it would seem, the pope himself cherished the idea of becoming, in his own person, the successor of the ancient Caesars in their own old capital. By the aid of the Frankish kings, he had been able to stop the Lombards from acquiring the succession to the derelict territories of the Eastern emperor in Italy (from which their last exarch had fled overseas in 752), and he had become the temporal sovereign of those territories. Successor to the Eastern emperor in central Italy, why should he not also become his successor as representative of the empire—all the more, since he was the head of the church, which was coextensive with the empire? Some such hope seems to inspire the Donation of Constantine, a document forged between 754 and 774, in which Constantine is represented as having conferred on Silvester I. the imperial palace and insignia, and therewith *omnes Italiae seu occidentalium regionum provincias loca et civitates.* But the hope, if it ever was cherished, proved to be futile. The popes had not the material force at their command which would have made them adequate to the position. The strong arm of the Frankish kings had alone delivered them from the Lombards: the same strong arm, they found, was needed to deliver them from the wild nobility of their own city. So they turned to the power which was strong enough to undertake the task which they could not themselves attempt, and they invited the Frankish king to become the representative of the imperial conception they cherished.[1] In the year 800 central Italy ceased to date its documents by the regnal years of the Eastern emperors; for Charlemagne was crowned emperor in their stead.

Coronation of Charlemagne as Emperor of the West.—The king of the Franks was well fitted for the position which he was chosen to fill. He was king of a stock which had been from the first Athanasian, and had never been tainted, like most of the Germanic tribes, by the adoption of Arian tenets. His grandfather, Charles Martel, had saved Europe from the danger of a Mohammedan conquest by his victory at Poitiers (732); his father, Pippin the Short, had helped the English missionary Boniface to achieve the conversion of Germany. The popes themselves had again and again turned to the Frankish rulers for support in the course of the 8th century. Gregory III., involved in bitter hostilities with the iconoclastic reformers of the East, appealed to Charles Martel for aid, and even offered the king, it is said, the titles of consul and patrician. Zacharias pronounced the deposition of the last of the Merovingian *rois fainéants,* and gave to Pippin, their "mayor of the palace," the title of king (751); while his successor Stephen II., hard pressed by the Lombards, who were eager to replace the Eastern emperors in the possession of central Italy, not only asked and received the aid of the new king, but also acquired, in virtue of Pippin's donation (754), the disputed exarchate itself. Thus was laid the foundation of the states of the church; and the grateful pope rewarded the donation by the gift of the title of *patricius Romanorum,* which conferred on its recipient the duty and the privilege of protecting the Roman Church, along with some undefined measure of authority in Rome itself.[1] Again, in 773, Pope Adrian I. had to appeal to Charles, the successor of Pippin, against the aggressions of the last of the Lombard kings; and in 774 Charles conquered the Lombard kingdom, and himself assumed its iron crown. Thus by the end of the 8th century the Frankish king stood on the very steps of the imperial throne. He ruled a realm which extended from the Pyrenees to the Harz, and from Hamburg to Rome—a realm which might be regarded as in itself a *de facto* empire. He bore the title of *patricius,* and he had shown that he did not bear it in vain by his vigorous defence of the papacy in 774. Here there stood, ready to hand, a natural representative of the conception of empire; and Leo III., finding that he needed the aid of Charlemagne to maintain himself against his own Romans, crowned him emperor at St. Peter's, on Christmas Day, 800.

The coronation of Charlemagne in 800 marks the coalescence into a single unity of two facts, or rather, more strictly speaking, of a fact and a theory. The fact is German and secular: it is the wide *de facto* empire, which the Frankish sword had conquered, and Frankish policy had organized as a single whole. The theory is Latin and ecclesiastical: it is a theory of the necessary political unity of the world, and its necessary representation in the person of an emperor—a theory half springing from the unity of the old Roman empire, and half derived from the unity of the Christian Church as conceived in the New Testament. If we seek for the force which caused this fact and this theory to coalesce in the Carolingian empire, we can only answer—the papacy. The idea of empire was in the church; and the head of the church translated this idea into fact. If, however, we seek to conceive the event of 800 from a political or legal point of view, and to determine the residence of the right of constituting an emperor, we at once drift into the fogs of centuries of controversy. Three answers are possible from three points of view; and all have their truth, according to the point of view. From the ecclesiastical point of view, the right resides with the pope. This theory was not promulgated (indeed no theory was promulgated) until the struggles of papacy and empire in the course of the middle ages; but by the time of Innocent III. it was becoming an established doctrine that a *translatio Imperii* took place in 800, whereby the pope transferred the Roman empire from the Greeks to the Germans in the person of the magnificent Charles.[2] One can only say that, as a matter of fact, the popes ceased to recognize the Eastern

[1]According to the view here followed, the church was the ark in which the conception of empire was saved during the dark ages between 600 and 800. Some influence should perhaps also be assigned to Roman law, which continued to be administered during these centuries, especially in the towns, and maintained the imperial tradition. But the influence of the church is the essential fact.

[1]In the 5th century the title *patricius* came to attach particularly to the head of the Roman army (*magister utriusque militiae*)—to men like Aetius and Ricimer, to made and unmade emperors (*cf.* Mommsen, *Gesammelte Schriften,* iv. 537, 545 *sqq.*). Later it had been borne by the Greek exarchs of Ravenna. The concession to Pippin of this great title makes him military head of the Western empire, in the sense in which the title was used in the 5th century; it makes him representative of the empire for Italy, in the sense in which it had been used of the exarchs.

[2]*See* the famous bull *Venerabilem* (*Corp. Iur. Canon.* Decr. Greg, i. 6, c. 34).

emperors, and recognized Charles instead, in the year 800; that, again, this recognition alone made Charles emperor, as nothing else could have done; but that no question arose, at the time, of any right of the pope to give the Empire to Charlemagne, for the simple reason that neither of the actors was acting or thinking in a legal spirit. If we now turn to study the point of view of the civil lawyer, inspired by legal ideas, and basing himself on the code of Justinian, we shall find that an emperor must derive his institution and power from a *lex regia* passed by the *populus Romanus;* and such a view, strictly interpreted, will lead us to the conclusion that the citizens of Rome had given the crown to Charlemagne in 800, and continued to bestow it on successive emperors afterwards. There is indeed some speech, in the contemporary accounts of Charlemagne's coronation, of the presence of "ancients among the Romans" and of "the faithful people"; but they are merely present to witness or applaud, and the conception of the Roman people as the source of empire is one that was only championed during the middle ages by antiquarian idealists like Arnold of Brescia and Cola di Rienzi. The *faex Romuli,* a population of lodging-house keepers, living upon pilgrims to the papal court, could hardly be conceived, except by an ardent imagination, as heir to the *Quirites* of the past. Finally, from the point of view of the German tribesman, we must admit that the empire was something which, once received by his king (no matter how), descended in the royal family as an heirloom; or to which (when the kingship became elective) a title was conferred, along with the kingship, by the vote of electors.[1]

But apart from these questions of origin, two difficulties have still to be faced with regard to the nature and position of the Carolingian empire. Did Charlemagne and his successors enter into a new relation with their subjects, in virtue of their coronation? And what was the nature of the relation between the new emperor now established in the West and the old emperor still reigning in the East? It is true that Charlemagne exacted a new oath of allegiance from his subjects after his coronation, and again that he had a revision of all the laws of his dominions made in 802. But the revision did not amount to much in bulk: what there was contained little that was Roman; and, on the whole, it hardly seems probable that Charlemagne entered into any new relation with his subjects. The relation of his empire to the empire in the East is a more difficult and important problem. In 797 the empress Irene had deposed and blinded her son, Constantine VI., and usurped his throne. Now it would seem that Charlemagne, whose thoughts were already set on empire, hoped to depose and succeed Irene, and thus to become the sole representative of the conception of empire, alike in the East and the West. Suddenly there came, in 800, his own coronation as emperor, an act apparently unpremeditated at the moment, taking him by surprise, as one gathers from Einhard's *Vita Karoli,* and interrupting his plans. It left him representative of the empire for the West only, confronting another representative in the East. Such a position he did not desire: there had been a single empire vested in a single person since 476, and he desired that there should still continue to be a single empire, vested only in his own person. He now sought to achieve this unity by a proposal of marriage to Irene. The proposal failed, and he had to content himself with a recognition of his imperial title by the two successors of the empress. This did not, however, mean (at any rate in the issue) that henceforth there were to be two conjoint rulers, amicably ruling a single empire as colleagues in the manner of Arcadius and Honorius. The dual government of a single empire established by Diocletian had finally vanished in 476; and the unity of the empire was now conceived, in the manner common before the days of Diocletian, as demanding a single representative. Henceforth there were two rulers, one at Aix-la-Chapelle and one at Constantinople, each claiming, whatever temporary concessions he might make, to be the sole ruler and representative of the Roman empire. On the one hand, the Western emperors held that, upon the deposition of Constantine VI., Charlemagne had succeeded him, after a slight interval, in the government of the whole empire, both in the East and in the West; on the other hand, the Eastern emperors, in spite of their grudging recognition of Charlemagne at the moment, regarded themselves as the only lawful successors of Constantine VI. in the title of emperor, and viewed the Carolings and their later successors as upstarts and usurpers, with no right to their imperial pretensions. Henceforth two halves confronted one another, each claiming to be the whole; two finite bodies touched, and each yet claimed to be infinite.

[1]Even on this view, an imperial coronation at the hands of the pope was necessary to complete the title; but this was regarded by the Germans (though not by the pope) as a form which necessarily followed.

Character of the Carolingian Empire.—If, as has been suggested, Charlemagne did not enter into any fundamentally new relations with his subjects after his coronation, it follows that the results of his coronation, in the sphere of policy and administration, cannot have been considerable. The empire added a new sanction to a policy and administration already developed. Charlemagne had already showed himself *episcopus episcoporum,* anxious not only to suppress heresy and supervise the clergy within his borders, but also to extend true Christianity outside them, even before the year when his imperial coronation gave him a new title to supreme governorship in all cases ecclesiastical. He had already organized his empire on a new uniform system of counties, and the *missi dominici* were already at work to superintend the action of the counts, even before the *renovatio imperii Romani* came to suggest such uniformity and centralization. Charlemagne had a new title; but his subjects still obeyed the king of the Franks, and lived by Frankish law, in the old fashion. In their eyes, and in the eyes of Charlemagne's own descendants, the empire was something appendant to the kingship of the Franks, which made that kingship unique among others, but did not radically alter its character. True, the kingship might be divided among brothers by the old Germanic custom of partition, while the empire must inhere in one person; but that was the one difference, and the one difficulty—which might easily be solved by attaching the name of emperor to the eldest brother. Such was the conception of the Carolings: such was not, however, the conception of the church. To the popes the empire was a solemn office, to which the kings of the Franks might most naturally be called, in view of their power and the traditions of their house, but which by no means remained in their hands as a personal property. By thus seeking to dissociate the empire from any indissoluble connection with the Carolingian house, the popes were able to save it. Civil wars raged among the descendants of Charlemagne: partitions recurred: the empire was finally dissolved, in the sense that the old realm of Charlemagne fell asunder, in 888. But the empire, as an office, did not perish. During the 9th century the popes had insisted, as each emperor died, that the new emperor needed coronation at their hands: and they had thus kept alive the conception of the empire as an office to which they invited, if they did not appoint, each successive emperor. The quarrels of the Carolingian house helped them to make good their claim. John VIII. was able to select Charles the Bald in preference to other claimants in 875; and before the end of his pontificate he could write that "he who is to be ordained by us to the empire must be by us first and foremost invited and elected." Thus was the unity of the empire preserved, and the conception of a united empire continued, in spite of the eventual dissolution of the realm of Charlemagne. When the Carolingian emperors disappeared, Benedict IV. could crown Louis of Provence (901), and John X. could invite to the vacant throne an Italian potentate like Berengar of Friuli (915); and even when Berengar died in 924, and the empire was vacant of an emperor, they could hold, and hold with truth, that the empire was not dead, but only suspended, until such time as they should invite a new ruler to assume the office.

The German Kingdom and the Empire.—Various causes had contributed to the dissolution of the realm of Charlemagne. Partitions had split it; feudalism had begun to honeycomb it; incessant wars had destroyed its core, the fighting Franks of Austrasia. But, above all, the rise of divisions within the realm, which, whether animated by the spirit of nationality or not, were ultimately destined to develop into nations, had silently under-

mined the structure of Pippin and Charlemagne. Already in 842 the oath of Strasbourg shows us one Caroling king swearing in French and another in German: already in 870 the partition of Mersen shows us the kings of France and Germany dividing the middle kingdom which lay between the two countries by the linguistic frontier of the Meuse and Moselle. The year 888 is the birth-year of modern Europe. France, Germany, Italy, stood distinct as three separate units (with Burgundy and Lorraine as debatable lands) as they were destined to remain for centuries to come. If the conception of empire was still to survive, the pope must ultimately invite the ruler of the strongest of these three units to assume the imperial crown; and this was what happened when in 962 Pope John XII. invited Otto I. of Germany to renew once more the Roman empire. As the strength of the whole Frankish realm had given it the Empire in 800, so did the strength of the East Frankish kingdom, now resting indeed on a Saxon rather than a Frankish basis, bring the empire to its ruler in 962. The centre of political gravity had already been shifting to the east of the Rhine in the course of the 9th century. While the Northmen had carried their arms along the rivers and into the heart of France, Louis the German had consolidated his kingdom in a long reign of 60 years (817–876); and at the end of the 9th century two kings of Germany had already worn the imperial crown. Early in the 10th century the kingship of Germany had come to the vigorous Saxon dukes (919); and strong in their Saxon basis Henry I. and his son Otto had built a realm which, disunited as it was, was far more compact than that which the Carolings of the West ruled from Laon. Henry I. had thought in his later years of going to Rome for the imperial crown: under Otto I. the imperial idea becomes manifest. On the one hand, he established a semi-imperial position in the West: by 946 Louis IV. d'Outremer is his protégé in France, and it is his arms which maintain the young Conrad on his throne in Burgundy. On the other hand, he showed, by his policy towards the German Church, that he was the true heir of the Carolingian traditions. He made churchmen his ministers; he established missionary bishoprics on the Elbe which should spread Christianity among the Wends; and his dearest project was a new archbishopric of Magdeburg. The one thing needful was that he should, like Charlemagne, acquire the throne of Italy; and the disunited condition of that country during the first half of the 10th century made its acquisition not only possible, but almost imperative. Begun in 952, the acquisition was completed ten years later; and all the conditions were now present for Otto's assumption of the imperial throne. He was crowned by John XII. on Candlemas Day 962, and thus was begun the Holy Roman empire, which lasted until 1806.[1]

The Holy Roman Empire.—The same ideas underlay the new empire as had underlain that of Charlemagne, but they were strengthened and reinforced by the fact that they had already found a visible expression before in that earlier empire. Historically, there was the tradition of the old Roman empire, preserved by the church as an idea, and preserved in the church, and its imperial organization, as an actual fact. Ecclesiastically, there was the Pauline conception of a single Christian Church, one in subjection to Christ as its Head, and needing (so men still thought) a secular counterpart of its indivisible unity.[2] To these two sanctions philosophy later added a third; and the doctrine of Realism, that the one universal is the true abiding substance—the doctrine which pervades the *De monarchia* of Dante—reinforced the feeling which demanded that Europe should be conceived as a single political unity. But if the Holy Roman empire of the German nation has the old foundations, it is none the less a thing *sui generis*. Externally, it meant far less than the empire of Charlemagne; it meant simply a union of Germany and northern Italy (to which, after 1032, one must also add Burgundy, though the addition is in reality nominal) under a single rule. Historians of the 19th century, during the years in which the modern German empire was in travail, disputed sorely on the advantages of this union; but whatever its advantages or disadvantages, the fact remains that the union of Teutonic Germany and Latin Italy was, from an external point of view, the essential fact in the structure of the mediaeval empire. Internally, again, the empire of the Ottos and their successors was new and unprecedented. If Latin imperialism had been combined with Frankish tribalism in the empire of Charlemagne, it now met and blended with feudalism. The Holy Roman emperor of the middle ages, as Frederick I. proudly told the Roman envoys, found his senate in the diet of the German baronage, his *equites* in the ranks of the German knights. Feudalism, indeed, came in time to invade the very conception of empire itself. The emperors began to believe that their position of emperor made them feudal overlords of other kings and princes; and they came to be regarded as the topmost summit of the feudal pyramid, from whom kings held their kingdoms, while they themselves held directly of God. In this way the old conception of the world as a single political society entered upon a new phase: but the translation of that conception into feudal terms, which might have made Diocletian gasp, only gave it the greater hold on the feudal society of the middle ages. Yet in one way the feudal conception was a source of weakness to the empire; for the popes, from the middle of the 12th century onwards, began to claim for themselves a feudal overlordship of the world, and to regard the emperor as the chief of their vassals. The theory of the *Translatio* buttressed their claim to be overlords of the empire; and the emperors found that their very duty to defend the papacy made them appear as its vassals—for was not the *advocatus* who defended the lands of an abbey or church its tenant by feudal service, and was not the emperor an "advocate" of the papacy and its patrimony in central Italy?

The Empire and the Papacy.—The relation of the empire to the papacy is indeed the cardinal fact in its history for the three centuries which followed the coronation of Otto I. (962–1250). For a century (962–1076) the relation was one of amity. The pope and the emperor stood as co-ordinate sovereigns, ruling together the commonwealth of Europe.[1] If either stood before the other, the emperor stood before the pope. The Romans had sworn to Otto I. that they would never elect or ordain a pope without his consent; and the rights over papal elections conceived to belong to the office of *patricius*, which they generally held, enabled the emperors, upon occasion, to nominate the pope of their choice. The partnership of Otto III., son of a Byzantine princess, and his nominee Silvester II. (the famous Gerbert, who had been *scholasticus* of the chapter school of Reims) forms a remarkable page in the annals of empire and papacy. Otto, once the pupil of Silvester in classical studies, and taught by his mother the traditions of the Byzantine empire, dreamed of renewing the empire of Constantine, with Rome itself for its centre; and this antiquarian idealism (which Arnold of Brescia and Cola di Rienzi were afterwards, though with some difference of aim, to share) was encouraged in his pupil by the pope. Tradition afterwards ascribed to the two the first project of a crusade, and the institution of the seven electors: in truth their faces were turned to the past rather than to the future, and they sought not to create, but to renovate. The dream of restoring the age of Constantine passed

[1] It is a curious fact that imperial titles (*imperator* and *basileus*) are used in the Anglo-Saxon documents of the 10th century, about the time of Otto I.'s coronation. Edred, for instance (946–955), is "imperator" and "basileus Anglorum huiusque insulae barbarorum": Edgar is "totius Albionis imperator Augustus" (*cf.* Stubbs, *Const. Hist.* i., c. vii. § 71). These titles partly show the turgidity of English Latinity in the 10th century, and partly indicate the quasi-imperial position held by the Wessex kings after the reconquest of the Dane-law. But there seems to be no real ground for Freeman's view (*Norman Conquest*, i. 548 *sqq.*) that England was regarded as a third empire, side by side with the other empires of Western and Eastern Europe.

[2] It is in virtue of this aspect that the Empire is holy. The term *sacrum imperium* seems to have been first used about the time of Frederick I., when the emperors were anxious to magnify the sanctity of their office in answer to papal opposition. The emperor himself (*see* under EMPEROR) was always regarded, and at his coronation treated, as a *persona ecclesiastica*.

[1] The emperor claimed suzerainty over the greater part of Europe at various dates. Hungary and Poland, France and Spain, the Scandinavian peninsula, the British Isles, were all claimed for the empire at different times (*see* Bryce, *Holy Roman Empire*, c. xii.). The "effective" empire, if indeed it may be called effective, embraced only Germany, Burgundy and the *regnum Italiae* (the old Lombard kingdom in the valley of the Po).

with the premature death of Otto; and after the death of Silvester II. the papacy was degraded into an appendage of the Tusculan family. From that degradation the church was rescued by Henry III. (the second emperor of the new Salian house, which reigned from 1024–1125), when in 1046 he caused the deposition of several popes, and afterwards filled the papal chair with his own nominees; but it was rescued more effectually by itself, when in 1059 the celebrated bull *In nomine Domini* of Nicholas II. reserved the right of electing the popes to the college of cardinals (*see* CONCLAVE). A new era of the papacy begins with the decree, and that era found its exponent in Hildebrand. If under Henry III. the empire stands in many respects at its zenith, and the emperor nominates to the Papacy, it sinks, under Henry IV., almost to the nadir of its fortunes, and a pope attempts, with no little success, to fight and defeat an emperor.

The rise of the papacy, which the action of Henry III. in 1046 had helped to begin, and the bull of 1059 had greatly promoted, was ultimately due to one of those movements of ecclesiastical revival which recur in the history of the Catholic Church. The aim of that movement was to separate the church from the world, and thus to make it independent of the laity and the lay power; and it sought to realize its aim first by the prohibition of clerical marriage and simony, and ultimately by the prohibition of lay investiture. A decree of Gregory VII. in 1075 forbade emperor, king or prince to "presume to give investiture of bishoprics," under pain of excommunication; and Henry IV., contravening the decree, fell under the penalty, and the War of Investitures began (1076–1122). Whether or not Henry humiliated himself at Canossa (and the opinion of German historians now inclines to regard the traditional account as exaggerated), the empire certainly suffered in his reign a great loss of prestige. The emperor lost his hold over Germany, where the aid of the pope strengthened the hands of the discontented nobility: he lost his hold over Italy, where the Lombard towns gradually acquired municipal independence, and the donation of the Countess Matilda gave the popes the germ of a new and stronger *dominium temporale*. The First Crusade came, but the emperor, its natural leader, could not lead it; and the centre of learning and civilization, in the course of the 50 years' War of Investitures, gradually shifted to France. The struggle was finally ended by a compromise—the Concordat of Worms—in 1122; but the papacy, which had fought the long War of Investitures and inspired the First Crusade, was a far greater power than it had been at the beginning of the struggle, and the emperor, shaken in his hold on Germany and Italy, had lost both power and prestige (*see* INVESTITURE). It is significant that a theory of the feudal subjection of the emperor to the pope, foreshadowed in the pontificate of Innocent II., and definitely enunciated by the envoys of Adrian IV. at the diet of Besançon in 1157, now begins to arise. The popes, who had called the emperors to the heads of the European commonwealth in 800 and again in 962, begin to vindicate that headship for themselves. Gregory VII. had already claimed that the pope stood to the emperor as the sun to the moon; and gradually the old idea of co-ordination disappeared in a new view of the subordination of the empire to the papal *plenitudo potestatis*. The claim of ecclesiastical independence made in the middle of the 11th century was rapidly becoming a claim of ecclesiastical supremacy in the middle of the 12th: the imperial claim to nominate popes, which had lasted till 1059, was turning into the papal claim to nominate emperors. Yet at this very time a new period of splendour dawned for the empire; and the rule of the three Hohenstaufen emperors, Frederick I., Henry VI. and Frederick II. (1152–1250), marks the period of its history which attracts most sympathy and admiration.

The Hohenstaufen Emperors.—Frederick I. regained a new strength in Germany, partly because he united in his veins the blood of the two great contending families, the Welfs and the Waiblingens; partly because he had acquired large patrimonial possessions in Swabia, which took the place of the lost Saxon demesne; partly because he had a greater control over the German episcopate than his predecessors had enjoyed for many years past. At the same time the revival of interest in the study of Roman law gave the emperor, as source and centre of that law, a new dignity and prestige, particularly in Italy, the home and hearth of the revival. Confident in this new strength, he attempted to vindicate his claims on Italy, and sought, by uniting the two under his sway, to inspire with new life the old Ottonian empire. He failed to crush Lombard municipal independence: defeated at Legnano in 1176, he had to recognize his defeat at the treaty of Constance in 1183. He failed to acquire control over the papacy: a new struggle of empire and papacy, begun in the pontificate of Adrian IV. on the question of control over Rome, and continued in the pontificate of Alexander III., because Frederick had recognized an anti-pope, ended in the emperor's recognition of his defeat at Venice in 1177. The one success was the acquisition of the Norman kingdom of Sicily for his son and successor Henry VI., who was married to its heiress, Constance. But the one success of Frederick's Italian policy proved the ruin of his house in the reign of his grandson Frederick II. On the one hand, the possession of Sicily induced Frederick II. to neglect Germany; and by two documents, one of 1220 and one of 1231, he practically abdicated his sovereign powers to the German princes in order to conciliate their support for his Italian policy. On the other hand, the possession of Sicily involved him in the third great struggle of empire and papacy. Strong in his Sicilian kingdom in the south, and seeking, like his grandfather, to establish his power in Lombardy, Frederick practically aimed at the unification of Italy, a policy which threatened to engulf the states of the church and to reduce the papacy to impotence. The popes excommunicated the emperor: they aided the Lombard towns to maintain their independence; finally, after Frederick's death (1250), they summoned Charles of Anjou into Sicily to exterminate his house. By 1268 he had done his work, and the mediaeval empire was practically at an end. When Rudolph of Habsburg succeeded in 1273, he was only the head of a federation of princes in Germany, while in Italy he abandoned all claims over the centre and south, and only retained titular rights in the Lombard plain.

Thus ended the first great chapter in the history of the Holy Roman Empire which Otto had founded in 962. In those three centuries the great fact had been its relation to the papacy: in the last two of those three centuries the relation had been one of enmity. The basis of the enmity had been the papal claim to supreme headship of Latin Christianity, and to an independent temporal demesne in Italy as the condition of that headship. Because they desired supreme headship, the popes had sought to reduce the emperor's headship to something lower than, and dependent upon, their own: because they desired a temporal demesne, they had sought to expel him from Italy, since any imperial hold on Italy threatened their independence. They had succeeded in defeating the empire, but they had also diminished the papacy; for the French aid which they had invoked against the Hohenstaufen developed, within 50 years of the fall of that house, into French control, and the captivity at Avignon (1308–78) was the logical result of the final victory of Charles of Anjou at Tagliacozzo. The struggle seemed to have ended in nothing but the exhaustion of both combatants. Yet in many respects it had in reality made for progress. It had set men thinking of the respective limits of church and state, as the many *libelli de lite imperatorum et pontificum* show; and from that thought had issued a new conception of the state, as existing in its own right and supreme in its own sphere, a conception which is the necessary basis of the modern nation-state. If it had dislocated Germany into a number of territorial principalities, it had produced a college of electors to represent the cause of unity: if it had helped to prevent the unification of Italy, and had left to Italy the fatal legacy of Guelph and Ghibelline feuds, it had equally helped to produce Italian municipal independence.

The Empire from the Election of Rudolph of Habsburg, 1273.—A new chapter of the history of the empire fills the three centuries from 1273–1556—from the accession of Rudolph of Habsburg to the abdication of Charles V. Italy was now lost: the empire had now no peculiar connection with Rome, and far less touch with the papacy. A new Germany had risen. The extinction of several royal stocks, and the nomination of anti-kings in the

course of civil wars, had made the monarchy elective, and raised to the side of the emperor a college of electors (*see* ELECTORS), which appears as definitely established soon after 1250. With Italy lost, and Germany thus transmuted, why should the empire have still continued to exist? In the first place, it continued to exist because the Germans still found a king necessary, and because, the German king having been called for three centuries emperor, it seemed necessary that he should still continue to bear the name. In this sense the empire existed as the presidency of a Germanic confederation, and as something analogous to the German empire between 1870 and 1918, with the one great difference that the Hohenzollerns derived from Prussia a strength which enabled them to make their imperial position a reality, while no Luxembourg of Habsburg was able to make his imperial position otherwise than honorary and nominal. In the second place, it continued to exist because the conception of the unity of western Europe still lingered, and was still conceived to need an exponent. In this sense the empire existed as a presidency, still more honorary and still more nominal, of the nations of western Europe. In both capacities the emperor may be said to have existed because he was a legal necessity—because, in Germany, he was necessary for the investiture of princes with their principalities, and because, in Europe, he was necessary, as the source of all rights, to bestow crowns upon would-be kings, or to act as the head of the great orders of chivalry, or to give patents to notaries. With the history of the empire regarded as a German confederation we are not here concerned. The reigns of the Habsburg, Luxembourg and Wittelsbach emperors belong to the history of Germany. Yet two of these emperors, Henry VII. and Louis IV., should not pass without notice, the one for his own sake, the other for the sake of his adherents, and both because, by interfering in Italy, and by coming into conflict with the papacy, they brought once more into prominence the European aspect of the empire.

Henry VII., the contemporary and the hero of Dante, descended into Italy in 1310, partly because he had no power and no occupation in Germany, partly because he was deeply imbued with the sense of his imperial dignity. Coming as a peacemaker and mediator, he was driven by Guelph opposition into a Ghibelline rôle; and he came into conflict with Clement V., the first of the Avignonese popes, who under the pressure of France attempted to enforce upon Henry a recognition of his feudal subjection. Henry asserted his independence: he claimed Rome for his capital, and the lordship of the world for his right; but, just as a struggle seemed impending, he died, in 1313. During the reign of his successor, Louis IV., the struggle came. Louis had been excommunicated by John XXII. in 1324 for acting as emperor before he had received papal recognition. None the less, in 1328, he came to Rome for his coronation. He had gathered round him strange allies; on the one hand, the more advanced Franciscans, apostles of the cause of clerical disendowment, and inimical to a wealthy papacy; on the other hand, jurists like Marsilius of Padua and John of Jandun, who brought to the cause of Louis the spirit and the doctrines which had already been used in the struggle between Boniface VIII. and Philip IV. of France. Marsilius in particular, in a treatise called the *Defensor Pacis,* insisted on the majesty of the lay state, and even on its superiority to the church. Perhaps it was Marsilius, learned as he was in Roman law, and remembering the *lex regia* by which the Roman people had of old conferred its power on the emperor, who suggested to Louis the policy, which he followed, of receiving the imperial crown by the decree and at the hands of the Roman people. The policy was remarkable: Louis embraced an alliance which Frederick Barbarossa had spurned, and recognized the mediaeval Romans as the source of imperial power. Not less remarkable was the new attitude of the German electors, who for the first time supported an emperor against the pope, because they now felt menaced in their own electoral rights; and the one permanent result which finally flowed from the struggle was the enunciation and definition of the rights and privileges of the electors in the Golden Bull of 1356 (*see* GOLDEN BULL).

In this struggle with the papacy the empire had shown something of its old universal aspect. It had come into connection with Italy, and into close connection with Rome: it had enlisted in defence of its rights at once an Italian like Marsilius and an Englishman like Ockham. The same universal aspect appeared once more in the age of the conciliar movement, at the beginning of the 15th century. One of the essential duties of the emperor, as defender of the church, was to help the assembling and the deliberations of general councils of the church. This was the duty discharged by Sigismund, when he forced John XXIII. to summon a council at Constance in 1414, and sought, though in vain, to guide its deliberations. The journey which Sigismund undertook in the interests of the council (1415–17) is particularly noteworthy. He sought to make peace throughout western Europe, acting as international arbitrator—in virtue of his presidency of western Europe—between England and France, between Burgundians and Armagnacs; but he failed in his aim, and when he returned to the council, it was only to witness the defeat of the party of reform which he championed. National feeling and national antipathies proved too strong for Sigismund's attempt to revive the mediaeval empire for the purposes of international arbitration; the same feeling, the same antipathies, made inevitable the failure of the council itself, in which western Europe had sought to meet once more as a single religious commonwealth. Early in the 15th century, therefore, the conception of the unity of western Europe, as a single empire-church, was already waning in both its aspects. The unity of the Church Universal was dissolving, and the conception of the nation-church arising (as the separate concordats granted by Martin V. to the different nations prove); while the unity of the empire was proved a dream by the powerlessness of the emperor in the face of the struggle of England and France.

Influence of the Reformation.—Renaissance and Reformation combined to complete the fall which the failure of Sigismund to guide the conciliar movement had already foreshadowed. The Renaissance, revolting against the mediaevalism of the *studium,* and not sparing even the *sacerdotium* of the middle ages, had little respect for the mediaeval *imperium;* and, going back to pure Latin and original Greek, it went back beyond even the classical empire to find its ideals and inspirations. But it is the coming of the Reformation, and with it of the nation-church, which finally marks the epoch at which the last vestige of the old conception of the political unity of the world disappears before the nation-state. Externally indeed it seemed, at the time of the Reformation, as if the old empire had been revived in the person of Charles V., who owned territories as vast as those of Charlemagne. But Charles's dominions were a dynastic agglomeration, knit together by no vivifying conception; and, though Charles was a champion of the one Catholic Church against the Reformation, he did not in any way seek to revive the power of the mediaeval empire. Meanwhile the reforming monarchs, while they cast off the Roman Church, cast off with it the Roman empire. Henry VIII. declared himself free, not only of the pope, but of all other foreign power; and not only so, but as he sought to take the place of the pope with regard to his own church, so he sought to take the place of the emperor with regard to his kingdom, and spoke of his "imperial" crown, a style which recurs in later Tudor reigns. The conception of one empire passed out of Europe, or, if it remained, it remained only in an honorary precedence accorded by other sovereigns to the king of Germany, who still entitled himself emperor. In Germany itself the honorary presidency which the emperor enjoyed over the princes came to mean still less than before, when religious differences divided the country, and the principle of *cujus regio ejus religio* accentuated the local autonomy of the prince. When Charles abdicated in 1556, the change which the accession of Rudolph of Habsburg had already marked was complete: there was no empire except in Germany, and in Germany the empire was nothing more than a convenient legal conception. The Reformation, by sweeping away the spiritual unity of western Christendom, had swept away any real conception of its political unity, and with that conception it had swept away the empire; while it had also, by splitting Germany into two religious camps, and making the emperor at the most the head of a religious faction, dissipated the last vestiges of a real empire in the

country which had, since 962, been its peculiar home.

From 1556 to 1806 the empire means a loose federation of the different princes of Germany, lay and ecclesiastical, under the presidency, elective in theory but hereditary in practice, of the house of Habsburg. The dissolution of the Holy Roman empire into this loose federation had already been anticipated by the concessions made to the princes by Frederick II. in 1220 and 1231; but the final organization of Germany on federal lines was only attained in the treaty of Westphalia of 1648. The attempt of Ferdinand II., in the course of the Thirty Years' War, to assert a practically monarchical authority over the princes of Germany, only led to the regular vindication by the princes of their own monarchical authority. The emperor, who had tried in the 15th century to be the international authority of all Europe, now sank to the position of less than inter-state arbitrator in Germany. That the empire and the emperor were retained at all, when the princes became so many independent sovereigns, was due partly to a lingering sense of quasi-national sentiment for a *magni nominis umbra*, partly to the need of some authority which should combine in one body principalities of very different sizes and strengths, and should protect the weak from the strong, and all from France. But this authority only found its *symbol* in the emperor. Such real federal authority as there was remained with the diet, a congress of sovereign princes through their accredited representatives; and the emperor's sole rights, as emperor, were those of granting titles and confirming tolls. The Habsburgs, emperors in each successive generation, never pursued an imperial, but always a dynastic policy; and they were perfectly ready to sacrifice to the aggrandizement of their house the honour of the empire, as when they ceded Lorraine to France in return for Tuscany (1735).

End of the Holy Roman Empire.—It needed the cataclysm of the French Revolution finally to overthrow the empire. Throughout the 18th century it lasted, a thing of long-winded protocols and never-ending lawsuits, "neither Holy, nor Roman, nor an Empire." But with Napoleon came its destroyer. As far back as the end of the 13th century, French kings had been scheming to annex the title or at any rate absorb the territories of the empire: at the beginning of the 19th century the annexation of the title by Napoleon seemed very imminent. Posing as the New Charlemagne ("because, like Charlemagne, I unite the crown of France to that of the Lombards, and my Empire marches with the East"), he resolved in 1806, during the dissolution and recomposition of Germany which followed the peace of Lunéville, to oust Francis II. from his title, and to make the Holy Roman empire part and parcel of the "Napoleonic idea." He was anticipated, however, by the prompt action of the proud Habsburg, who was equally resolved that no other should wear the crown which he himself was powerless to defend, and accordingly, on Aug. 6, 1806, Francis resigned the imperial dignity. So perished the empire. Out of its ashes sprang the Austrian empire, for Francis, in 1804, partly to counter Napoleon's assumption of the title of Emperor of the French, partly to prepare for the impending dissolution of the old empire, had assumed the title of "Hereditary Emperor of Austria."

General Influence of the Empire.—What had been the results of the Holy Roman empire, in the course of its long history, upon Germany and upon Europe? It has been a vexed question among German historians, whether or not the Empire ruined Germany. Some have argued that it diverted the attention of the German kings from their own country to Italy, and that, by bringing them into conflict with the popes, and by thus strengthening the hands of their rebellious baronage with a papal alliance, it prevented the development of a national monarchy in Germany, such as other sovereigns of western Europe were able to found. Others again have emphasized the racial division of Saxon and Frank, of High German and Low German, as the real cause of the failure of Germany to grow into a united national whole: they have sought to ascribe to the influence of the empire such unity as was achieved; and they have attributed the learning, the trade, the pre-eminence of mediaeval Germany to the Italian connection and the prestige which the empire brought. It is difficult to pronounce on either side; but it is possible that the old localism and individualism which characterized the early German, and had never, on German soil, been combined with and counteracted by a large measure of Roman population and Roman civilization, as they were in Gaul and Spain, would in any case have continued to divide and disturb Germany till late in her history, even if the empire had never come to reside within her borders. On the larger question of the influence of the empire on Europe at large, all that can here be said is that Europe was all the better for the survival of some idea of unity. An empire which represented, as a Holy empire, the unity of all the faithful in one body—an empire which, as a Roman empire, represented with an unbroken continuity the order of Roman administration and law—such an empire could not but make for the betterment of the world. It was not an empire resting on force, a military empire; it was not, as in modern times empires have sometimes been, an autocracy warranted and stamped by the plébiscite of the mob. It was an empire resting neither on the sword nor on the ballot-box, but on two great ideas, taught by the clergy and received by the laity, that all believers in Christ form one body politic, and that the one model and type for the organization of that body is to be found in the past of Rome. It was indeed the weakness of the empire that its roots were only the thoughts of men; for the lack of material force, from which it always suffered, hindered it from doing work it might well have done—the work, for instance, of international arbitration. Yet, on the other hand, it was the strength and glory of the empire that it lived, all through the middle ages, an unconquerable idea of the mind of man. Because it was a being of their thought, it stirred men to reflection: the empire, particularly in its clash with the papacy, produced a political consciousness and a political speculation reflected for us in the writings of mediaeval schoolmen and lawyers, not least in those of Dante and Marsilius of Padua. Roman, it perpetuated the greatest monument of Roman thought—that ordered scheme of law, which either became, as in England, the model for the building of a native system, or, as in Germany from the end of the 15th century onwards, was received in its integrity and administered in the courts. Holy, it fortified and consolidated Christian thought, by giving a visible expression to the kingdom of God upon earth; and not only so, but it maintained, however imperfectly, some idea of international obligation, and some conception of a commonwealth of Europe.

The Holy Roman empire of western Europe had in its own day a contemporary and a rival—that East Roman empire of which we have already spoken. From Arcadius to John Palaeologus, from A.D. 395 to 1453, the Roman empire was continued at Constantinople—not as a theory and an idea, but as a simple and daily reality of politics and administration. In one sense the East Roman empire was more lineally and really Roman than the West: it was absolutely continuous from ancient times. In another sense the Western empire was the more Roman; for its capital—in theory at least—was Rome itself, and the Roman Church stood by its side, while Constantinople was Hellenic and even Oriental. Between the two empires there was fixed an impassable gulf. They were divided by deep differences of thought and temper, which appeared more particularly in the sphere of religion, and expressed themselves in the cleavage between the Catholic and the Orthodox Churches. But as, when Rome fell, the Catholic Church survived, and ultimately found for itself a new empire of the West, so, when Constantinople fell, the Orthodox Church continued its life, and found for itself a new empire of the East—the empire of Russia. Under Ivan the Great (1462–1505) Moscow became the metropolis of Orthodoxy; Byzantine law influenced his code; and he took for his cognizance the double-headed eagle. Ivan the Terrible, his grandson, finally assumed in 1547 the title of Tsar; and henceforth the Russian emperors became, in theory and very largely in fact, the successors of the old East Roman emperors,[1] the heads of the Orthodox Church, with the mission of vengeance on Islam for the fall of Constantinople.

[1]The Turks, occupying Constantinople, have also claimed to be the heirs of the old emperors of Constantinople; and their sultans have styled themselves *Keisar-i-Rûm*.

Subsequent Empires.—In the 19th century the word "empire" has had a large and important bearing in politics. In France it has been the apanage of the Bonapartes, and has meant a centralized system of government by an efficient Caesar, resting immediately on the people, and annihilating the powers of the people's representatives. Under Napoleon I. this conception had a Carolingian colour: under Napoleon III. there is less of Carolingianism, and more of Caesarism—more of a popular dictatorship. While in modern France empire has meant autocracy instead of representative government, in Germany it has meant a greater national unity and a federal government in the place of a confederation. The German empire (1870–1918) was at once like and unlike the old Holy Roman empire. It was unlike the old mediaeval empire; for it had no connection with the Catholic Church, and no peculiar relation to Rome. But it was like the Holy Roman empire of the 17th and 18th centuries—for it represented a federation, if a more real and more unitary federation, of the several states of Germany. The likeness is perhaps more striking than the dissimilarity; and in virtue of this likeness, and because the memory of the old German *Kaiserzeit* was a driving force in 1870, we may speak of the modern German empire as the successor of the old Holy Roman empire, if only we remember that we are speaking of that empire in its last two centuries of existence. The "empire of Austria," on the other hand, as it existed from 1804 to 1918, was not an empire in the sense of a federation, but a convenient designation for a sum of territories, ruled by a single sovereign under various titles (king of Bohemia, archduke of Austria, etc.), and very imperfectly unified in a single political system. The title of emperor was assumed in Austria, as we have seen, through an historical accident; and, though the Habsburgs of the 19th century were personally the lineal descendants of the old Holy Roman emperors, their empire was in no sense the successor or representative of the old Holy Roman empire of the middle ages.

There is one empire which remains to be mentioned—an empire which, unlike the other empires of which we have spoken, is entirely independent of the tradition and memory of Rome. Thus is the British empire (*q.v.*) or, as it is coming more and more to be called, the British commonwealth. It is an empire so much *sui generis*—a federation of national states at once so independent and so interconnected—that it is altogether a matter for separate consideration. This much, however, may be said of its nature. The British empire is, in a sense, an aspiration rather than a reality, a thought rather than a fact, a common culture and not a common government; but, just for that reason, it is like the old empire of which we have spoken; and though it be neither Roman nor Holy, yet it has, like its prototype, one law, if not the law of Rome, at any rate the common law of England—one faith, if not in matters of religion, at any rate in the field of political and social ideals.

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EMPIRE COTTON GROWING CORPORATION, THE. This body grew out of the British Cotton Growing Association, founded in 1904, to develop fresh cotton fields within the British empire. It is a body representative both of the industry and the State. The income of the Empire Cotton Growing Corporation is derived in part from a capital contribution of nearly £1,000,000 made by the Government, and in part from the proceeds of a levy of 6d. per bale on all cotton purchased by British spinners. The British Cotton Growing Association retains its separate identity, and works in close alliance with the corporation; its chief work is the development of new areas, and the handling of the cotton, *i.e.*, ginning, baling and marketing, and it is particularly concerned in research work and the training and supply of experts. (*See* TROPICAL AGRICULTURE.)

From small beginnings the amount of cotton grown in new fields in the British empire (excluding India) increased to 82,000 bales in 1914, 261,900 in 1924, and 439,300 in 1926, of the approximate value of £9,301,300. The significance of these figures lies in the fact that 25 years ago West Africa exported no cotton, Uganda was just settling down after a civil war and was in the throes of sleeping sickness, and in the Sudan the first experiments were being made. In 1927 at least 140,000 bales were produced in the Sudan alone.

In 1928 several million pounds of "artificial cotton" were marketed in England at a fixed price; less than that of real cotton. This new product, successfully grown in Sussex and Essex counties, was transplanted from British Guiana. It was accidently discovered when a bird was found picking a certain plant, stripping and treating it for its nest and evolving a fibre that resembled cotton. It is said to meet every demand of the "coarse count" required by the British cotton industry and can be treated by existing cotton machinery. It is also asserted that its yarn can be blended with silk and wool and will take dyes with ease.

EMPIRE MARKETING BOARD. An official non-political body appointed in May, 1926, to advise the British secretary of State for Dominion Affairs, who is its chairman *ex officio*, in his control of an annual grant, voted by Parliament for the furtherance of the marketing in Great Britain of Empire products, including in the first place home agricultural produce. The board acts largely upon the recommendations of the Imperial Economic Committee though its work covers in some respects a wider field.

Mr. Baldwin, in explaining to Parliament (Dec. 1924), that the Imperial Economic Committee would forthwith be appointed and would be charged with the duty of advising the projected executive committee—subsequently created as the Empire Marketing Board—stated:—"In giving this assistance it is the hope and intention of the Government that it should be used to enable the Dominions to secure a larger share of that part of the home market which has to be supplied by importation from abroad. The Dominions have always recognized that our home producers have and should always have the first place in the home market but they ask—and we think rightly ask—that they should have a preference over foreign countries as regards that part of the home market which cannot be supplied by the home producer." The duty of the Empire Marketing Board to the home producer was thus made clear from the outset.

The membership of the board includes certain members of the Government *ex officio* together with representatives of the oversea parts of the Empire, of different political parties and other organizations appointed by the secretary of State. The membership of its committees includes also men of recognized experience in the widely various branches of the board's activity.

The board does not allow itself to be influenced by any consideration of party politics, and it endeavours to work through existing Government departments and other existing institutions rather than independently. There are, however, certain questions, notably publicity and marketing investigations, with which the

board has been obliged to deal directly. Its work fell naturally into two main branches, the one publicity and the other research, including both scientific research and economic investigation.

Research.—The board has made no attempt itself to engage directly in scientific research. Instead, it has regarded its proper functions as being the fortifying of existing scientific institutions in such measure as to enable them to intensify or to develop their work and the establishment of new institutions to meet new and proved needs.

In its allocation of grants it is consistently guided by the different Government organizations, at home and overseas, best qualified to advise it. Among the subjects of research work in aid of which grants have been made by the Empire Marketing Board are—tropical and sub-tropical research, including the establishment or strengthening of research stations, low temperature research, horticultural research, entomological research including the eradication of insect pests and the control of noxious weeds, animal breeding, and animal husbandry, including enquiries into the mineral contents of natural pastures.

Many of the board's grants are made conditional upon the receipt of contributions from other sources, and a considerable volume of research work has thus been put in hand at a relatively small expense to the Empire Marketing fund.

In addition to pure research work, the board has also interested itself in economic investigation, particularly in questions concerning the packing, grading and transport of certain foodstuffs. A substantial grant was placed at the disposal of the Ministry of Agriculture and Fisheries to be devoted to the interests of the home producer in this field. (S. G. T.)

EMPIRE STYLE, a term loosely describing the neo-classic style which developed in France during the consulate and empire of Napoleon, spreading rapidly throughout Europe and even to America. It originated primarily in Napoleon's desire to re-create the grandeur and luxury of imperial Rome. To this desire the spirit of the times was particularly congenial: scientific archaeology was beginning, knowledge of classic detail was increasing and the popular imagination was being fired by excavations at Pompeii and Herculaneum. In addition to the purely Roman motives, certain Egyptian ideas, such as the sphinx, were adopted, due to Napoleon's Egyptian campaign. In architecture, the style is characterized by monumental grandeur and a close following of Roman precedent, as in the front of the Chamber of Deputies, Paris. In furniture, rectangularity, massiveness and a great use of bronze *appliqué* ornament are universal. Where curves occur they are large and swelling, as in the ends of the typical sofa of the period. The use of heavy textiles, frequently embroidered with Napoleon's monogram or the symbolic bees, was widespread. The style lasted in a modified form until about 1840. The later forms are unduly monotonous and heavy. (*See* MODERN ARCHITECTURE.)

EMPIRICISM, in philosophy, the theory that all knowledge is derived from sense experience (from Gr. ἔμπειρος skilled in, from πεῖρα, experiment). It is opposed to all forms of intuitionalism, and holds that the mind is originally an absolute blank (*tabula rasa*), on which, as it were, sense-given impressions are mechanically recorded, without any action on the part of the mind. The process by which the mind is thus stored consists of an infinity of individual impressions. The frequent or invariable recurrence of similar series of events gives birth in the mind to what are wrongly called "laws"; in fact, these "laws" are merely statements of experience gathered together by association, and have no other kind of validity. In other words from the empirical standpoint the statement of such a "law" does not contain the word "must"; it merely asserts that such and such series have been invariably observed. In this theory there can strictly be no "causation"; one thing is observed to succeed another, but observations cannot assert that it is "caused" by that thing; it is *post hoc,* but not *propter hoc.* The idea of *necessary* connection is a purely mental idea, an a priori conception, in which observation of empirical data takes no part; empiricism in ethics likewise does away with the idea of the absolute authority of the moral law as conceived by the intuitionalists. The moral law is merely a collection of rules of conduct based on an infinite number of special cases in which the convenience of society or its rulers has subordinated the inclination of individuals. The fundamental objection to empiricism is that it fails to give an accurate explanation of experience; individual impressions as such are momentary, and their connection into a body of coherent knowledge presupposes mental action distinct from mere receptivity. Empiricism was characteristic of all early speculation in Greece. During the middle ages the empiric spirit was in abeyance, but it revived from the time of Francis Bacon and was systematized especially in the English philosophers Locke, Hume, the two Mills, Bentham and the associationist school generally. (*See* ASSOCIATION OF IDEAS; METAPHYSICS; PSYCHOLOGY; LOGIC; besides the biographies of the empirical philosophers.)

In *medicine,* the term is applied to a school of physicians who, in the time of Celsus and Galen, advocated accurate observation of the phenomena of health and disease in the belief that only by the collection of a vast mass of instances would a true science of medicine be attained. This point of view was carried to extremes by those who discarded all real study, and based their treatment on rules of thumb. Hence the modern sense of empirical as applied to the guess work of an untrained quack or charlatan.

EMPLOYEE REPRESENTATION, a term used (especially in the United States) to designate a plan whereby management seeks to establish a point of contact with its employees on matters of mutual interest to secure greater co-operation, mutual confidence and good-will. The first attempts to bring this about in the U.S.A. took the form of shop committees, whose principal function was to provide a means for bringing the wants or grievances of employees to the attention of the management. The second stage of development was due to the activities of the National War Labor Board, the U.S. Railroad Administration and the Shipbuilding Labor Adjustment Board, which agencies used the shop committee as part of the machinery for adjusting labour disputes. Since that time, employee representation plans have been the subject of much controversy. Labour leaders have claimed that the movement is an attempt to disrupt labour unions. In other instances, labour unions have co-operated with the management in the establishment of shop councils.

Employee representation plans may be roughly classified into: (1) those having very limited power, usually advisory only; (2) those which have definite provision for settling disputes, and where the representatives take some actual part in settling the point at issue; (3) those which either directly or indirectly give the employees representation on the board of directors of the company; and (4) those which maintain some direct affiliation with labour unions. Another way to classify employee representation plans would be to separate them into those which maintain some direct connection with a trade union or are non-conflicting, and those which have been organized as a substitute for a union organization, either because the employer wished it so or because no union existed. The structure of the plans is either a joint committee type of organization wherein representatives of the employee and the management meet in committee or it is imitative of the so-called Federal form of Government. This latter type usually provides for such bodies as a house of representatives made up of employee representatives, a senate made up of supervisory employees, and a cabinet made up of executive officers. The details of arbitration machinery, powers and procedure vary widely. In common with nearly all of the so-called industrial relations activities, the success of employee representation rests upon the motives underlying the inauguration and continuance of the particular plan in question. Properly carried out, it provides an opportunity for managers to learn much about men and these to learn much about management. (O. G. S.)

EMPLOYEE STOCK OWNERSHIP, a plan whereby employees are offered an opportunity to purchase the stock of the company which employs them. Plans of this kind are usually undertaken by a company in the belief that they will promote a more intimate relationship with employees, encourage thrift, attract a better type of employee and possibly reduce turnover. From the standpoint of the employee, there are both advantages

and disadvantages in such stock ownership plans. While they provide an opportunity for regular savings and perhaps profitable investment of funds, they tend to multiply his economic risks in that his job and his invested savings are both dependent on the success of the same enterprise. The stock sold to employees may be either "common" or "preferred," the desirability of either depending largely upon the financial structure of the company involved. Whether or not the company wishes its employees to hold stock carrying a voting privilege, also becomes a consideration in the choice of stock to be sold. The stock itself is usually secured by treasury issue or by the setting aside of a block of new issue for sale to employees. Occasionally, a special employees' stock is issued by the company. While the actual sale of stock is usually made directly by the company to its employees, there are instances where the company allows the sale to be carried on through an employees' organization. Eligibility requirements for participation in employee stock ownership plans vary widely. Some companies allow all employees to subscribe; others require a minimum term of employment before eligibility; others limit the subscription to certain classes of employees, such as those holding responsible positions or perhaps senior executives only. Salary may also be a determining factor in eligibility. The number of shares which an employee may purchase is almost always controlled. These restrictions are most commonly related to salary. Length of service may also be considered.

Instead of selling stock to employees at the prevailing market price, many employers offer the stock at a price slightly below its market value, in order partially to protect the employee against price fluctuation, and also to make the offer additionally attractive. Some companies offer to assist the employee in the purchase of the stock and have a definite scale of contribution often based on length of service and number of shares. Again, other companies give stock to their employees either as a reward for meritorious service during a given period of time or as a reward for length of service; thus the stock distribution is actually a bonus plan where stock is given in lieu of cash. Where the employee pays for all or part of the stock, this may be accomplished either by cash payment in full at the time of purchase, by monthly installments over a given period, by payment into a convertible fund or by subscription to a stock pool. Method of payment is usually liberal and where deferred payments are allowable, arrangement is often made for payroll deduction. Title to the stock, however, ordinarily does not pass until the payments have been completed, nor are dividends credited to the employee except as payments on account. The sale or transfer of stock is usually restricted. Many companies offer inducements to employees to hold stock. These inducements most frequently take the form of extra dividends. Where the sale of stock is restricted, a re-purchase provision is included in the plan. The success of employee stock ownership plans depends primarily upon the liberality and soundness of the plan, the existence of mutual confidence between the employer and the employee, and the business integrity of the organization as a whole. (O. G. S.)

EMPLOYEES, TRAINING OF. Arrangements for the training of employees date back as far as industrial history. They were among the most important objects of the mediaeval guilds (*q.v.*) and the whole basis of the system of apprenticeship (*q.v.*). But with the introduction of the factory system the personal relationship between the master craftsman and the beginner changed substantially, and since then employee training has been carried on, if at all, generally in an unorganized, sporadic, haphazard and ineffective way.

Corporation Schools.—In the United States, however, as early as the '90s, a few corporations had formed what were commonly called "corporation schools," the assumption being that the training function should be exercised by a department especially equipped and trained to perform the job of training the employees. This change was due to the assumption that the foreman could not be expected to train employees partly because he was poorly equipped to teach and could not be trained to teach and partly because it was assumed that he had too many other responsibilities. It was not unusual for corporations establishing schools or educational departments to appoint as the head of that department some one who, presumably, was better able than the supervisor to train employees. Not infrequently an engineer or a public school teacher or official was chosen for such a position, partly on the basis of a more complete education and often partly on the basis of personality. By 1913 there were in America a sufficient number of corporation schools to warrant the formation of a National Association of Corporation Schools, and this association grew in influence and numbers substantially from 1913 until 1921. Meanwhile, similar associations were formed in England, France, Japan and in some other countries. Most of these schools adopted the pedagogical methods which had been in vogue in the public schools and in engineering and other colleges during the days when the director of education had attended them. Without any particular knowledge of pedagogical methods, he naturally adopted the methods with which he was most familiar including often the formalism of the classroom and its more or less inevitable removal from occupational activity or other relationships. By 1918 or 1919 many corporations in America were training employees without the formality of a corporation school and this trend of thought found its expression in the renaming of the association, National Association of Corporation Training.

There has been a strong tendency for corporations to abandon the formal classroom instruction method of training and to return to the earlier method of making training fundamentally the responsibility of the line supervisor. There is, however, this very important difference, namely, it is being recognized that the supervisor should be trained in the teaching process and that he can be trained. Furthermore, it is being recognized that the instructional materials for training purposes, usually referred to as instructural outlines, must be organized in such a way that the supervisor will cover all aspects of the training programme so that they will not be left to mere chance.

Industrial School Training Inadequate.—During this change in methods of training employees, United States public educational authorities were giving more and more attention to the preparation of youth for industrial and commercial pursuits. The industrial and trade school supported by communities as part of the public educational system became quite general. The first tendency in this movement was to assume that the public schools could take over a very large part of the programme of training for industry as well as education for life, and for a time it was easy to find vigorous advocates of public educational institutions which would entirely relieve industry and commerce of the problem of training for the job. There has been, however, a distinct swing away from the assumption that the public schools could entirely relieve industry of its own responsibility. It is now realized that the public schools have failed to perform the whole task of education and training for occupational activity, that the failure was inevitable, that the problem cannot be transferred in its entirety to the public schools and that industry, whether it wishes to or not, must assume its own share of responsibility for training.

At first many corporation schools undertook what is generally conceded to be the responsibility of the public schools, *i.e.*, the responsibility of educating young people and even others for the broader relationships of life, most of which, of course, have some bearing on the effectiveness of an employee in his occupation. For the most part, this tendency has been or is being abandoned. Organized business now expects the public schools to prepare youth for most life relationships, and by eliminating this feature from its own programme, industry can devote itself more intensively and effectively to training for the job.

Training a Management Problem.—A very large number of companies have what is commonly referred to as an educational department or an educational director. One of the largest electric manufacturing companies has practically done away with all formal classroom instruction of employees and is concentrating its efforts in teaching the foreman to train. A syllabus for supervisors in an electrical public utility company consists largely—practically 90 to 95%—of material which deals with teacher training for foremen, the assumption being that in order to make the training programme really effective, steps must be taken to make

the training of the worker continuous from the time of entering the business until he leaves it, and on the principle that the best training is that which is given in connection with actual work under normal circumstances of supervision, incentive and responsibility. The president of a large company in the United States has stated that management is in large measure, 80 to 90%, an educational and training job. He illustrates by saying that on one occasion a number of executives of this company analysed exactly what management is in terms of specific operations and, that after classifying all of the typical operations, nine out of ten of them were listed under education and training.

The preparation of instructional materials is, of course, one of the most important steps in a training programme. At one time, the usual practice was for the instructor himself to learn every element of the job and then proceed to convey the information to the employee usually by the lecture process in a classroom. More recently emphasis is being laid on the job difficulties of the employee, and the result has been a pronounced movement in the direction of analysing the job difficulties and the man requirements, the learning difficulties of the employee and the order in which these appear. Out of this analysis it is possible to set up a body of instructional materials which attack, not training for the whole job, but rather, the problem of training the employee to overcome the job difficulties. Another important step in a modern training programme is an analysis of the teaching process in terms of the difficulties of the foreman or department head in training his employees for the job. Such an analysis leads to the development of a body of instructional materials on the technique of training and is naturally followed by a programme of instructing the supervisor to train. Employee training has come to be recognized as a management problem and the subject of training employees takes a very large place in all discussions of management societies the world over. (W. J. Do.)

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EMPLOYERS' ASSOCIATIONS: *see* ASSOCIATIONS, INDUSTRIAL.

EMPLOYERS' LIABILITY: *see* WORKMEN'S COMPENSATION.

EMPLOYMENT EXCHANGE, an agency for bringing together employers requiring labour and workpeople desiring work; also variously known as a Labour Exchange, Labour Bureau or Employment Agency. The primary function is to record "vacancies," *i.e.*, requirements of an employer, with conditions offered by him, and to register qualifications of applicants for employment, with a view to submitting suitable workpeople for the vacancies. Such an agency may be privately owned, or under municipal or State control or management, may charge fees to employers or workpeople, or both, for the introductions effected, or may defray the expenses of administration from private or public funds. Its scope may be limited as to the trades and occupations in which notifications of vacancies are received, or as to the classes of workers (skilled, unskilled, male or female) placed in employment. An exchange may be local, national or, exceptionally, international in its range of action. Finally, the notification of vacancies may be obligatory upon employers, while refusal of suitable employment offered may entail suspension or disallowance of an applicant's out-of-work pay. (*See* UNEMPLOYMENT INSURANCE.)

Although the functions of employment exchanges (particularly in the case of privately owned "registry offices" for domestic servants) may terminate with the "vacancy work" or "placing," other duties are usually combined with this work, especially when the exchanges are under the direction of a public authority. A combination of vacancy work with the administration of out-of-work pay schemes has long been the practice of Trades Unions and is an essential feature of the National Unemployment Insurance scheme of Great Britain. The association of exchanges with the payment of unemployment benefit enables, in Sir Wm. Beveridge's words, "the beneficial and natural test" of a situation offered through the exchange to be substituted for abstract enquiries directed to ascertaining the genuineness of an applicant's search for work. "The two systems are complementary; they are man and wife; they mutually support and sustain each other" (Mr. Winston Churchill, House of Commons, May 19, 1909).

Theory of Employment Exchanges.—The object of exchanges is to increase the mobility of labour, but at the same time to prevent its needless displacement. By concentrating the notification of vacancies and the registration of applicants for employment at convenient centres linked together by a clearing house system, the numbers, classes, occupations, and the duration of the employment of the industrial population, together with the opportunities for further employment, are recorded and tabulated. The fluctuating requirements of the labour market, themselves a cause of unemployment, are thus measured; and supply is related to demand. If the surplus is local, by the use of a clearing house system which informs the local exchange of opportunities of employment elsewhere (aided by the advance of railway fares given unconditionally or by way of a loan), the surplus is enabled to transfer to areas of shortage and to find work there. If the surplus is general, as in outdoor occupations of the building trade in winter, the dovetailing of occupations, by the transfer of the seasonably unemployed to subsidiary occupations or to any alternative work for which they may be qualified, is assisted by the use of the same machinery. Where the surplus is both general in extent and permanent in character (as may happen when new industrial processes or changes in fashion modify existing methods of production) the exchanges, guide displaced workers to other forms of employment. Finally, the exchange may serve as a medium for paying unemployment benefit.

The practical application of the theory of employment exchanges would present no difficulties if every unemployed person were free to take any kind of work wherever it was available. The mobility of labour, the interchangeability of occupations, the existence of subsidiary qualifications, the ability of unemployed men to move their homes, all of which are implicit in the theory, are, however, necessarily affected by differences in wage levels, increasing trade specialization, difficulties of occupational transfers, housing shortages, family circumstances, and a variety of psychological factors. It may be doubted, too, whether prejudices due to experiences of the exchange system in its early stages of development have yet disappeared. A loss of time and a slowing down of production are anticipated by some critics if, instead of engaging labour at the works gates, *all* vacancies are notified to the labour exchange and the employer waits while machinery outside his control selects for his approval and engagement apparently suitable men. Against this it is contended that industry as a whole saves time by the use of an agency which concentrates reserves of labour, assesses its industrial value, and directs to each establishment, as required, suitable men. The view expressed is that the best workmen do not register at exchanges and therefore are not available for submission. If, however, the exchanges are associated with the payment of unemployment benefit, all claimants are automatically within the field of selection. A more serious objection has been made by trade unionist critics that the exchanges may be used to fill vacancies caused by trade disputes; also that, as no preference is shown to trade unionists in submitting applicants for vacancies, the organization of labour to which they aspire may be hindered. These objections were taken into account when labour exchanges were established in Great Britain and the act of 1909 provided that no submissions should be made to "black-leg" vacancies without the applicants' consent and that men refusing to be so submitted or otherwise to accept employment below standard conditions should suffer no disability.

Employment Exchanges in Great Britain.—Under powers conferred upon local authorities in Great Britain by the Unemployed Workmen act of 1905, exchanges had been established in London and some provincial centres, while a co-ordinating author-

ity for the metropolis, the Central (Unemployed) Body, had maintained, with some success, employment exchanges, including a clearing house system. Prior to this certain metropolitan borough councils and provincial local authorities had set up labour bureaux, which, however, worked independently of each other and had a limited range. Both bureaux and exchanges, however, were so generally associated with relief works that they mostly failed to secure the confidence of employers and the best type of work-people. From 1905–09 the treatment of distress due to unemployment came under the review of the Royal Commission on the Poor Laws. While criticizing the existing exchanges, both for their organization and limited scope, the commission were satisfied that their failure had been due to local and special causes and not to any inherent defect. The commission accordingly recommended that:—

"1. A national system of labour exchanges should be established and worked by the Board of Trade for the general purposes of assisting the mobility of labour and of collecting accurate information as to unemployment.

"2. The labour exchanges should be in charge of officers of the Board of Trade, assisted by committees of employers, workmen, and representatives of local authorities.

"3. There should be no compulsion to use the labour exchanges, but the object of the Government and the local authorities should be to encourage and popularize them in every way, *e.g.*, by propaganda and by making use of the exchanges in engaging workmen.

"4. The labour exchanges should be granted free postal and telephone facilities by the State.

"5. Arrangements should be made to enable the labour exchanges to grant passes entitling workmen travelling to a situation to specially cheap railway fares; in suitable cases the cost of the passes might be provided and recovered afterwards from the workmen."

The Labour Exchanges act of 1909 embodied most of the commission's recommendations. A national system of exchanges, charging no fee to employers or workpeople making use of it, was established by the Board of Trade, and by Feb. 1910, 61 offices, including 19 taken over from the Central (Unemployed) Body, were available to the public. The introduction two years later of the State Unemployment Insurance scheme, its great extension, and the growth of unemployment after the World War led to considerable increases in the number of exchanges. At the end of 1927 there were nearly 400 exchanges and 700 branch employment offices maintained by the Ministry of Labour, to whom the functions of the Board of Trade in this matter had been transferred in 1917. The previous year had seen the term "employment exchanges" officially substituted for the statutory designation.

Statutory exchanges and branch employment offices are administered by the Employment and Insurance department of the ministry of Labour, consisting of a headquarters staff in London and seven divisional offices under the charge of a divisional controller. Ordinarily, all exchanges have separate departments for men and women. Where the local education authority does not establish juvenile employment bureaux under the Choice of Employment Act, 1910 (embodied in Section 107 of the Education Act, 1921), the exchange has a branch for assisting juveniles to find suitable employment. It has not always been practicable to house all departments in the same building but, wherever possible, this is done. At each divisional office there is a senior woman officer responsible for the women's and juveniles' section. Exchanges are assisted by advisory committees consisting of equal numbers of employers' and workpeople's representatives and a certain number of individuals nominated by local authorities, ex-service men's associations, juvenile advisory committees, territorial force associations and bodies interested in social work.

Vacancy Work.—It has already been shown that, through the association in Great Britain of unemployment insurance administration with exchange work, all unemployed persons claiming benefit are registered at one or other of the 1,100 local offices of the Labour Ministry. All such persons attend at the nearest office to sign the unemployed register as often as may be required. This attendance from day to day of unemployed workpeople of all occupations serves also to provide a "live register" of the facts of unemployment and to relate the supply of labour to the demand. If a new factory is to be erected in a semi-rural district where there has hitherto been no industrial development, the contractors, who may be strangers to the district, will notify their requirements to the nearest exchange. There will be vacancies for navvies, bricklayers, masons, carpenters, fitters, skilled and unskilled workers. Probably a sufficient number of labourers will be signing the local unemployed register to meet the employer's requirements for this part of the "order." If so, the exchange manager will give each suitable man an introduction card to the works foreman; the foreman fills in the card and returns it to the exchange to show whether the applicant has been engaged or not. Where the area of selection of men has to be widened, the exchange manager will telephone one or more adjacent exchanges to ascertain whether any suitable applicants are within daily travelling distance of the work, and similar arrangements for interview are made. If, owing to local shortages of some of the types of labour in demand, a still wider circulation is necessary, this is obtained by communication with the divisional clearing house. The latter receives at frequent intervals from each exchange in its area "surplus labour slips," showing for each of the occupations in demand in its own or another clearing house area the numbers and special qualifications of applicants on the local register who are available for submission to distant vacancies. The clearing house may therefore be in a position to refer the "vacancy exchange" (the office to which the "order" has been given) to an "applicant exchange" (*i.e.*, an office at which suitable men of the occupations in demand are signing the unemployed register) and thus arrange for the submission to the employer of particulars of suitably qualified men. Where the divisional clearing house has no positive knowledge of the whereabouts of surplus labour of the required kind, it includes particulars of the "order" in the daily list of vacancies circulated to all exchanges in the area, or, if necessary, to the London headquarters for inclusion in the printed *National Clearing House Gazette* which is distributed daily to all exchanges in the country. Divisional and national clearing house lists are also exhibited in the "vacancy section" of all exchanges. Railway warrants are issued in necessary cases to enable the men engaged to travel to their new employment, or, in some cases, to be interviewed prior to engagement. Sometimes the fare is paid by the employer, sometimes the amount is deducted later from the wages by weekly instalments; the vacancy exchange normally acts as the collecting office for the sums advanced. Thus, though the use of the national clearing house enables the whole labour supply of the country to be drawn upon where necessary, the local and nearer sources are exhausted first.

Exchange officers are required to act impartially in submitting applicants to vacancies, having regard only to industrial suitability, save that, as a matter of Government policy, a preference is given to ex-service men as between equally qualified applicants. In appropriate cases the branch secretary of the trade union concerned is consulted to see whether any unemployed members of his branch are suitable and available for the vacancy.

Statistics.—Although the Labour Exchanges act imposed no obligation on employers to notify vacancies to the exchanges, many important industrial undertakings recruit their labour entirely through their agency. In Aug. 1927 the Mining Association of Great Britain agreed, under s. 18 of the Mining Industry Act, 1926, to restrict until the end of 1929 the engagement of new entrants into the coal-mining industry. All vacancies for adults in practically all forms of colliery employment are therefore notified to the exchanges in order that, within a period of 14 days, men formerly employed in the specified occupations can be submitted for engagement. If none can be found to take the employment offered within this period, a new entrant may be engaged. On a register of approximately 1,000,000 unemployed persons, the exchanges in 1926–27 placed in employment some 25,000 to 30,000 applicants each week. In 1927–28 the average weekly un-

employed register was 1½ millions and again the exchanges placed in employment each week some 25,000 to 30,000 applicants.

Employment Exchanges in Other Countries.—Since the beginning of this century exchanges resembling in their main features those established in Great Britain have been operating in several European countries. The municipal and State systems of Germany served as a model for the British exchanges. The adoption internationally of a uniform system has resulted from the proceedings of the First (Washington) Session of the International Labour Conference, 1919, which had been brought into existence by the Treaty of Versailles (Part XIII.). A draft convention on employment adopted by the conference provided in its second article as follows:—

"Each member (*i.e.*, State) which ratifies this Convention shall establish a system of free public employment agencies under the control of a central authority. Committees, which shall include representatives of employers and workers, shall be appointed to advise on matters concerning the carrying on of these agencies.

"Where both public and private free employment agencies exist, steps shall be taken to co-ordinate the operation of such agencies on a national scale.

"The operations of the various national systems shall be co-ordinated by the International Labour Office in agreement with the countries concerned."

In addition to Great Britain the under-mentioned members of the International Labour Organization have ratified (1928) the Employment Convention and, where their legislation was not previously in accord, have since taken steps, or are adapting their legislation, to give effect to it, viz., Austria, Bulgaria, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Irish Free State, Italy, Japan, Luxemburg, Norway, Poland, Rumania, Serb-Croat-Slovene Kingdom, South Africa, Spain, Sweden and Switzerland.

Certain States which are not members of the International Labour Organization or have not ratified the convention have within their territories employment exchanges under Government control and satisfying some or all of the conditions laid down by the conference. The New Zealand Government, for example, established exchanges so long ago as 1891.

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United States.—In the United States public employment offices have been organized by municipalities, States and by the Federal Government. New York city established the first municipal office in 1834. Los Angeles and Seattle established municipal offices during the panic of 1893. From that time on, the demand for seasonal labour in the farming countries caused employment offices to be opened in many western cities. In 1907 and in 1913, the movement expanded again and over 40 municipal employment offices were opened. Many of these subsided as their period of usefulness ended, or they were absorbed by other agencies. The first State employment agency was established in Ohio in 1890. In 1927, 33 States were operating public employment offices. The Federal Government established an employment agency in 1907 fo the placement of immigrants. This was known as the division of information of the bureau of immigration. In Jan. 1918, the U.S. employment service was organized. State agencies were considered as local units and many of the then existing local offices were absorbed. This rather extensive movement did not last long and in 1919 the so-called field service work of the Government was discontinued and the individual States reorganized their local employment agencies on an independent basis.

In the absence of an extensive system of public employment agencies, there has been a marked development of the so-called private or semi-public employment agency. These have been variously financed by employers, employees, fraternal associations, professional organizations, schools, etc. Employment agencies organized by employers are often administered by chambers of commerce, trade associations or merchants' associations. They usually flourish when labour is scarce. Agencies organized by workers are usually administered through trade unions for the purpose of keeping their members employed. Many fraternal organizations, professional bodies, colleges and training schools maintain employment agencies for the purpose of securing positions for their members or their graduates. They are, therefore, more apt to be concerned with supplying technical and professional help. Philanthropic organizations have in many instances established agencies to provide relief during periods of widespread unemployment. In addition to the foregoing, and important because of the extensive nature of its operations, is the employment agency organized as a business enterprise and on a fee-charging basis. Many of these organizations do a flourishing business, have a large staff of trained employees and a wide range of contact. Some States now seek to regulate this type of agency by requiring licences and bonds. The need for regulation, however, is the exception rather than the rule. The larger private employment agencies are usually sound and reputable institutions. Many conduct extensive studies and issue reports on the labour market, current rates of pay and similar data.

The larger employers of labour in the United States do not depend entirely on outside employment agencies, either public or private, for the continuance of their labour supply. Most large business organizations maintain extensive employment or personnel departments. Contacts are developed with schools and professional associations so that suitable applicants for the positions requiring special training may be secured. These departments also study intensively the problems of labour turnover, wages rates and sources of labour supply and all the related problems affecting the maintenance of an adequate operating personnel. (O. G. S.)

EMPOLI, town, Tuscany, Italy, province of Florence, 20 m. W. by S. of Florence by rail. Pop. (1921) 8,120 (town); 21,730 (commune). It is 89 ft. above sea-level, to the south of the Arno. The principal church, the Collegiata, or Pieve di S. Andrea, founded in 1093, still preserves the lower part of the original arcaded façade in black, white and coloured marble. The principal square is surrounded by old houses with arcades. Empoli is on the main railway line from Florence to Pisa, and is the point of divergence of a line to Siena.

EMPORIA, a city of eastern Kansas, U.S.A., on the Neosho river, 70m. S.W. of Topeka; the county seat of Lyon county. It is on Federal highway 50S, and is served by the Missouri–Kansas–Texas and the Santa Fe railways. The population at the State census of 1925 was 12,243 (90% native white). The city has railroad shops and other manufacturing industries, with an aggregate output valued in 1925 at $1,211,425; but it is primarily an educational centre and a commercial metropolis for a large agricultural and stock-raising region. The original State normal school of Kansas, established at Emporia in 1863, became the Kansas State teachers' college of Emporia in 1923, and now has an enrolment of over 5,000. The College of Emporia (enrolment about 500) is a Presbyterian co-educational institution, established in 1882. Emporia was settled in 1856 and incorporated as a city in 1870. It is the home of William Allen White (b. 1868, in Emporia), who in 1894 bought the Emporia *Gazette* (established 1890) and became its editor.

EMPORIUM, a trade-centre such as a commercial city, to which buyers and dealers resort for transaction of business. (From Gr. ἐμπόριον; ἐν, in, and stem of πορεύεσθαι, to travel for purpose of trade.) The word is often applied to a large shop.

EMPSON, SIR RICHARD (d. 1510), English statesman, born at Towcester, was in 1491 one of the members of parliament for Northamptonshire and speaker of the House of Commons. Early in the reign of Henry VII. he became associated with Edmund Dudley (*q.v.*) in carrying out the king's rigorous and arbitrary system of taxation. He was made a knight in 1504,

and was soon high steward of the University of Cambridge, and chancellor of the duchy of Lancaster; but his official career ended with Henry's death in April 1509. Thrown into prison by order of the new king, Henry VIII., he was charged, like Dudley, with the crime of constructive treason, and was convicted at Northampton in Oct. 1509. His attainder by the parliament followed, and he was beheaded on Aug. 17 or 18, 1510.

See Francis Bacon, *History of Henry VII.*, ed. J. R. Lumby (Cambridge, 1881); and J. S. Brewer, *The Reign of Henry VIII.*, ed. J. Gairdner (1884).

EMPYEMA, a term in medicine applied to an accumulation of purulent fluid within the cavity of the pleura (*see* HEART AND LUNG, SURGERY OF).

EMPYREAN, the place in the highest heaven, which in ancient cosmologies was supposed to be occupied by the element of fire. It was used as a name for the firmament, and in Christian literature (so Milton, in *Paradise Lost*) for the dwelling-place of God and the blessed, and as the source of light. The word is used both as a substantive and as an adjective; it is accented on the third syllable.

EMS, a town and watering-place of Germany, in the Prussian province of Hesse-Nassau, situated on the Lahn, 11 m. E. from Coblenz on the railway to Cassel and Berlin. Pop. (1925) 7,121. There is some mining industry (silver and lead). Ems is a watering-place, its waters—hot alkaline springs—being used both for drinking and bathing. A funicular railway runs up to the Malberg (1,000 ft.), where is a sanatorium and whence extensive views are obtained over the Rhine valley. In 1786 Ems was the scene of the conference of the delegates of the four German archbishops, known as the congress of Ems, which issued (Aug. 25) in the famous joint pronouncement, known as the Punctuation of Ems, against the interference of the papacy in the affairs of the Catholic Church in Germany (*see* FEBRONIANISM).

EMS, a river of Germany, rising on the south slope of the Teutoburger Wald, at an altitude of 358 ft., and flowing generally north-west and north through Westphalia and Hanover to the east side of the Dollart, immediately south of Emden. After passing through the Dollart the navigable stream bifurcates, the eastern Ems going to the east, and the western Ems to the west, of the island of Borkum to the North sea. Length, 200 miles.

Between 1892 and 1899 the river was canalized for a distance of 43 miles. At the same time, and as part of the plan to provide an entirely German outlet for the Westphalian industrial district, the Dortmund-Ems canal was constructed. It runs from Dortmund to Meppen (94 m.) where it joins the canalized Ems (55 m.) and then follows the open river to Emden. Altogether, the canal is 170 m. in length, has a surface width of 99 ft. and a depth of 11 to 12 ft. The total fall is 230 ft., overcome by 19 locks and a ship-lift. It will take boats of 750 and even 800 tons. From Henrichenburg a branch runs to Herne, which is connected with the Rhine near Ruhrost by the Rhine-Herne canal. There is a difference in level of 46 ft. between the main canal and the Herne branch, and this necessitated a huge lift at Henrichenburg. The canal is connected with the Mittelland canal system at Bevergern. Northward traffic is mostly in coke and coal from the Westphalian coalfield, to which it brings imported iron ore and other raw material and foodstuffs.

See Victor Kurs, "Die künstlichen Wasserstrassen des deutschen Reichs," in *Geog. Zeitschrift* (1898) and *Deutsche Rundschau f. Geog. und Stat.* (1898); W. H. Lindley, *Report on the Waterways of France, Germany*, etc. (Stationery Office, 1909); A. Krziza, *Emden und der Dortmund-Ems-Kanal* (Kiel, 1912).

EMSER, JEROME or **HIERONYMUS** (1477–1527), antagonist of Luther, was born of a good family at Ulm on March 20, 1477. He studied Greek at Tübingen and jurisprudence at Basel, and after acting for three years as chaplain and secretary to Raymond Peraudi, cardinal of Gurk, lectured on classics at Erfurt (1504), where Luther may have been among his audience. In the same year he became secretary to Duke George of Albertine Saxony. At first Emser sided with the reformers, but like his patron he desired a practical reformation of the clergy without any doctrinal breach with the past or the church; and his liberal sympathies were mainly humanistic. As late as 1519 Luther referred to him as "Emser noster," but the disputation at Leipzig in that year completed the breach between them. Emser warned his Bohemian friends against Luther, and Luther retorted with an attack on Emser which outdid in scurrility all his polemical writings. In the violent controversy that followed Emser wrote some eight tracts. At Duke George's instance he prepared, in 1523, a German translation of Henry VIII.'s "Assertio Septem Sacramentorum contra Lutherum," and criticized Luther's "New Testament." He also entered into a controversy with Zwingli, he took an active part in organizing a reformed Roman Catholic Church in Germany, and in 1527 published a German version of the New Testament as a counter-blast to Luther's. He died on Nov. 8, in that year.

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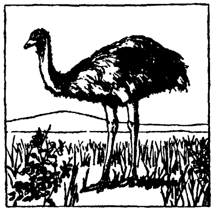
EMU or **EMEU,** the name given to Ratite birds of the family *Dromaeidae.* With the cassowaries (*q.v.*), the emus form the order Casuariiformes, peculiar to the Australian region and characterized by the fact that the "after-shaft" of each feather is as long as the main shaft (*see* RATITAE; FEATHER). The emus differ from the cassowaries in having feathers on the head, no helmet or cervical caruncles, and in bearing on their inner toes a peculiar claw. The best known species is *Dromaeus novae-hollandiae* of S.E. Australia. Next to the ostrich the largest of living birds, the emu has been much diminished in numbers by constant persecution. It inhabits open country, feeding on fruits, roots and herbage and keeping in small companies. The nest is a shallow pit in the ground containing 9 to 13 blue-green eggs, which are incubated by the cock. The young at birth are clad in striped down. The peculiar structure of the trachea is correlated with the loud booming note of the bird during the breeding season. This, or an allied species, formerly inhabited Tasmania.



BY COURTESY OF THE NEW YORK ZOOLOGICAL SOCIETY

AUSTRALIAN EMU, NEXT TO THE OSTRICH THE LARGEST OF LIVING BIRDS

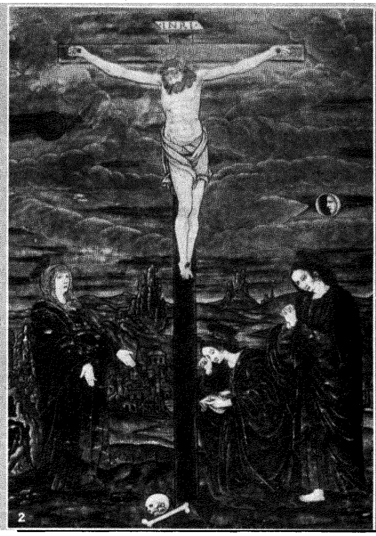
EMULSIONS are mechanical mixtures of liquids that are immiscible under ordinary conditions, and which may be separated into layers on standing, heating, freezing, by agitation, the addition of other chemicals, etc. Familiar examples of emulsions are milk and butter—the first, an emulsion of oil in water; the latter an emulsion of water in oil. The term emulsion is also applied (although not with complete accuracy) to mechanical mixtures in which finely-divided solid particles are suspended in liquids in which they are insoluble. More properly, such mixtures are known as colloidal solutions or suspensoids. In dyeing, tanning, tinting of certain coloured glassware, water purification, etc., emulsions play an important part.

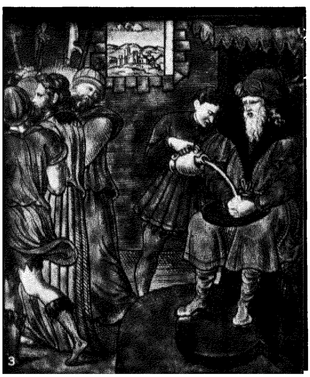
Froth flotation, by means of which many millions of tons of minerals annually are separated from their ores, employs emulsions of various vegetable and mineral oils (*see* METALLURGY). Basically, photography (*q.v.*) is also dependent on the use of emulsions, for dry plates and films are generally coated with gelatin emulsions.

ENAMEL, a vitreous glaze or combination of vitreous glazes fused on a metallic surface. The general term *enamels* is conveniently applied to objects of which the principal decoration consists of this material. The art is of great antiquity and probably of Western Asian origin.

I. EUROPEAN ENAMELS

It was upon pottery and brick that the ancient Egyptians and Assyrians achieved their greatest work in enamelling. As yet no





BY COURTESY OF (1, 3, 4) THE TRUSTEES OF THE BRITISH MUSEUM, (2) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM

MEDIAEVAL AND MODERN PAINTED ENAMELS

1. Portrait in enamel by Léonard Limosin of Catherine of Lorraine, duchesse de Montpensier, daughter of Francis of Lorraine, duc de Guise, in the "Fine Style" of Limoges of the 16th century. She is represented wearing an amber coloured cap set with pearls and emeralds. Her costume is richly jewelled. One of the puffs on her left shoulder is pricked with the artist's name
2. Enamelled plaque of the crucifixion by Jean Limosin, descendant of Léonard Limosin, in the "Minute Style" of Limoges of the early 17th century, at the beginning of the period of decline. Three holy women mourn at the foot of the cross, and the dark blue sky is covered with clouds through which shines a golden light. The sun and moon appear on either side of the crucifix, and in the background is the city of Jerusalem
3. Painted enamel of Limoges, Pilate Washing his Hands, in the "Fine Style" of the 16th century, a style less sumptuous in colour than the one preceding it and distinctly under the influence of the Italian Renaissance
4. Triptych of painted enamel, attributed to Nardon Pénicaud, in the "Early Style" of Limoges, 15th century, representing the entombment, between the descent from the cross on the left and the resurrection on the right. The plaque is executed in bright translucent colours on a white ground, the effect heightened by picking out lights and lesser details with gold, and by using small discs of foil placed beneath the enamel on the garments to simulate gems
5. A painted enamelled plaque called "The Virgin and the Doves," executed in translucent enamels, by Alexander Fisher, a distinguished modern English enameller. Fisher does not belong to any school; his work is marked by a preference for opalescent hues

ENAMEL

BY COURTESY OF (1) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, (2) EDWARD F. CALDWELL AND CO.

MODERN ENAMELS

1. Enamel portrait of H. Benedict de Saussure (1740–99), by Abraham Constantin (1785–1855), a Swiss, from the original by Jean Pierre St. Ours (1752–1809), also Swiss
2. Bookcover in *champlevé* enamel, made for the guestbook of the Architectural League of New York. The inserted medallions are in silver. The back has five plates in enamel, with the symbols of the arts
3. Portrait in enamel, with silver frame and base, by Alexander Fisher (1864–), reviver of the art of enameling in England. Fisher is particularly successful in combining enamel with precious metals and jewels
4. The Dream of Brahm, an allegorical subject, by Alexander Fisher
5. A group in enamel, decoration on a casket, by Alexander Fisher, combining decorative work in precious metals with enamel
6. Enamel portrait by Alexander Fisher
7. Children with bear, *cloisonné* enamel panel for a casket, by Harold Stabler, England, a contemporary worker in metals and enamels, distinguished for his decorative style and his use of strong colour
8. War Memorial, *champlevé* enamel panel, by Oswald Reeves
9. Children with leopards, *cloisonné* enamel panel for a casket, by Harold Stabler, a companion piece to the panel of 7

work of such magnificence as the great enamelled walls of the palace of Rameses III. at Tell el-Yehudia in the Delta of the Nile, or the palace of Nimrod in Babylon, has been discovered upon metal of any kind. But there were gold ornaments and jewellery enamelled of noble design in opaque turquoise, cobalt, emerald green and purple, some of which can be seen at the British Museum and the Louvre.

Many exquisite pieces of enamel jewellery from the subsequent Greek and Roman civilizations have been found. The Greek sculptors of the 4th and 5th centuries B.C., moreover, in many instances, made not only the eyes of enamel, as in the fine bronze head found at Anticythera (Cerigotto) in 1902, but in the colossal figure of Zeus for the temple at Olympia made by Pheidias the gold drapery was gorgeously enamelled with figures and flowers. This work, now destroyed, was in all probability the crowning triumph of a long series of essays in this material. The art of ancient Rome lacked the inspiration of Greece, being mainly confined to copying Greek forms and style, and enamelling was no exception. But the Roman and Etruscan glass has many beautiful qualities of form and colour that do not seem entirely borrowed, and the enamel work upon them so far as we can discern is of graceful design and rich colour.

The next time enamelling appears is in an oft-quoted passage (*c.* A.D. 240) from the writings of the great sophist Philostratus, who says (*Icones*, i. 28):—"It is said that the barbarians in the ocean pour these colours into bronze moulds, that the colours become as hard as stone, preserving the designs,"—a more or less inaccurate description of the process of *champlevé* (*see* description of enamel process appended). This has been understood (from an interpretation given to a passage in the commentary on it by Olearius) to refer to the Celts of the British Islands. It also goes to prove that enamelling was not practised at this day in Greece. We have no British enamels to show so early as this, but belonging to a later period, from the 6th to the 9th century, a number of fine gold and bronze ornaments, horse trappings, shields, fibulae and ciboria have been discovered of Celtic and Saxon make.

The close resemblance of method, style, design and colour would suggest that from Ireland the art was transferred to Byzantium. At all events it flourished there for several centuries. The finest known work belonging to this period is the Pala d'Oro at St. Mark's, Venice, believed to have been brought from Constantinople to Venice about 1105. This magnificent altar-piece is in *cloisonné* enamel. A typical example is the ciborium and chalice belonging to the South Kensington loan collection. The design entirely covers the whole of the surface in one rich mass composed of circular or vesica-shaped medallions filled with sacred subjects and foliated scrolls. These are engraved and enamelled, and the metal bands of the scrolls and figures are engraved and gilt. The characteristic colour scheme is composed almost wholly of primaries. Red, blue and yellow predominate, with a little white and black. Occasionally the secondaries, green and purple, are used, but through the whole period of Byzantine enamelling there is a total absence of what to-day is termed "subtle colouring." The arrangement of the enamels is also distinct, in that the divisions of the colours are not always made by the cloison, but are frequently laid in side by side without the adjoining colours mingling or running together whilst being melted. In most instances the enamels were made in separate little plates rudely fastened with nails, screws or rivets to a metal or wood foundation. The design and drawing of the figures in Byzantine enamels is similar to the mosaic and carving. The figures are treated entirely as decorations, with scarcely ever the least semblance of expression, although here and there an intention of piety or sorrow is to be descried through the awkward postures in which they are placed. In spite of this, the sense of decorative design, the simplicity of conception, the strength of the general character and the richness of the colour places this period as one of the finest that the art of enamelling has seen.

The next great application of these kinds of enamelling was at Cologne, for there we find not only the renowned work of Nicolas of Verdun, the altar front at Klosterneuberg, which consists of 50 plates in *champlevé* enamel, but in that Rhenish province there are many shrines of magnificent conception. From here the secrets of the craft were taken to Limoges, where the greatest activity was displayed. But no new method or distinct advance is to be noticed, during these successive revivals at Byzantium, Cologne or Limoges, and it is to early 14th-century Italy that we owe one of the most beautiful developments, that of the process subsequently called *basse-taille*, which signifies a low-cut relief upon which transparent enamel is fused.

Basse-taille demanded the highest knowledge of an artist with the consummate skill of both sculptor and enameller. Witness the superb gold cup, called the King's Cup, now in the British Museum, and the silver cup at King's Lynn. The first is in an excellent state of preservation, as it is upon gold, but the latter, like most of the ancient enamelling upon silver, has lost most of its enamel, due—the present writer, after much experiment, believes—to the impurity of the silver employed. The King's Cup (13th century) is one of the finest works in enamelling extant. It consists of a gold cup and cover, hammered out of pure gold; and around the bowl, base and cover there are bands of figures, illustrating scenes from the life of St. Agnes. The hands and faces are of pale amethyst which over the carved gold gives a beautiful flesh tone. The draperies are in most resplendent ruby, sapphire, emerald, ivory, black and orange. The stem was subsequently altered by an additional piece inserted and enamelled with Tudor roses.

The discovery about the same time of the process called *plique-à-jour* forms another most interesting and beautiful development. Owing to the difficulty of its manufacture and its extreme fragility there are very few examples left. One of the finest specimens is now at the Victoria and Albert Museum, South Kensington. It is in the form of two bands of emerald green enamel which decorate a silver beaker. They are in the form of little stained glass windows, the cloisons forming (as it were) the leads.

The end of the 15th century saw a revolutionary development. Until then enamelling had relied on the enclosing edges of the metal or the cloison to hold it to the metal ground and in part to preserve it in the shape of the pattern, much as a setting holds a jewel; all enamel had been sunk into cells or cloisons. Two discoveries were made; first, that enamel without enclosing ribbon could be fused on both sides of the metal object; secondly, that after an enamel had been fused to a surface of metal, another could be superimposed and fused to the first layer without any danger of separation from each or from the metal ground. In most of these enamel paintings the subject was laid on with a white enamel upon a dark ground. The white was modulated; so that possessing a slight degree of translucency, it was grey in the thin parts and white in the thick. Thus was obtained a certain amount of light and shade. This gave the process called *grisaille*. But strange to say, it was not until a later period that this was practised alone, and then the modelling of the figures and draperies became very elaborate. At first it was only done in a slight degree, just sufficiently to give expression and to add to the richness of the form. Probably the earliest painter in enamel was Nardon Pénicaud, many of whose works (one of them, dated 1503, is in the Cluny Museum) have been preserved. He had many followers, the most distinguished of whom was Léonard Limosin (*i.e.*, of Limoges). He excelled in portraiture. Examples of his work (between 1532 and 1574) are to be found in most of the larger public and private collections. Jean Pénicaud, Jean Court de Vigier, Pierre Raymond and Pierre Courteys excelled in *grisaille*.

MODERN EUROPEAN ENAMELS

The cultivated taste which prompted the acquisition and collection of the finer enamels such as those made in *basse-taille*, *plique-à-jour*, "Limoges" or painted and translucent enamels has always been confined to a few connoisseurs and patrons. And on the other hand the artists engaged in this work who have had the courage and persistence to carry on in spite of the failures incidental to such delicate and elaborate processes have been comparatively small in number at any time. So that it is not to be wondered at that the enamels of this character and standing have not been produced in quantities especially during recent years

PHOTOGRAPH. HERBERT G. PONTING. F.R.P.S.

THE PROCESS OF CLOISONNÉ

A cloisonné artist of Japan at work. The details of a design are outlined on a vase, with narrow bands or cloisons of metal (copper, silver or gold), which are soldered edgewise to the surface so as to make a pattern of shallow cells. Enamel colours, ground to a fine powder, and moistened, are then tightly packed into the cells, to complete the design

when the patronage of the arts generally has fallen off to so great an extent. On the other hand the simpler processes of *cloisonné* and *champlevé* which lend themselves readily to the decoration and enrichment of metal surfaces have been employed in many diverse ways.

The application of enamel in these processes, which are the oldest and most primitive, has been largely due to the tuition in the classes held in the Schools of Art, the municipal and County Council schools and the technical institutes in Great Britain and Ireland and to similar educational bodies which foster the Arts and Crafts in Europe, America and the British colonies. There has been no attempt made at any advance on these ancient methods. The style and treatment both of the design and process remain the same; for indeed it would be difficult to improve them. The study of the old examples in these processes has carried with it the due appreciation of the suitability and character of the design.

The desire to perpetuate the names of the fallen in the World War brought about a demand for memorials in bronze, copper and silver on which the names of the men, the shields of their native towns, the badges of the regiments and companies and other heraldic achievements were done in enamel. These memorials are to be found in the cathedrals, churches, public buildings and the chapels of the colleges and universities. Besides which there has continued to be a considerable use of enamel on the altar ornaments of the churches. And the chalices, Bible covers and lamps have occasionally been enriched with either *cloisonné* or *plique-à-jour* enamels.

Again on the public presentation gifts of trophies, caskets, cups and other like ornaments there has been the suitable adornment of enamel designs. These various applications of enamel have constituted the main output of the art worker in enamels.

These examples, however, do not leap to the eye so much as the uses to which enamel has been put in commerce and trade. The enamelled iron advertisement plates have been exhibited on the walls and hoardings for many years, and have shown no advance in either technique or colour and design, but of recent years there has been a recognition of the beauty of the colour of enamel when artistically employed, and that this quality is of equal value to its permanence. It is effectively used in the lettering of the names of firms, of shopkeepers, with the trademark and emblems. These have been made in translucent enamel fused over copper and silver foil or in opaque enamels in the *champlevé* process. The great improvement in the design, spacing, drawing and form of the lettering is to be seen over shop and store windows replacing the ugly lettering and thus adding a refinement to the streets.

In the jewellers', gold and silversmiths', and fancy-goods shops a great advance had been made in the design and colour of the enamel decoration of gold and silver cigarette boxes, watches, the backs of brushes for the toilet table and indeed of all such things of a similar kind. There still remains a tendency to use an engine-turned ground on the silver and gold objects over which a clear transparent enamel has been fixed. The chief reason for the engine-turning is to give a "key" to the enamel by which it obtains a firmer hold on the metal than if it were applied to a smooth surface. Most of these articles are made in Russia, Czecho-Slovakia, Germany and Sweden.

Enamelling Processes.—The base of enamel is a clear, colourless, transparent vitreous compound called flux, which is composed of silica, minium and potash. This flux or base—termed *fondant* in France—is coloured by the addition of oxides of metals while in a state of fusion, which stain the flux throughout its mass. Enamels are either hard or soft, according to the proportion of the silica to the other parts in its composition. They are termed hard when the temperature required to fuse them is very high. The harder the enamel the less liable is it to be affected by atmospheric agencies, which in soft enamels produce a decomposition of the surface first and ultimately of the whole enamel. Pure—or almost pure—metals are in most respects the best to receive and retain the enamel. Enamels composed of a great amount of soda or potash, as compared with those wherein red lead is in greater proportion, are more liable to crack and are less cohesive. It is better not to use silver as a base, although it is capable of reflecting a higher and more brilliant white light than any other metal. Fine gold and pure copper as thin as possible are the best metals upon which to enamel. If silver is to be used, it should be fine silver, treated in the methods called *champlevé* and *cloisonné*.

The brilliancy of the substance enamel depends upon the perfect combination and proportion of its component parts. The intimacy of the combination depends upon an equal temperature being maintained throughout its fusion in the crucible. For this purpose it is better to obtain a flux which has been already fused and most carefully prepared, and afterwards to add the colouring oxides, which stain it dark or light according to the amount of oxide introduced. Many of the enamels are changed in colour by the difference of the proportion of the parts composing the flux, rather than by the change of the oxides. For instance, turquoise blue is obtained from the black oxide of copper by using a comparatively large proportion of carbonate of soda, and a yellow green from the same oxide by increasing the proportionate amount of the red lead. All transparent enamels are made opaque by the addition of calx, which is a mixture of tin and lead calcined. White enamel is made by the addition of stannic and arsenious acids to the flux. The amount of acid regulates the density or opacity of the enamel.

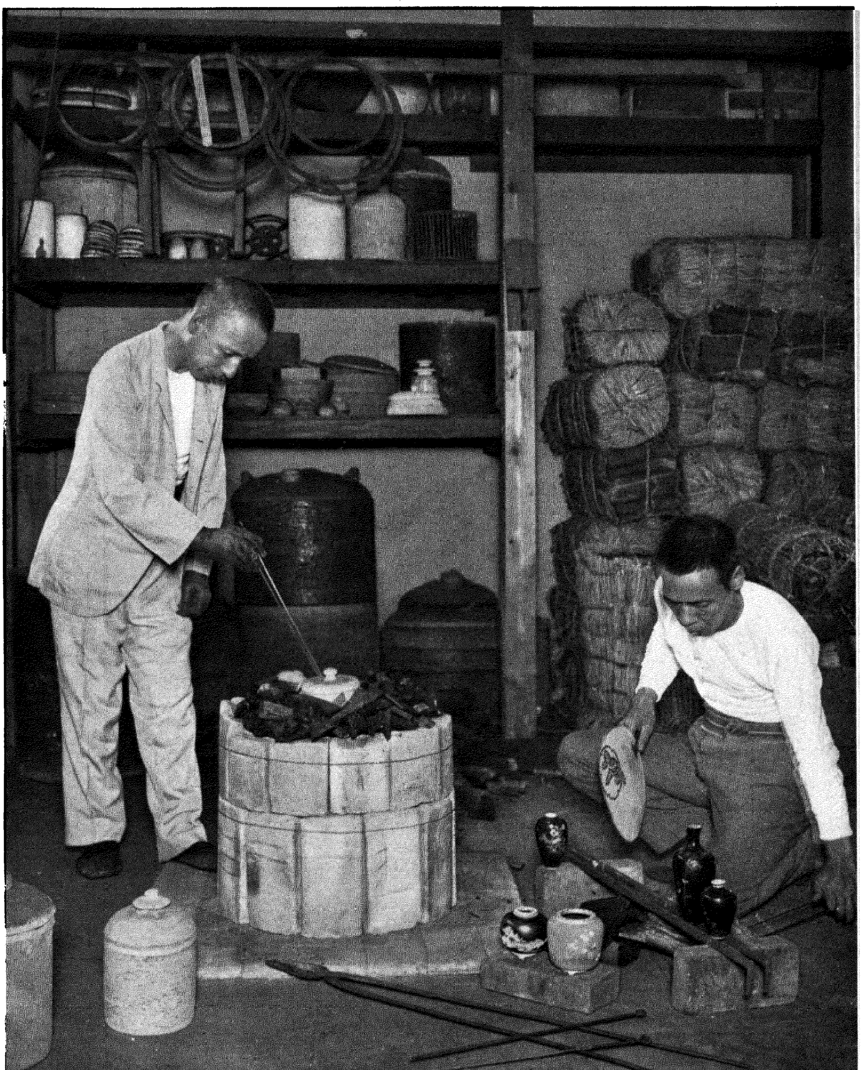
After the enamel has been procured in the ump, the next stage in the process, common to all methods of enamelling, is to pulverize it. To do this properly the enamel must first be placed in an agate mortar and covered with water; next, with a wooden mallet a number of sharp blows must be given to a pestle held vertically over the enamel, to break it; then holding the mortar firmly in the left hand, the pestle must be rotated with the right, with as much pressure as possible on the enamel, grinding it until the particles are reduced to a fine grain. The powder is then subjected to a series of washings in distilled water, until all the floury particles are removed. After this the metal is cleaned by immersion in acid and water. For copper, nitric acid is used; for silver, sulphuric, and for gold, hydrochloric acid. All trace of acid is then removed, first by scratching with a brush and water, and finally by drying in warm oak sawdust. After this the pulverized enamel is carefully and evenly spread over those parts of the metal designed to receive it, in sufficient thickness just to cover them and no more. The piece is then dried in front of the furnace, and when dry is placed gently on a fire-clay or iron *planche*, and introduced carefully into the muffle of the furnace, which is heated to a bright pale red. It is now attentively watched until the enamel shines all over, when it is withdrawn from the furnace. The firing of enamel, unlike that of glass or pottery, takes only a few minutes, and in nearly all processes no annealing is required.

The following are the different modes of enamelling: *champlevé, cloisonné, basse-taille, plique-à-jour, painted enamel, encrusted* and *miniature-painted*. These processes were known at successive periods of ancient art in the order in which they are named. To-day they are known in their entirety. Each has been largely developed and improved. No new method has been discovered, although variations have been introduced into all. The most important are those connected with painted enamels, encrusted enamels and *plique-à-jour*.

Champlevé enamelling is done by cutting away troughs or cells in the plate, leaving a metal line raised between them, which forms the outline of the design. In these cells the pulverized enamel is laid and then fused; afterwards it is filed with a corundum file, then smoothed with a pumice stone and polished by means of crocus powder and rouge.

In *cloisonné enamel*, upon a metal plate or shape, thin metal strips are bent to the outline of the pattern, then fixed by silver solder or by the enamel itself. These strips form a raised outline, giving cells as in the case of *champlevé*. The rest of the process is identical with that of *champlevé* enamelling.

The *basse-taille* process is also a combination of metal work in the form of engraving, carving and enamelling. The metal, either silver or gold, is engraved with a design, and then carved into a bas-relief (below the general surface of the metal like an Egyptian



PHOTOGRAPH, HERBERT G PONTING, F.R.P.S.

FIRING THE ENAMELS

Japanese cloisonné artists firing enamels in a charcoal fire. This process is repeated several times because of the shrinkage of the enamel under heat and the pitting which takes place. When the firing has been satisfactorily completed the surface of the vase is ground down to an even texture with pumice and polished with charcoal, and the metal surfaces of the cloisons, now clearly visible, are gilded

bas-relief) so that when the enamel is fused it is level with the uncarved parts of the metals, and the design shows through the transparent enamel.

Plique-à-jour enamelling is done in the same way as *cloisonné* enamelling, except that the wires or strips of metal which enclose the enamel are not soldered to the metal base, but are soldered to each other only. Then these are simply placed upon a sheet of platinum, copper, silver, gold or hard brass, which, after the enamel is fused and sufficiently annealed and cooled, is easily removed.

Painted enamels are different from any of these processes both in method and in result. The metal in this case is either copper, silver or gold, but usually copper. It is cut with shears into a plate of the size required, and slightly domed with a burnisher or hammer, after which it is cleaned by acid and water. Then the enamel is laid equally over the whole surface both back and front, and afterwards "fired." The first coat of enamel being fixed, the design is carried out, first by laying it in white enamel or any other which is opaque and most advantageous for subsequent coloration.

In the case of a *grisaille painted enamel* the white is mixed with water or turpentine, or spike oil of lavender, or essential oil of petroleum (according to the taste of the artist) and the white is painted thickly in the light parts and thinly in the grey ones over a dark ground, whereby a slight sense of relief is obtained and a great degree of light and shade.

In *coloured painted enamels* the white is coloured by transparent enamels spread over the *grisaille* treatment, parts of which when fired are heightened by touches of gold, usually painted in lines. Other parts can be made more brilliant by the use of foil, over which the transparent enamels are placed and then fired.

Miniature enamel painting is not true enamelling, for after the white enamel is fired upon the gold plate, the colours used are not vitreous compounds—not enamels in fact—as is the case in any other form of metal enamelling; but they are either raw oxides or other forms of metal, with a little flux added, not combined. These colours are painted on the white enamel, and afterwards made to adhere to the surface by partially fusing the enamel, which when in a state of partial fusion becomes viscous.

Amongst the chief workers in the modern revival are Claudius Popelin, Alfred Meyer, Paul Grandhomme, Fernand Thesmar, Hubert von Herkomer, Alexander Fisher, P. Oswald Reeves and Harold Stabler. The work of Claudius Popelin is characterized by good technical skill, correctness and a careful copying of the old masters. Consequently it suffers from a lack of invention and individuality. His work was devoted to the rendering of mythological subjects and fanciful portraits of historical people. Alfred Meyer and Grandhomme are both accomplished and careful enamellers; the former is a painter enameller and the author of a book dealing technically with enamelling. Grandhomme paints mythological subjects and portraits in a very tender manner, with considerably more artistic feeling than either Meyer or Popelin. There is a specimen of his work in the Luxemburg Museum. Fernand Thesmar is the great reviver of *plique-à-jour* enamelling in France. Specimens of his work are possessed by the art museums throughout Europe, and one is to be seen in the Victoria and Albert Museum, London. They are principally valued on account of their perfect technical achievement. Lucien Falize was an employer of artists and craftsmen, and to him we are indebted for the production of specimens of *basse-taille* enamel upon silver and gold, as well as for a book reviewing the revival of the art in France, bearing particularly on the work of Claudius Popelin. Until within recent years there was a clear division between the art and the crafts in the system of producing art objects. The artist was one person and the workman another. It is now acknowledged that the artist must also be the craftsman, especially in the higher branches of enamelling. Falize initiated the production of a gold cup which was enamelled in the *basse-taille* manner. The band of figures was designed by Olivier Merson, the painter, and carved by a metal carver and enamelled by an enameller, both able craftsmen employed by Falize. Other pieces of enamelling in *champlevé* and *cloisonné* were also produced under his supervision but on this system; therefore lacking the one quality which would make them complete as an expression of artistic emotion by the artist's own hands. René Lalique is among the jewellers who have applied enamelling to their work in a peculiarly technically perfect manner.

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II. CHINESE AND JAPANESE ENAMELS

Enamels do not appear to have reached China until long after they were to be found throughout Europe. The Chinese make no claim to their invention; but, on the contrary the native term, "*Fu-lin* ware" (hence *Fa-lan*), directly suggests an origin in the eastern Roman provinces, that name having been applied to the Byzantine empire by Chinese historians as early as the 7th century. The derivation of the word has been the subject of controversy and is uncertain; but all authorities are agreed as to the western origin of the art; which was, in all probability, introduced into China by Arab traders, or by travelling craftsmen working their way eastwards as opportunity arose of plying their craft profitably. Glass, which in China was also of alien origin, was imported from the Roman empire certainly as early as the 3rd century A.D.; but it was not until the reign of T'ai Wu (424–452) of the northern Wei dynasty that craftsmen from an Indo-Scythian kingdom on the north-west border of India came to the Wei capital in Shansi and succeeded in making excellent opaque glass of various colours from local minerals.

Although the Chinese were thus informed as to the production of an essential material for the making of enamels and were already most highly skilled in the working of bronzes and other metals, it is remarkable that there appears to have been no development of the art of enamelling at least until the 13th century, when the Mongolian conquests introduced into the Far East so many arts hitherto unknown. A record exists, in the *Ko ku yao lun*, a book on antiquities published in 1387, of the production on a large and varied scale of enamelled ware which "resembles the cloisonné work of Fo-lang." This is herein termed also *Kuei kuo yao*, ware of the devils' country. It also states that natives of Yunnan have established factories for this ware in Peking and that the enamels made at the provincial capital, Yunnan-fu, are "fine, lustrous and beautifully finished." It appears therefore that the *Ta shih yao* or Arabian (so-called) enamel ware was well established in China at this period; and that Byzantine work of similar character was also so well known as to invite comparison with the native product and that, as pointed out by M. Paléologue, "the workmanship (of the Chinese enamels) presents occasionally, in fact, striking resemblances with certain enamels of the Byzantine School: the mixture of different enamels inside the wall of the same cell, the employment of gold encrustations in the treatment of the figures and hands, etc."

From the technical point of view, Chinese enamels fall into three categories—cloisonné, champlevé and painted. In none does the technique vary appreciably from that employed in western countries.

Cloisonné.—In *cloisonné*, the outlines of practically every detail of the design are defined with narrow bands or ribbons of metal—copper, silver or gold—soldered edgewise to the base, in such a way as to cover the whole surface to be decorated, with shallow cells sometimes called *cloisons*, but this term is more correctly employed to designate the bands themselves. These are then filled with the appropriate enamel colours, ground to a fine powder, moistened and tightly packed into their respective cells. "The piece," says Dr. S. W. Bushell, "is usually fired in the open courtyard, protected only by a primitive cover of iron network,

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PAINTED, CLOISONNÉ AND CHAMPLEVÉ CHINESE ENAMELS OF THE XVIII. AND XIX. CENTURIES

1. Imperial teapot of Peking enamel painted, Ch'ien Lung period (1736–95)
2. Round screen of Peking enamel, with a landscape design
3. Incense burner of cloisonné on copper, in three parts, bowl, ring and cover. It is decorated with floral designs and openwork on turquoise blue ground; height, 16 inches. 19th century
4. Incense burner in cloisonné with stand and cover of same material and design. Turquoise blue ground; 24½ x 12½ inches. Ch'ien Lung period
5. Large dish of Peking enamel decorated with Taoist sages walking. Ch'ien Lung period.
6. Cloisonné snuff bottle of turquoise blue and white enamel ground, with coral stopper; height, 2-3/7 inches. Ch'ien Lung period
7. Seated figures and tripod censer of cloisonné. The figures, 37 inches in height, are on garden seats, also in cloisonné, and represent an empress (left) and a princess, probably of the Ch'ien Lung period. The robes of the former are executed with designs on chocolate colour ground and those of the latter on a ground of blue and imperial yellow. Faces and hands are gilt. The censer is enamelled in both cloisonné and champlevé on turquoise blue ground. The handles are of archaic sceptre-shape and the cover is surmounted by a gilt bronze finial; height 36 inches. Era of Tao-kuang (1821–50)
8. Gourd-shaped cloisonné snuff bottle, with metal and enamel stopper, on wood stand; height, 2⅞ inches. Ch'ien Lung period

the charcoal fire being regulated by a number of men standing round with large fans in their hands." This process has to be repeated several times, on account of the shrinkage, under heat, of the enamel, and the pitting which also takes place. When the whole surface is thus satisfactorily covered in this manner it is ground down to an even texture with pumice stone and polished with charcoal; the metal surfaces of the cloisons, now clearly visible being gilded, as well as those parts of the object which have not been adorned with enamel; for instance, the neck, rims and foot of a vase as well as any decoration in relief which projects beyond the enamelled surface.

The earliest examples of cloisonné enamel that can be authentically associated with the Far East, are mirrors in the *Shôsō in* ("lonely building"), at Nara in Japan. The backs of these have cloisonné work, somewhat crude in character. There is no doubt that these and other objects in the collection were deposited in the *Shōsō in* in the year 756 by Kōmyō-Kōgō, widow of the Emperor Shomo-Tennō (724–749), with other treasures collected during his life. We have here, therefore, authentic examples of the art that must date back at least to the T'ang dynasty, and may, as is certainly the case with some other objects in the collection, be of Chinese workmanship. It is generally agreed that they are neither Japanese nor Byzantine. So far as is known at present, the sequence of Chinese enamels with which we are acquainted begins, however, only in the Yuan period; and the earliest recorded marks belong to the reign of the last emperor of that dynasty (1341–1367). The great period of the production is certainly that of the Ming dynasty which followed and existed until 1643.

The mark most commonly found within this epoch is that of the Ching T'ai reign (1450–1456); so Dr. Bushell suggests that there must have been a great revival of the art at this time, as even in his day, the term *Ching T'ai Lan* was "commonly used in Peking as a general synonym for cloisonné enamels." He points out the significance of the fact that this reign covers the time of the last siege and capture of Constantinople by the Turks (1453) when some of the craftsmen then dispersed may have even penetrated to China. However this may be, the Ming enamels, bold in design, with fine depth and purity of colour, were never surpassed in later epochs. The two shades of blue, a dark lapis-lazuli tone and a pale sky-blue with a very slight tinge of green, are particularly excellent. The red is of dark coral tint and the yellow full-bodied and pure. Greens derived from copper are sparingly used and Dr. Bushell states that *rouges d'or* (reds made of gold) do not come into the colour scheme at all. The black and white are the least successful; the former shallow and dull, the latter clouded and muddy. At the same time, an imperfection of technique is noted, a close examination revealing minute pitting in the enamels, due to inadequate packing of the material, and some want of polish in the surface. These technical defects, however, do not appreciably detract from the artistic value of the Ming enamels and, indeed, serve as a clue to their identification.

To the patronage of the Emperor K'ang Hsi (1662–1722) was due a great revival of art industries. In 1680 he established a whole series of imperial factories for this purpose, of which that devoted to the manufacture of enamels was No. 6 on the official list. Here he had made sets of incense vessels of cloisonné enamel for presentation to the numerous Buddhist temples in the neighbourhood of Peking, founded under his auspices and other objects for the honorific gifts which were characteristic of his enlightened reign. The enamels of his time were marked by an improvement in technical quality as compared with those of the Ming period, while the finer qualities of the latter are still, to a considerable extent, in evidence. In many cases the forms of ancient bronze vessels were revived for these purposes, with the addition of enrichments in enamel. The style of this reign persisted during that of K'ang Hsi's successor, Yung Chêng (1723–1735); while the long period on the throne occupied by Ch'ien Lung (1736–1795) was marked, as in the case of many other industrial arts, by a further perfection of technique, but with the loss of much of the vigour of design and breadth of execution that distinguished the products of earlier periods. Modern enamels, chiefly imitations of older work, are more hurriedly made and not so well finished. The quality of the gilding especially is far below that of the older productions.

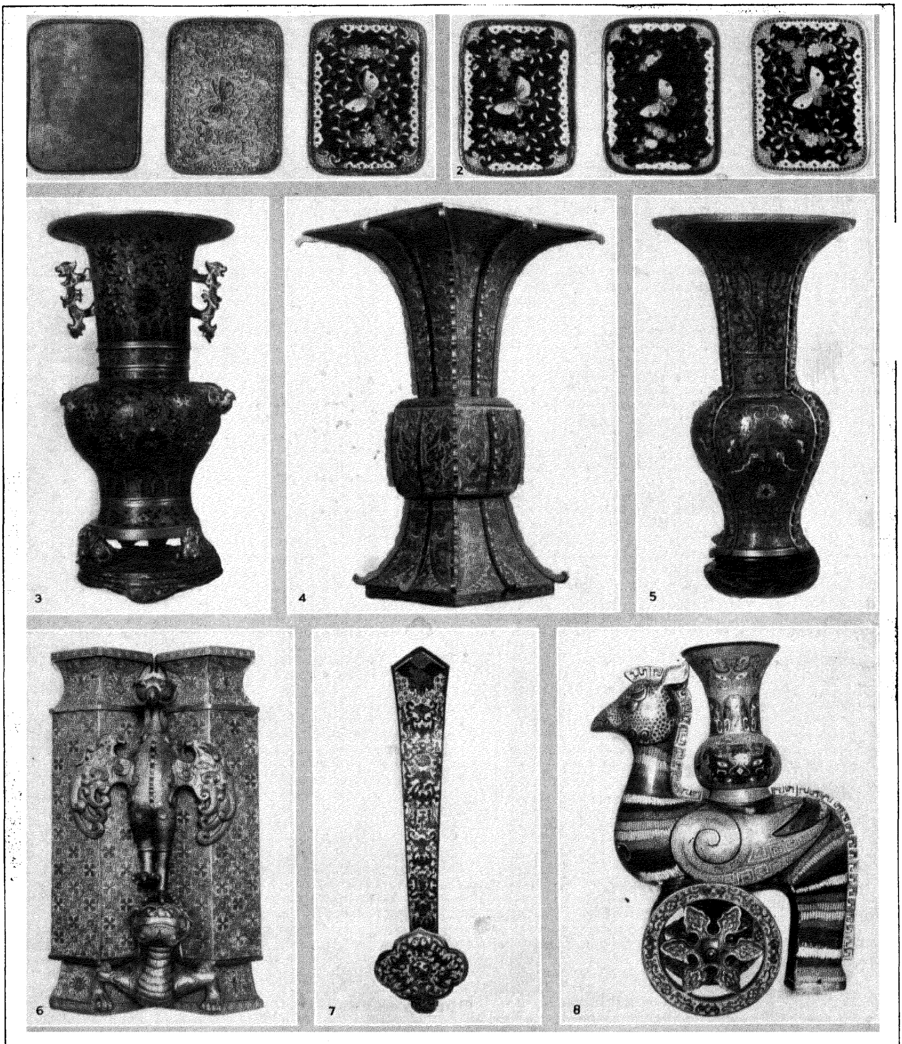
Champleve.—In *champlevé enamels,* cloisons are not used, the hollows to be filled with colour being cut out of the metal with graving tools. Otherwise the process is similar to that last described. It is probably the oldest method of enamelling known, and there is no evidence as to the date of its introduction into China, though some of the most ancient examples extant belong to this class. The general trend of design and execution, historically, is much the same as that of cloisonné. Examples in which both methods are employed are not infrequent.

Painted Enamels.—The *painted enamels* of China, generally known from the principal seat of their manufacture as *Canton enamels,* are practically identical in technique with the Limoges and other painted enamels of Europe. Specimens of these are known to have been taken to China by the missionaries of the late 17th and 18th centuries, and not only to have exercised direct influence on the Chinese ware, but also, in some cases, to have been copied. Representations of European subjects, copies of engravings and armorial decorations, are also found there. Painted enamels are termed by the Chinese *Yang t'zu* (literally "foreign porcelain"), the palette of colours used being the same as with enamelled porcelain though, in the case of enamels it is termed *Yang ts'ai* (foreign colours). A ground of opaque enamel, generally white, is laid on the copper; and on this the colours are superimposed and fired. Owing to the soft nature of the ground, these sink in and are incorporated with it, producing a loss of brilliance, which, as admitted by the Chinese, renders them inferior to enamelled porcelain with which they may well be compared. The earliest dated example of Canton enamel consists of a set of objects inscribed *Yung chêng yu chih* (1723–1735) made to imperial order. Although imitations have continued to be made, nothing of real quality in this style was produced after the termination of the reign of Ch'ien Lung in 1795. The method has always been looked upon by the Chinese as in alien taste; a writer of 1782 (quoted by Bushell) remarks, "They are only fit for use as ornaments of ladies' apartments—not at all for the chaste furniture of the library of a simple scholar." Enamels of this kind were also made, with characteristic decoration, for the Siamese market.

Translucent (as opposed to opaque) enamels were occasionally made by Chinese artisans. Important pieces are rare, but sometimes of fine quality, a deep blue, obtained from a native cobaltiperous ore of manganese, and a pale turquoise blue from copper being especially successful. This method more often appears in conjunction with gold and silver in Chinese jewellery; in which, also, imitations, in enamel, of real gems are frequently employed.

Japanese Enamels.—The examples of enamel in the imperial treasury at Nara, Japan, have already been referred to; and it may now be repeated that they cannot be attributed to Japanese craftsmanship. No examples of authentic enamels of Japanese origin that can be dated earlier than the end of the 16th century seem to exist. The western influence which promoted the art in China does not appear to have penetrated to Japan; the first Japanese appearance of the art seems to have been in the form of the decoration of sword furniture by the founders of the Hirata family who worked at Kyōto under the patronage of the Tokugawa Shōgun, Iyeyasu about the year 1611. They made use, on a small scale, both of the cloisonné and champlevé methods. A dull green was one of the first colours obtained. The range of colours was afterwards extended with a white of good quality. There was no further development of importance until the 19th century, when Kaji Tsunikichi (born A.D. 1802) of Nagoya established in that city an important and successful manufacture of cloisonné which obtained a considerable vogue especially among foreigners. On this basis further developments have taken place of considerable interest.

Modern Japanese artists have modified the cloisonné process with remarkable ingenuity and have produced work of great interest, in which the cloisons are sometimes completely veiled, the resultant effect being that of enamelled porcelain with realistic designs of flowers, etc., and a wide and almost unrestricted range



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THE CLOISONNÉ PROCESS AND CHINESE CLOISONNÉ ENAMELS OF THE XV.–XVIII. CENTURIES

1 and 2. *Stages in the process of cloisonné enamelling, showing first, the* metal plate on which the design is executed by soldering thin metal bands or *cloisons* to the base to form shallow cells (second step). These cells are filled with powdered enamel colours, and the piece is then fired and polished. 3. Beaker-shaped imperial vase with gilt bronze dragon and phoenix handles. Turquoise blue ground sustaining flowers and vines; height 41½ inches. Reign of Ch'ing Tai (1450–56), Ming dynasty. 4. Trumpet-shaped vase decorated with eyes and cloud forms on turquoise blue ground; height, 14½ inches. Ming dynasty. 5. Beaker-shaped vase with floriated *ornament*, scrolls and palmettes; height, 21½ inches. K'ang-hsi period (1662–1722). 6. Twin vases enamelled in green and joined by bronze ornaments, signifying the unity of the universe; height, 25½ inches. Era of Yung-Cheng (1723–35). 7. Jui sceptre (repaired); length, 15¾ inches. K'ang-hsi period. 8. Dove-shaped altar wine vessel on wheels, patterned after a type of ancient vessel used at rituals. Besides the conventional ornamentation, the decoration consists of scrolls and various designs, such as monsters' heads, copied from very old bronzes; height, 22 inches. K'ang-hsi period

of colour. Namikawa of Tōkyō has been one of the most successful of these. A Kyōto artist of the same name has worked with credit in true *cloisonné*. J. Ando of Nagoya has obtained novel effects by the use of translucent enamel on a silver basis. These developments have carried the art of enamel very far from the old traditions, but, while the skill and ingenuity of technique they evince may be appreciated, it cannot be said that in decorative value they compare with the older Chinese tradition. During the 19th century, the Japanese produced many imitations of the latter; which, for a time gave rise to quite a false appreciation of their place in the history of the art.

Bibliography.—F. Brinkley, *Japan and China*, vol. vii. (1904); Brooklyn Museum of the Institute of Arts and Sciences, *The Avery Collection of Ancient Chinese Cloisonnes* (1912); S. W. Bushell, *Chinese Art*, vol. ii. (1919); R. L. Hobson, *Chinese Cloisonné Enamels*, in *Burlington Magazine*, vol. xxi., pp. 137, 202, Ibid. *Canton Enamels*, in *Burlington Magazine*, vol. xxii., p. 165. (E. F. S.)

ENAMELLED IRON WARE: *see* Porcelain Enamelling.

ENCAENIA, a festival commemorating a dedication, in Greek τὰ ἐγκαίνια, particularly used of the anniversary of the dedication of a church (*see* Dedication). The term is also used at the University of Oxford of the annual Commemoration, held in June, of founders and benefactors (*see* Oxford).

ENCAMPMENT: *see* Camp.

ENCAUSTIC PAINTING. The name *encaustic* (from the Greek for "burnt in") is applied to paintings executed with vehicles in which wax is the chief ingredient. The term was appropriately applied to the ancient methods of painting in wax, because these required heat to effect them. Wax may be used as a vehicle for painting without heat being requisite; nevertheless the ancient term *encaustic* has been retained, and is indiscriminately applied to all methods of painting in wax. The durability of wax, and its power of resisting the effects of the atmosphere, were well known to the Greeks, who used it for the protection of their sculptures. As a vehicle for painting it was commonly employed by them and by the Romans and Egyptians; but in recent times it has met with only a limited application. Of more modern encaustic paintings those by Schnorr in the Residenz at Munich are the most important. Modern paintings in wax, in their chromatic range and in their general effect, occupy a middle place between those executed in oil and in fresco. Wax painting is not so easy as oil, but presents fewer technical difficulties than fresco.

Ancient authors often make mention of *encaustic*, which, if it had been described by the word *inurere*, to burn in, one might have supposed to have been a species of enamel painting. But the expressions "incausto pingere," "pictura encaustica," "ceris pingere," "pictura inurere," used by Pliny and other ancient writers, make it clear that some other species of painting is meant. Pliny distinguishes three species of encaustic painting. In the first they used a stylus, and painted either on ivory or on polished wood, previously saturated with some certain colour; the point of the stylus or stigma served for this operation, and its broad or blade end cleared off the small filaments which arose from the outlines made by the stylus in the wax preparation. In the second method it appears that the wax colours, being prepared beforehand, and formed into small cylinders for use, were smoothly spread by the spatula after the outlines were determined, and thus the picture was proceeded with and finished. By the side of the painter stood a brazier which was used to heat the spatula and probably the prepared colours. This is the method which was probably used by the painters who decorated the houses of Herculaneum and of Pompeii, as artists practising this method of painting are depicted in the decorations. The third method was by painting by a brush dipped into wax liquefied by heat; the colours so applied attained considerable hardness, and could not be damaged either by the heat of the sun or by the effects of sea-water. It was thus that ships were decorated; and this kind of encaustic was therefore styled "ship-painting."

About the year 1749 Count Caylus and J. J. Bachelier, a painter, made some experiments in encaustic painting, and the count undertook to explain an obscure passage in Pliny, supposed to be the following (xxxv. 39):—"Ceris pingere ac picturam inurere quis primus excogitaverit non constat. Quidam Aristidis inventum putant, postea consummatum a Praxitele; sed aliquanto vetustiores encausticae picturae exstitere, ut Polygnoti et Nicanoris et Arcesilai Pariorum. Lysippus quoque Aeginae picturae suae inscripsit ἐνέκαυσεν, quod profecto non fecisset nisi encaustica inventa." There are other passages in Pliny bearing upon this subject, in one of which (xxi. 49) he gives an account of the preparation of "Punica cera." The nature of this Punic wax, which was the essential ingredient of the ancient painting in encaustic, has not been definitely ascertained. The chevalier Lorgna, who investigated the subject in a small but valuable tract, asserts that the *nitron* which Pliny mentions is not the nitre of the moderns, but the *natron* of the ancients, viz., the native salt which is found crystallized in Egypt and other hot countries in sands surrounding lakes of salt water. This substance the Carthaginians, according to Pliny, used in preparing their wax, and hence the name Punic seems to be derived. Lorgna made a number of experiments with this salt, using from three to twenty parts of melted white wax with one of natron. He held the mixture in an iron vessel over a slow fire, stirring it gently with a wooden spatula, till the mass assumed the consistency of butter and the colour of milk. He then removed it from the fire, and put it in the shade in the open air to harden. The wax being cooled liquefied in water, and a milky emulsion resulted from it like that which could be made with the best Venetian soap.

Experiments, it is said, were made with this wax in painting in encaustic in the apartments of the Count Giovanni Battista Gasola by the Italian painter Antonio Paccheri, who dissolved the Punic wax when it was not so much hardened as to require to be "igni resoluta," as expressed by Pliny, with pure water slightly infused with gum-arabic, instead of sarcocolla, mentioned by Pliny. He afterwards mixed the colours with this wax so liquefied as he would have done with oil, and proceeded to paint in the same manner; nor were the colours seen to run or alter in the least; and the mixture was so flexible that the pencil ran smoother than it would have done with oil. The painting being dry, he treated it with caustic, and rubbed it with linen cloths, by which the colours acquired peculiar vivacity and brightness.

LATER METHODS

About the year 1755 further experiments were made by Count Caylus and several French artists. One method was to melt wax with oil of turpentine as a vehicle for the colours. It is well known that wax may be dissolved in spirit and used as a medium, but it dries too quickly to allow of perfect blending, and would by the evaporation of the spirit be prejudicial to the artist's health. Another method suggested about this time, and one which seems to tally very well with Pliny's description, is the following. Melt the wax with strong solution of salt of tartar, and let the colours be ground up in it. Place the picture when finished before the fire till by degrees the wax melts, swells, and is bloated up upon the picture; the picture is then gradually removed from the fire, and the colours, without being injuriously affected by the operation of the fire, become unalterable, spirits of wine having been burnt upon them without doing the least harm. Count Caylus's method was different, and much simpler: (1) the cloth or wood designed for the picture is waxed over, by rubbing it simply with a piece of beeswax; (2) the colours are mixed up with pure water; but as these colours will not adhere to the wax, the whole ground must be rubbed over with chalk or whiting before the colour is applied; and (3) when the picture is dry it is put near the fire, whereby the wax is melted and absorbs the colours. It must be allowed that nothing could well be simpler than this process, and it was thought that this kind of painting would be capable of withstanding the weather and of lasting longer than oil painting. This kind of painting has not the gloss of oil painting, so that the picture may be seen in any light, a quality of the very first importance in all methods of mural painting. The colours too, when so secured, are firm, and will bear washing, and have a property which is perhaps more important still, viz., that exposure to smoke and foul vapours merely leaves a deposit on the surface without injuring the work. The "encausto pingendi" of the ancients could not have been enamelling, as the word

"inurere," taken in its rigorous sense, might at first lead one to suppose, nor could it have been painting produced in the same manner as encaustic tiles or encaustic tesserae; but that it must have been something akin to the count's process would appear from the words of Pliny already quoted, "Ceris pingere ac picturam inurere."

Werner of Neustadt found the following process very effectual in making a wax emulsion with water. For each pound of white wax he took twenty-four ounces of potash, which he dissolved in two pints of water, warming it gently. In this lye he boiled the wax, cut into little bits, for half an hour, after which he removed it from the fire and allowed it to cool. The wax floated on the surface of the liquor in the form of a white saponaceous matter; and this being triturated with water produced a sort of emulsion, which he called wax milk, or encaustic wax. This preparation may be mixed with all kinds of colours, and consequently can be applied in a single operation.

Mrs. Hooker of Rottingdean, at the end of the 18th century, made many experiments to establish a method of painting in wax, and received a gold palette from the Society of Arts for her investigations in this branch of art. Her account is printed in the tenth volume of the Society's Transactions (1792), under the name of Miss Emma Jane Greenland. Modern experiments have shown that it is quite possible to paint with the brush with pigments mixed with melted wax if the panel is kept warm. Each stroke must be laid directly where and as required. (*See* also PAINTING.)

See also Lorgna, *Un Discorso sulla cera punica;* Pittore Vicenzo Requeno, *Saggi sul ristabilimento dell' antica arte de' Greci e Romani* (Parma, 1787); *Phil. Trans.* vol. xlix. part 2; Muntz on *Encaustic Painting;* W. Cave Thomas, *Methods of Mural Decoration* (London, 1869); Cros and Henry, *L'Encaustique*, etc. (1884); Donner von Richter, *Über Technisches in der Malerei der Alten* (1885); Ernst Berger, *Beiträge zur Entwickelungsgeschichte der Maltechnik* (to be read with caution); Laurie, *Greek and Roman Methods of Painting.* (W. C. T.)

ENCEINTE, a French term used technically in fortification for the inner ring of fortifications surrounding a town. (Lat. *in*, within, *cinctus*, girdled; to be distinguished from the word meaning "pregnant," from *in*, not, and *cinctus, i.e.*, with girdle loosened.) Strictly the term was applied to the continuous line of bastions and curtains forming the "body of the place," this last expression being often used as synonymous with *enceinte*. The outworks, however, close to the enceinte were not considered as forming part of it. In modern fortification the enceinte is usually simply the innermost continuous line of fortifications. In architecture an enceinte is the close or precinct of a cathedral, abbey, castle, etc.

ENCEPHALITIS LETHARGICA, a disease of the brain characterized by coma (sleepy sickness). The virus is unknown. Filtrable organisms have been described and also the transmission of the disease by injection of nervous tissues, but these experiments are at present inconclusive. The incubation period is estimated at two weeks. The degree of infectivity must be small. The duration of infectivity and of the persistence of the virus in the body are unknown. Apparently the virus may lie quiescent and return to activity after long periods, since late manifestations have been known to develop after two to four years, sometimes after apparent cure in the intervals. No age is immune to infection.

Symptoms.—It is very difficult to classify the different cases. The best scheme provisionally is that of MacNalty. This classifies the cases under the following main types:

1. In which there is general disturbance of the functions of the central nervous system but without localization.

2. In which, in addition to general disturbance, there are various localizations in the central nervous system. The most frequent of these are affections of the third pair of cranial nerves, but no portion of the nervous system is immune.

3. Mild or so-called abortive cases (*formes frustes*).

The clinical manifestations are very variable and complex and are best classified, according to Walshe's scheme into general and nervous.

I. General: (1) negative, (2) positive.
II. Focal: (1) negative, (2) positive.

The positive symptoms denote exaltation of function due either to irritation of nervous tissue or to a loss of the control exerted normally by the higher centres of the brain; negative symptoms denote depression or loss of function due principally to destruction of nervous tissue.

The onset of the disease may be sudden or insidious. Occasionally the onset is extraordinarily sudden, the patient falling asleep almost without warning or sometimes becoming delirious. More frequently it is insidious either with the development of drowsiness or with more general symptoms. The general symptoms are not in themselves distinguishable from those of other conditions. Headache is common, and nausea and vomiting are frequent without being very severe. The temperature is very variable. It may be about 102° F. at the onset, falling after a few days, or it may be normal at the onset and rise later in the first week. A persistent rise is a serious sign. Some cases are apyrexial throughout. There is no characteristic eruption. In the mild and abortive types the general condition may suggest influenza and the nature of the illness only be recognized long subsequently by the development of characteristic late manifestations. Most cases undoubtedly commence with some grade of the characteristic symptoms of lethargy and double vision.

Lethargy.—The depth of this varies from apathy or drowsiness to deep sleep. The patient can usually be roused and may then answer questions with unexpected clearness. Occasionally the lethargy gradually deepens to stupor and fatal coma. Most commonly the lethargy lasts for two to three weeks, but it varies from a few days to several months. Rarely is it completely absent. Occasionally there may be somnolence by day and insomnia by night.

Double Vision.—Diplopia, or double vision, also occurs in the majority of cases, and is due to some form of paralysis of the ocular muscles. Other ocular manifestations may occur, such as ptosis or drooping of the eye-lids. The pupils may exhibit every possible variation from the normal in size, shape and reactions. Coarse nystagmoid movements are also common. Optic neuritis is never marked and a definite degree of swelling of the optic disc suggests an error in the diagnosis.

Nervous Symptoms.—Certain of the nervous manifestations which occur more commonly during convalescence or after the acute stages have passed will be referred to under the heading of "residual and late manifestations," but any of them may occur at the onset or at any point in the course of the disease.

The positive symptoms are represented by restlessness, delirium, acute mania and various degrees of excitement. General convulsions are not common but are usually fatal. Negative symptoms are represented by the characteristic lethargy referred to above.

Among the positive symptoms may be mentioned muscular pains which are occasionally severe and may simulate many diseases. In the positive group fall also the rigidity, Parkinsonism and the various involuntary movements which are referred to below among the late manifestations. The negative symptoms are represented by paralysis. The ocular manifestations have been mentioned above. Affection of the remaining cranial nerves may produce facial paralysis, difficulty in swallowing, rapid respiration and paralysis of the pharyngeal and laryngeal muscles. Aphasia and paralysis of the limbs may also occur. The deep reflexes are usually absent in the acute stages of severe cases, but there is no constant rule. The cerebro-spinal fluid may show a moderate increase in the number of lymphocytes but in at least one-third of the cases the fluid is normal.

Residual and Late Manifestations.—These are of the highest importance. The manifestations here referred to develop most frequently during convalescence, yet they may be present from the very outset of the disease, while in other cases long intervals, even of years, may elapse after the acute stages before their appearance. The initial attack may be so mild as to be overlooked at the time.

The most important of these manifestations are as follow:

The Parkinsonian Syndrome.—This is characterized by the

remarkable absence of facial expression which is termed the "Parkinsonian mask." There is also general muscular rigidity and a striking absence of slight and automatic movements. The general appearance resembles the condition known as paralysis agitans though the general effect is not quite identical.

Mental Changes.—These are of great importance from their frequency and character and are present to some extent in about 75% of cases. The changes may be of all grades, from slight weakness of the intellectual powers to definite dementia and insanity.

In adults the usual manifestation is a general weakness of the intellectual powers. The subject shows a marked lack of attention, concentration and initiative. Definite melancholia is not very common. There may be some irritability of temper but the excitement which occurs in children is not often seen in adults. Insomnia is a not infrequent symptom and may be very persistent. On the other hand there may be persistent drowsiness.

In children the mental changes are far more varied and of greater importance than in adults. As in adults the commonest effect is a weakening of the powers of concentration.

A second group, numerically smaller, is characterized by excitement. These children are usually under ten years of age. The excitement may be most marked during the night. For the time they are quite beyond control.

This group merges into a third group in which there are definite alterations in the moral character. Most of the children are between the ages of ten and 18 years. This group, though small, is important owing to the difficulty in dealing with the subjects. They become morally and sexually perverted. These changes are more common in children of families with a bad record mentally and criminally. There is a small group in which idiocy develops, usually in children under five years of age, and in a few cases there has been definite certifiable insanity. In addition to these mental changes Parkinsonism may be present and also the myoclonic and other movements described below. The treatment and especially the disposal of children in the second and third groups is a matter of great difficulty. Home surroundings are rarely suitable and the child will render ordinary family life impossible.

Involuntary Movements.—This group of "excito-motor" symptoms includes numerous varieties of involuntary movements and muscular contractions. Though they are more common late in the disease many of them occasionally occur at the onset. The most definite type is myoclonus which is characterized by short, rapid, rhythmic contractions of the muscles: a single muscle such as the diaphragm, or even a part of a single muscle may be affected. There is generally no movement at the joints, but in some cases the contractions are of a slow, rhythmic type and may lead to very complex movements. Various choreiform and athetoid movements are also met with. Tremors and tics of all types may also develop. Epidemic hiccough may be a variety.

Respiratory Abnormalities.—Rapid or deep breathing may be present, either continuously or in paroxysms at any period of the acuter stages. Violent spasmodic cough occasionally develops in children or sniffing and various respiratory spasms.

Paralysis.—The persistence of these is relatively uncommon. Diplopia is rarely permanent. Many nervous diseases, however, are occasionally simulated such as disseminated sclerosis. Numerous other late manifestations are observed more rarely. Among these may be mentioned obesity which is occasionally associated with polyuria, suggesting disturbance of the pituitary gland.

Progress and Prognosis.—A. J. Hall states as a rough approximation that of 100 cases, 25 recover completely, 25 die, and 50 have various residua of which at least 25 exhibit Parkinsonism. It is impossible to give a good prognosis during the acute stages in any case of encephalitis lethargica, owing to the fact that serious late manifestations may develop after a mild initial attack. Further, long quiescent periods may occur with subsequent recrudescence of activity and fresh manifestations. Such intervals may be several years, but the limit is at present unknown.

In the acute stages the outlook for life is bad with severe general symptoms, with a rapid onset, with high temperature, with acute delirium or with mania. Slight early symptoms may, however, also progress to serious grades. Deep, early lethargy is not necessarily a serious symptom. Early myoclonus and involuntary movements do not appear to be especially unfavourable. Most deaths occur within the first month and the prognosis for life improves after this.

With regard to special manifestations, the Parkinsonian syndrome may be recovered from partially or even completely when it develops early in the disease, but when it appears later it usually progresses and mental changes may also occur. The outlook in the cases with the severer mental changes is poor; recovery is rarely more than partial and relapses may follow.

The influence on pregnancy has been carefully studied by Hall. He considers that there is no evidence that pregnancy predisposes to infection with encephalitis lethargica, or that it is associated with a higher mortality or influences the course of the disease in any way. Residual manifestations, however, may be aggravated in a woman who has passed through an attack and become pregnant subsequently.

Diagnosis.—The disease is often easily recognized from the combination of lethargy and double vision. The milder forms, however, are easily overlooked at the onset and may frequently be unavoidably mistaken for influenza. When the more complex nervous symptoms are present the diagnosis may be of great difficulty. The conditions with which confusion most often occurs are meningitis (especially tuberculous), cerebral tumour, cerebral vascular lesions and cerebral syphilis.

Treatment.—This is on the general lines of treatment of acute febrile disease. Unfortunately there are no specific measures. The administration of hexamine may be recommended. The withdrawal of cerebro-spinal fluid by lumbar puncture is frequently performed but there is no evidence that it is beneficial.

Bibliography.—The monograph on Epidemic Encephalitis by A. J. Hall (John Wright and Sons, 1924) contains a complete and classified bibliography. The following articles include the earliest reports: C. von Economo, *Wien. Klin. Woch.*, xxx. 581 (1917); *Münch. Med. Woch.*, lxvi. 1311 (1919); A. J. Hall, *Lancet*, i. 568 (1918); W. Harris, *Lancet*, i. 586 (1918); E. F. Buzzard, *Lancet*, i. 616 (1918).

(H. L. T.)

ENCINA, JUAN DEL (1469–1529?), often called the founder of the Spanish drama. His *églogas* mark the transition from the purely ecclesiastical to the secular stage. The most characteristic are the *Auto del Repelón*, the *Égloga de Fileno* and *Plácida y Vitoriano*. Their intrinsic interest is slight, but they are historically important, for the lay pieces form a new departure, and the devout eclogues prepare the way for the *autos* of the 17th century. Encina's *Cancionero* (1496) contains also lyrical poems remarkable for their intense sincerity and devout grace.

See R. Mitjana, *Sobre Juan del Encina, músico y poeta* (Málaga, 1895).

ENCKE, JOHANN FRANZ (1791–1865), German astronomer, was born at Hamburg on Sept. 23, 1791. Matriculating at the University of Göttingen in 1811, he began to devote himself to astronomy under Carl Friedrich Gauss. In 1816, he was appointed assistant in the observatory of Seeberg near Gotha. There he completed his investigation of the comet of 1680, for which the Cotta prize was awarded to him in 1817; he correctly assigned a period of 71 years to the comet of 1812; and discovered the swift circulation of the remarkable comet which bears his name (*see* Comet). Eight masterly treatises on its movements were published by him in the Berlin *Abhandlungen* (1829–59). From a discussion of the transits of Venus in 1761 and 1769 he deduced (1822–24) a solar parallax of 8″·57, long accepted as authoritative. In 1822 he became director of the Seeberg observatory, and in 1825 was promoted to a corresponding position at Berlin. He died at Spandau on Aug. 26, 1865.

See C. Bruhns, *Johann Franz Encke, sein Leben und Wirken* (Leipzig, 1869), to which a list of his writings is appended. Also, *Month. Notices Roy. Astr. Society*, xxvi. 129; *V.J.S. Astr. Gesellschaft*, iv. 227; *Berlin. Abhandlungen* (1866), i., G. Hagen; *Sitzungsberichte*, Munich Acad. (1866), i. p. 395, etc.

ENCLAVE, a term signifying a country or, more commonly, an outlying portion of a country entirely surrounded by the territories of a foreign or other power. It is, however, generally used in a looser sense to describe a colony or other territory of a State, which, while possessing a seaboard, is entirely surrounded

landward by the possession of another power; or, if inland territory, nearly though not entirely so enclosed, *e.g.*, the Lado Enclave in equatorial Africa.

ENCOIGNURE, in furniture, literally the angle, or return, formed by the junction of two walls. The word is now chiefly used to designate a small armoire, commode, cabinet or cupboard made to fit a corner; a *chaise encoignure* is called in English a three-cornered chair. In its origin the thing, like the word, is French, and the delightful Louis XV. or Louis XVI. *encoignure* in lacquer or in mahogany elaborately mounted in gilded bronze was made in a vast variety of forms.

ENCORE (Fr. "again"), a word which has long been used by English audiences at musical performances to signify their desire for the repetition of a work.

ENCYCLICAL, an ecclesiastical epistle intended for general circulation, now almost exclusively used of such letters issued by the pope (from Late Lat. *encyclicus*, for *encyclius*=Gr. ἐγκύκλιος, from ἐν and κύκλος, "a circle"). The forms *encyclica* and *encyclic* are sometimes, but more rarely, used. The old adjectival use of the word in the sense of "general" (encircling) is now obsolete, though it survives in the term "encyclopaedia."

ENCYCLOPAEDIA. The Greeks seem to have understood by encyclopaedia (ἐγκυκλοπαιδεία, or ἐγκύκλιος παιδεία) instruction in the whole circle (ἐν κυκλῷ) or complete system of learning—education in arts and sciences. Thus Pliny, in the preface to his *Natural History*, says that his book treated of all the subjects of the encyclopaedia of the Greeks, "Iam omnia attingenda quae Graeci τῆς ἐγκυκλοπαιδείας vocant." The word encyclopaedia was probably first used in English by Sir Thomas Elyot. In his Latin dictionary, 1538, he explains "Encyclios et Encyclia, the cykle or course of all doctrines," and "Encyclopedia, that lernynge whiche comprehendeth all lyberall science and studies." The term does not seem to have been used as the title of a book by the ancients or in the middle ages. The edition of the works of Joachimus Fortius Ringelbergius, printed at Basle in 1541, is called on the title-page *Lucubrationes vel potius absolutissima* κυκλοπαιδεια. Paulus Scalichius de Lika, a Hungarian count, wrote *Encyclopaediae seu orbis disciplinarum epistemon* (1599). Alsted published in 1608 his *Encyclopaedia cursus philosophici,* and afterwards expanded this into his great work, noticed below, calling it without any limitation *Encyclopaedia,* because it treats of everything that can be learned by man in this life. This is now the most usual sense in which the word encyclopaedia is used—a book treating of all the various kinds of knowledge. The form "cyclopaedia" is not merely without any appearance of classical authority, but is etymologically less definite, complete and correct. For as Cyropaedia means "the instruction of Cyrus," so cyclopaedia may mean "instruction of a circle." Vossius says, "Cyclopaedia is sometimes found, but the best writers say encyclopaedia."

In a more restricted sense, encyclopaedia means a system or classification of the various branches of knowledge, a subject on which many books have been published, especially in Germany, as Schmid's *Allegemeine Encyklopädie und Methodologie der Wissenschaften* (Jena, 1810). In this sense the *Novum Organum* of Bacon has often been called an encyclopaedia. Fortunius Licetus, an Italian physician, entitled several of his dissertations on Roman altars and other antiquities encyclopaedias (as, for instance, *Encyclopædia ad Aram mysticam Nonarii* 1631), because in composing them he borrowed the aid of all the sciences. Encyclopaedia is often used to mean a book which is, or professes to be, a complete or very full collection or treatise relating to some particular subject, as Blaine's work, *The Encyclopaedia of Rural Sports; The Encyclopaedia of Wit; The Vocal Encyclopaedia,* a collection of songs, catches, etc. The word is frequently used for an alphabetical dictionary treating fully of some science or subject, as Murray, *Encyclopaedia of Geography;* Lefebvre Laboulaye, *Encyclopédie technologique: Dictionnaire des arts et manufactures;* the *Encyclopaedia Biblica.* Whether under the name of "dictionary" or "encyclopaedia" large numbers of this class of reference-work have been published. These are essentially encyclopaedic, being *subject books* and not *word-books.* The important books of this character are referred to in the articles dealing with the respective subjects.

Early Examples.—The great Chinese encyclopaedias are referred to in the article on CHINESE LITERATURE. It will be sufficient to mention here the *Wên hsien t'ung k'ao,* compiled by Ma Twa-lin in the 14th century, the encyclopaedia ordered to be compiled by the Emperor Yung-loh in the 15th century, and the *Ku chin t'u shu chi ch'êng* prepared for the Emperor K'ang-hi (d. 1721), in 5,020 volumes. A copy of this enormous work, bound in some 700 volumes, is in the British Museum.

THE MOST ANCIENT WORKS

The most ancient encyclopaedia extant is Pliny's *Natural History* in 37 books (including the preface) and 2,493 chapters, which treat of cosmography, astronomy and meteorology, geography, zoology (including man), the invention of the arts, botany, medicines, vegetable and animal remedies, medical authors and magic, metals, fine arts, mineralogy and mineral remedies. Pliny, who died A.D. 79, was not a naturalist, a physician or an artist, and collected his work in his leisure intervals while engaged in public affairs. He says it contains 20,000 facts (too small a number by half, says Lemaire), collected from 2,000 books by 100 authors. Hardouin has given a list of 464 authors quoted by him. His work was a very high authority in the middle ages, and 43 editions of it were printed before 1536.

Martianus Minneus Felix Capella, an African, wrote (early in the 5th century), in verse and prose, a sort of encyclopaedia, which is important from having been regarded in the middle ages as a model storehouse of learning, and used in the schools, where the scholars had to learn the verses by heart, as a text-book of high-class education in the arts. It is sometimes entitled *Satyra,* or *Satyricon,* but is usually known as *De nuptiis Philologiae et Mercurii,* though this title is sometimes confined to the first two books, a rather confused allegory ending with the apotheosis of Philologia and the celebration of her marriage in the Milky Way, where Apollo presents to her the seven liberal arts, who, in the succeeding seven books, describe their respective branches of knowledge from grammar to music (including poetry). The style is that of an African of the 5th century, full of grandiloquence, metaphors and strange words.

Isidore, bishop of Seville from 600 to 630, wrote *Etymologiarum libri XX.* (often also entitled his *Origines*) at the request of his friend Braulio, bishop of Saragossa, who after Isidore's death divided the work into books, dealing with a great variety of subjects, from grammar to war and games, from angel to animal, from mathematics to ships, buildings and garments. Isidore appears to have known Hebrew and Greek, and to have been familiar with the Latin classical poets, but he is a mere collector and his derivations are often absurd. He seldom mentions his authorities except when he quotes the poets or historians. Yet his work was a great one for the time, and for many centuries was a much valued authority and a rich source of material for other works, and he had a high reputation for learning both in his own time and in subsequent ages.

Hrabanus Maurus, whose family name was Magnentius, was educated in the abbey of Fulda, ordained deacon in 802, sent to the school of St. Martin of Tours, then directed by Alcuin, where he seems to have learned Greek, and is said by Trithemius to have been taught Hebrew, Syriac and Chaldee by Theophilus an Ephesian. He was ordained archbishop of Mainz in 847, and died in 856. He compiled an encyclopaedia *De universo* (also called *De universali natura, De natura rerum,* and *De origine rerum*) in 22 books. It is chiefly a rearrangement of Isidore's *Etymologies,* omitting a considerable part of it, and adding the meanings given in the Bible to the subject matter of the chapter; while things not mentioned in Scripture, especially such as belong to classical antiquity, are omitted, so that his work seems to be formed of two alternating parts. His arrangement of beginning with God and the angels long prevailed in methodical encyclopaedias. His omissions are characteristic of the diminished literary activity and more contracted knowledge of his time. His work was presented to Louis the German, king of Bavaria, at Hersfeld in Oct.

847, and was printed in 1473, probably at Venice, and again at Strasbourg by Mentelin about 1472–75.

Michael Constantine Psellus, the younger, wrote Διδασκαλία παντοδαπή, dedicated to the emperor Michael Ducas, who reigned 1071–78. It was printed by Fabricius in his *Bibliotheca Graeca* (1712), vol. v., in 193 chapters, each containing a question and answer. Beginning with divinity, it goes on through natural history and astronomy, and ends with chapters on excessive hunger, and why flesh hung from a fig-tree becomes tender.

Works of the Middle Ages.—The author of the most famous encyclopaedia of the middle ages was Vincent (*q.v.*) of Beauvais (*c.* 1190–*c.* 1264), whose work *Bibliotheca mundi* or *Speculum majus*, was the great compendium of mid-13th century knowledge. Vincent of Beauvais preserved several works of the middle ages and gives extracts from many lost classics and valuable readings of others, and did more than any other mediaeval writer to awaken a taste for classical literature. As Vincent did not know Greek or Arabic, he used Latin translations.

Brunetto Latini of Florence, the master of Dante and Guido Cavalcanti, while an exile in France between 1260 and 1267, wrote in French *Li Livres dou Tresor*. The Bible, natural history, ethics and politics, astronomy and geography are among the subjects covered. The last part, the most original and interesting of all, treats of the government of the Italian republics of the time. Brunetto's work was translated into Italian in the latter part of the 13th century by Bono Giamboni. Napoleon I. had intended to have the French text of the *Tesoro* printed with commentaries, and appointed a commission for the purpose. It was at last published in the *Collection des documents inédits* (1863), edited by Chabaille from 42 mss.

Bartholomew de Glanville, an English Franciscan friar, wrote about 1360 a most popular work, *De proprietatibus rerum*, in 19 books, beginning with God and the angels and ending with colours, scents, flavours and liquors, with a list of 36 eggs. There were 15 editions before 1500. An English translation was completed on Feb. 11, 1398, by John Trevisa, and printed by Wynkyn de Worde (? 1495).

Pierre Bersuire (Berchorius), a Benedictine, prior of the abbey of St. Eloi in Paris, where he died in 1362, wrote a kind of encyclopaedia, chiefly relating to divinity, in three parts. The three parts were printed together as *Petri Berchorii opera omnia* (an incorrect title, for he wrote much besides).

A very popular small encyclopaedia, *Margarita philosophica* (1496), in 12 books, was written by Georg Reisch, a German, prior of the Carthusians of Freiburg, and confessor of the emperor Maximilian I. Books 1–7 treat of the seven liberal arts; 8, 9, principles and origin of natural things; 10, 11, the soul, vegetative, sensitive and intellectual; 12, moral philosophy.

Raphael Maffei (1451–1522), called Volaterranus, being a native of Volterra, wrote *Commentarii Urbani* (1506), so called because written at Rome. This encyclopaedia, printed eight times up to 1603, is remarkable for the great importance given to geography, and also to biography, a subject not included in previous encyclopaedias. The books are not divided into short chapters in the ancient manner, like those of its predecessors. The edition of 1603 contains 814 folio pages.

Giorgio Valla, born about 1430 at Placentia, and therefore called Placentinus, died at Venice in 1499 while lecturing on the immortality of the soul. Aldus published his book, edited by his son Giovanni Pietro Valla, *De expetendis et fugiendis rebus*, an encyclopaedic work containing 49 books and 2,119 chapters.

Antonio Zara, born 1574, made bishop of Petina in Istria 1600, finished in 1614 a work published as *Anatomia ingeniorum et scientiarum*. The first section, on the dignity and excellence of man, considers him in all his bodily and mental aspects. The first membrum describes his structure and his soul, and in the latter part contains the author's preface, the deeds of his ancestors, an account of himself, and the dedication of his book to Ferdinand, archduke of Austria. Four membra treat of the discovery of character by chiromancy, physiognomy, dreams and astrology. The rest of the work treats of 16 "sciences of the imagination," 8 "sciences of intellect," and 12 "sciences of memory." The book, now very rare, is well arranged, with a copious index, and is full of curious learning.

ENCYCLOPAEDIAS AND DICTIONARIES

Alsted's Encyclopaedia.—Johann Heinrich Alsted, born 1588, died 1638, published *Encyclopaedia septem tomis distincta* (1630). It treats of a wide range of subjects, including not only the more important sciences, but paradoxologia, the art of explaining paradoxes; dipnosophistica, the art of philosophizing while feasting; cyclognomica, the art of conversing well *de quovis scibili*, and tabacologia, the nature, use and abuse of tobacco. Alsted's encyclopaedia was received with very great applause, and was highly valued. Lami (*Entretiens*, 1684) thought it almost the only encyclopaedia which did not deserve to be despised. Alsted's learning was very various. He wrote not long before the appearance of encyclopaedias in modern languages superseded his own and other Latin books, and but a short time before the alphabetical arrangement began to prevail over the methodical.

Jean de Magnon, historiographer to the king of France, undertook to write an encyclopaedia in French heroic verse, which was to fill ten volumes of 20,000 lines each, and to render libraries merely a useless ornament. But he did not live to finish it, as he was killed at night by robbers on the Pont Neuf in Paris, in 1662. The part he left was printed as *La Science universelle* (1663)—10 books containing about 11,000 lines. They begin with the nature of God, and end with the history of the fall of man. His verses, say Chaudon and Delandine, are perhaps the most nerveless, incorrect, obscure and flat in French poetry; yet the author had been the friend of Molière, and had acted with him in comedy.

Louis Moréri (born in 1643, died in 1680 at Paris) wrote a dictionary of history, genealogy and biography, *Le Grand Dictionnaire historique, ou le mélange curieux de l'histoire sacrée et profane* (Lyons, 1674), the 20th edition of which was published in 1759. Moréri's dictionary, still very useful, was of great value and importance, although not the first of the kind.

Johann Jacob Hofmann (1635–1706), son of a schoolmaster at Basle, which he is said never to have left, and where he was professor of Greek and History, wrote *Lexicon universale historico-geographico-chronologico-poëtico-philologicum* (1677), a dictionary of history, biography, geography, genealogies of princely families, chronology, mythology and philology. In 1683 he published a continuation in two volumes. From the great extent of his plan, many articles, especially in history, are superficial and faulty.

Etienne Chauvin was born at Nîmes in 1640. He fled to Rotterdam on the revocation of the edict of Nantes, and in 1688 supplied Bayle's place in his lectures on philosophy. In 1695 he was invited to go as professor of philosophy to Berlin, where he became the representative of the Cartesian philosophy. He wrote *Lexicon rationale, sive thesaurus philosophicus ordine alphabetico digestus* (1692). An improved and enlarged edition was printed as *Lexicon philosophicum secundis curis* in 1713. This great work may be considered as a dictionary of the Cartesian philosophy.

Dictionaries of Arts and Sciences.—The great dictionary of French, begun by the French Academy on Feb. 7, 1639, excluded all words especially belonging to science and the arts. But the success of the rival dictionary of Furetière, which, as its title-page, as well as that of the *Essais* published in 1684, conspicuously announced, professed to give "les termes de toutes les Sciences et des Arts," induced Thomas Corneille, a member of the Academy, to compile *Le Dictionnaire des arts et des sciences*, which the Academy published with the first edition of their dictionary (1694) as a supplement in two volumes. A long series of dictionaries of arts and sciences have followed Corneille in placing in their titles the arts before the sciences, which he probably did merely in order to differ from Furetière.

Pierre Bayle (1647–1706) wrote a very important and valuable work, *Dictionnaire historique et critique* (Rotterdam, 1697). His design was to make a dictionary of the errors and omissions of Moréri and others, but he was much embarrassed by the numerous editions and supplements of Moréri. The fourth edition (4 vols., Rotterdam, 1720) was much enlarged from his manuscripts,

and was edited by Prosper Marchand. It contains 3,132 pages besides tables, etc. It was translated into English from the second edition in 1709. Prosper Marchand, editor of the fourth edition, left at his death on Jan. 14, 1756, materials for a supplementary *Dictionnaire historique* (La Haye, 1758). It had occupied his leisure moments for 40 years. Much of his work was written on small scraps of paper, sometimes 20 in half a page and no larger than a nail, in such small characters that not only the editor but the printer had to use powerful magnifiers. Bayle's dictionary is still a work of great importance and value.

Vincenzo Maria Coronelli, a Franciscan friar, who was born in Venice about 1650, made cosmographer to the republic in 1685, and became general of his order in 1702, began in 1701 to publish a general alphabetical encyclopaedia, written in Italian, at which he had been working for 30 years, *Biblioteca universale sacro-profana.* It was to explain more than 300,000 words, to include history and biography as well as all other subjects, and to extend to 45 volumes folio. But seven volumes only were published (Venice, 1701–06), A to Caque. This work is remarkable for the extent and completeness of its plan, and for being the first great alphabetical encyclopaedia, as well as for being written in a modern language, but it was hastily written and very incorrect. Never, perhaps, says Tiraboschi, was there so quick a writer; he composed a folio volume as easily as others would a page.

The First Alphabetical Encyclopaedias in English.—The first alphabetical encyclopaedia written in English was the work of a London clergyman, John Harris (born about 1667, elected first secretary of the Royal Society in 1709, died 1719), *Lexicon technicum, or an universal English Dictionary of Arts and Sciences* (1704). As in many subsequent English encyclopaedias the pages are not numbered. It professes not merely to explain the terms used in the arts and sciences, but the arts and sciences themselves. The author omits theology, antiquity, biography and poetry. This volume was reprinted in 1708. A second volume of 1,419 pages appeared in 1710, with a list of about 1,300 subscribers. A great part of it consisted of mathematical and astronomical tables, as he intended his work to serve as a small mathematical library. He was allowed by Sir Isaac Newton to print his treatise on acids. The mathematical and physical part is considered very able. He often mentions his authorities, and gives lists of books on particular subjects, as botany and chronology. His dictionary was long very popular. The fifth edition was published in 1736.

Johann Hübner, rector of the Johanneum in Hamburg, born 1668, wrote prefaces to two dictionaries written in German, which bore his name, and were long popular. The first was *Reales Staats Zeitungs- und Conversations-Lexicon* (Leipzig 1704); the second, published as a supplement, was *Curieuses und reales Natur-Kunst- Berg- Gewerb- und Handlungs-Lexicon* (Leipzig, 1712), frequently reprinted to 1792. The first relates to the political state of the world, treating of religion, orders, States, rivers, towns, castles, mountains, genealogy, war, ships; the second to nature, science, art and commerce. They were the work of many authors, among whom Paul Jacob Marpurger, a celebrated and voluminous writer on trade and commerce, was an extensive contributor.

Johann Theodor Jablonski, who was born at Danzig in 1654, and was appointed secretary to the newly founded Prussian Academy in 1700, when he went to Berlin, published *Allgemeines Lexicon der Künste und Wissenschaften* (Leipzig, 1721), a short but excellent encyclopaedia still valued in Germany. It does not include theology, history, geography, biography and genealogy. He not only names his authorities, but gives a list of their works.

Ephraim Chambers (*q.v.*) published his *Cyclopaedia; or an Universal Dictionary of Art and Sciences, containing an Explication of the Terms and an Account of the Things Signified thereby in the several Arts, Liberal and Mechanical, and the several Sciences, Human and Divine,* in 1728 (2 vols.). Chambers endeavoured to connect the scattered articles relating to each subject by a system of references, and to consider "the several matters, not only in themselves, but relatively, or as they respect each other; both to treat them as so many wholes and as so many parts of some greater whole." Under each article he refers to the subject to which it belongs, and also to its subordinate parts; thus Copyhold has a reference to Tenure, of which it is a particular kind, and other references to Rolls, Custom, Manor, Fine, Charterland and Freehold. His work, he says, is a collection, not the produce of one man's wit, for that would go but a little way, but of the whole commonwealth of learning. To the subjects given by Harris he adds theology, metaphysics, ethics, politics, logic, grammar, rhetoric and poetry, but excludes history, biography, genealogy, geography and chronology, except their technical parts. A second edition appeared in 1738. A few articles were added and some others enlarged, but he was prevented from doing more because "the booksellers were alarmed with a bill in parliament containing a clause to oblige the publishers of all improved editions of books to print their improvements separately." The bill after passing the Commons was unexpectedly thrown out by the Lords; but fearing that it might be revived, the booksellers thought it best to retreat though more than 20 sheets had been printed. An Italian translation (Venice, 1748–49), was the first complete Italian encyclopaedia. When Chambers was in France in 1739 he rejected very favourable proposals to publish an edition there dedicated to Louis XV. His work was judiciously, honestly and carefully done, and long maintained its popularity. At his death, on May 15, 1740, he had collected and arranged materials for seven new volumes. The *Supplement,* edited hastily by Dr. (later Sir) John Hill, was published in 1753. As Hill was a botanist, the botanical part, which had been very defective in the *Cyclopaedia,* was the best. Abraham Rees (1743–1825), a Nonconformist minister, published a revised and enlarged edition, "with the supplement and modern improvements incorporated in one alphabet" (1778–88). It was published in 418 numbers at 6d. each. Rees said that he added more than 4,400 new articles.

Zedler's Universal Lexicon.—One of the largest and most comprehensive encyclopaedias was undertaken and in a great measure completed by Johann Heinrich Zedler, a bookseller of Leipzig, who was born at Breslau in 1706, made a Prussian commerzienrath in 1731, and died at Leipzig in 1760—*Grosses vollständiges Universal Lexicon Aller Wissenschaften und Künste welche bisher durch menschlichen Verstand und Witz erfunden und verbessert worden* (64 vols., Halle and Leipzig, 1732–50); and *Nöthige Supplemente* (*ib.,* 1751–54, vols. i. to iv., A. to Caq, 3,016 pages). Nine editors were employed, and the whole of each subject was entrusted to the same person, that all its parts might be uniformly treated. The work was published by subscription. Johann Heinrich Wolff, an eminent merchant and shopkeeper in Leipzig, came to Zedler's assistance by advancing the funds for expenses and becoming answerable for the subscriptions, and spared no cost that the work might be complete. Zedler very truly says that his *Universal Lexicon* was a work such as no time and no nation could show, and both in its plan and execution it is much more comprehensive and complete than any previous encyclopaedia. Its plan embraces not only history, geography and biography, but also genealogy, topography, and from vol. xviii., published in 1738, lives of illustrious living persons. Zedler enquires why death alone should make a deserving man capable of having his services and worthy deeds made known to the world in print. Cross references generally give not only the article referred to, but also the volume and column, and, when necessary, such brief information as may distinguish the word referred to from others similar but of different meaning. Lists of authorities, often long, exact and valuable, are frequently appended to the articles. This work, which is well and carefully compiled, and very trustworthy, is still a most valuable book of reference on many subjects, especially topography, genealogy and biography. The genealogies and family histories are excellent, and many particulars are given of the lives and works of authors not easily found elsewhere.

A work on a new plan was published by Dennis de Coetlogon, a Frenchman naturalized in England, who styled himself "Knight of St. Lazare, M.D., and member of the Royal Academy of Angers"—*An Universal History of Arts and Sciences* (2 vols., 1745). He "endeavours to render each treatise as complete as possible, avoiding above all things needless repetitions, and never puzzling the reader with the least reference." The subject matter

is sometimes curious. The author says that his work is the only one of the kind, and that he wrote out with his own hand every line, even the index. But notwithstanding the novelty of his plan, his work does not seem ever to have been popular.

Gianfrancesco Pivati (1689–1764), secretary of the Academy of Sciences at Venice, who had published in 1744 a 4to volume containing a *Dizionario universale*, wrote *Nuovo dizionario scientifico e curioso sacroprofano* (Venice, 1746–51, 10 vols., 597 plates). It is a general encyclopaedia, including geography, but not history or biography. It is remarkable for the number of its plates, which are engraved on copper.

The French Encyclopaedists.—One of the greatest and most remarkable literary enterprises of the 18th century, the famous French *Encyclopédie,* originated in a French translation of Ephraim Chambers's *Cyclopaedia,* begun in 1743 and finished in 1745 by John Mills, an Englishman resident in France, assisted by Gottfried Sellius. They applied to Lebreton, the king's printer, to publish the work, to fulfil the formalities required by French law, with which, as foreigners, they were not acquainted, and to solicit a royal privilege. This he did for them, but only in his own name. Mills complained so loudly and bitterly of this deception that Lebreton had to acknowledge formally that the privilege belonged *en toute propriété* to John Mills. Mills, however, again became the victim of trickery and was ultimately despoiled of the work he had both planned and executed, and had to return to England. Jean Paul de Gua de Malves, professor of philosophy in the college of France, was then engaged as editor merely to correct errors and add new discoveries. But he proposed a thorough revision, and obtained the assistance of many learned men and artists, among whom Desessarts names Louis, Condillac, d'Alembert and Diderot. But the publishers did not think his reputation high enough to ensure success, withheld their confidence, and often opposed his plans as too expensive. De Gua resigned the editorship. The publishers, who had already made heavy advances, offered it to Diderot, who was probably recommended to them by his very well received *Dictionnaire universel de médicine* (1746–48), a translation, made with the assistance of Eidous and Toussaint, of the celebrated work of Dr. Robert James (inventor of the fever powders), *A Medicinal Dictionary.* The proposed work was to have been similar in character.

De Gua's papers were handed over to Diderot in great confusion. He soon persuaded the publishers to undertake a far more original and comprehensive work. His friend d'Alembert undertook to edit the mathematics. Other subjects were allotted to 21 contributors, each of whom received the articles on his subject in Mills's translation to serve as a basis for his work. But they were in most cases so badly composed and translated, so full of errors and omissions, that they were not used. The contributions were to be finished in three months, but none was ready in time, except Music by Rousseau, which he admits was hastily and badly done. Diderot was imprisoned at Vincennes, on July 29, 1749, for his *Lettre sur les aveugles.* He was closely confined for 28 days, and was then for three months and ten days a prisoner on parole in the castle. This did not stop the printing, though it caused delay. The prospectus by Diderot appeared in Nov. 1750. The work was to form 8 vols., with at least 600 plates. The first volume was published in July 1751; the second appeared in Jan. 1752. An *arrêt* of the council suppressed both volumes as injurious to the king's authority and to religion. Malesherbes, director-general of the Librairie, stopped the issue of vol. ii. on Feb. 9, and on the 21st went with a *lettre de cachet* to Lebreton's to seize the plates and the mss., but did not find even those of vol. iii., as they had been taken to his own house by Diderot and one of the publishers. The Jesuits tried to continue the work, but in vain. It was less easy, says Grimm, than to ruin philosophers. The Government had to request the editors to resume the work as one honourable to the nation. Vol. iii., rather improved by the delay, appeared in Oct. 1753; and vol. vii., completing G, in Nov. 1757. The clamours against the work soon recommenced. D'Alembert retired in Jan. 1758, weary of sermons, satires and intolerant and absurd censors. The parlement of Paris, by an *arrêt* of Jan. 23, 1759, stopped the sale and distribution of the *Encyclopédie* and other books; and by an *arrêt* of Feb. 6, ordered them all to be burnt, but referred the *Encyclopédie* for examination to a commission of nine. A *arrêt du conseil* (March 7) revoked the privilege of 1746, and stopped the printing. Vol. viii. was then in the press. Malesherbes warned Diderot that he would have his papers seized next day; and when Diderot said he could not make a selection, or find a place of safety at such short notice, Malesherbes said, "Send them to me, they will not look for them there." Malesherbes, Choiseul and Mme. de Pompadour protected the work. Diderot obtained private permission to go on printing, but with a strict charge not to publish any part until the whole was finished. The Jesuits were condemned by the parlement of Paris in 1762, and by the king in Nov. 1764. Vol. i. of plates appeared in 1762, and vol. viii. to xvii., ten volumes of text, 9,408 pages, completing the work, with the 4th volume of plates in 1765, when there were 4,250 subscribers. The work was secretly distributed in Paris and Versailles. The general assembly of the clergy, on June 20, 1765, approved articles in which it was condemned, and on Sept. 27 adopted a *mémoire* to be presented to the king. They were forbidden to publish their acts which favoured the Jesuits, but Lebreton was required to give a list of his subscribers, and was put into the Bastille for eight days in 1766. A royal order was sent to the subscribers to deliver their copies to the lieutenant of police. Voltaire in 1774 relates that, at a *petit souper* of the king at Trianon, there was a debate on the composition of gunpowder. Mme. de Pompadour said she did not know how her rouge or her silk stockings were made. The duc de la Vallière regretted that the king had confiscated their encyclopaedias, which could decide everything. The king said he had been told that the work was most dangerous, but as he wished to judge for himself, he sent for a copy. Three servants with difficulty brought in the 21 volumes. The company found everything they looked for, and the king allowed the confiscated copies to be returned. Lebreton, who had the largest printing office in Paris, employed 50 workmen in printing the last ten volumes. He had the articles set in type exactly as the authors sent them in, and when Diderot had corrected the last proof of each sheet, he and his foreman, hastily, secretly and by night, unknown to his partners in the work, cut out whatever seemed to them daring, or likely to give offence, mutilated most of the best articles without any regard to the consecutiveness of what was left, and burnt the manuscript. The printing of the work was nearly finished when Diderot, having to consult one of his great philosophical articles in the letter S, found it entirely mutilated. He was confounded, says Grimm, at discovering the atrocity of the printer; all the best articles were in the same confusion. This discovery put him into a state of frenzy and despair from rage and grief. Diderot at first refused to correct the remaining proofs, or to do more than write the explanations of the plates. He required, according to Mme. de Vandeul, that a copy (now at Leningrad with his library) should be printed with columns in which all was restored. Diderot's articles were on very many subjects, but principally on grammar, history, morality, philosophy, literature and metaphysics. As a contributor, his special department of the work was philosophy, and arts and trades. He passed whole days in workshops, and began by examining a machine carefully, then he had it taken to pieces and put together again, then he watched it at work, and lastly worked it himself. He thus learned to use such complicated machines as the stocking and cut velvet looms. He at first received 1,200 livres a year as editor, but afterwards 2,500 livres a volume, besides a final sum of 20,000 livres. All the publishers made large fortunes; their expenses amounted to 1,158,000 livres and their profits to 2,162,000.

In the *Encyclopédie,* as in Ephraim Chambers's *Cyclopaedia,* history and biography were excluded, except incidentally; thus Aristotle's life is given in the article Aristotélisme. The science to which an article belongs is generally named at the beginning of it, references are given to other articles, and the authors' names are marked by initials, of which lists are given in the earlier volumes, but sometimes their names are subscribed in full. Articles by Diderot have no mark, and those inserted by him as editor have an asterisk prefixed. Among the contributors were Voltaire,

Euler, Marmontel, Montesquieu, D'Anville, D'Holbach and Turgot, the leader of the new school of economists which made its first appearance in the pages of the *Encyclopédie*. No encyclopaedia perhaps has been of such political importance, or has occupied so conspicuous a place in the civil and literary history of its century. It sought not only to give information, but to guide opinion. It was, as Rosenkranz says (*Diderot*, i. 157), theistic and heretical. It was opposed to the church, then all-powerful in France, and it treated dogma historically. It was, as Desnoiresterres says (*Voltaire*, v. 164), a war machine; as it progressed, its attacks both on the church and the still more despotic Government, as well as on Christianity itself, became bolder and more undisguised, and it was met by opposition and persecution unparalleled in the history of encyclopaedias. Its execution is very unequal, and its articles of very different value. It was not constructed on a regular plan, or subjected to sufficient supervision; articles were sent in by the contributors, and not seen by the editors until they were in type. In each subject there are some excellent articles, but others are very inferior, and references are often given to articles which do not exist. The style is too generally loose, digressive and inexact; dates are seldom given; and discursiveness, verbosity and dogmatism are frequent faults. Voltaire was constantly demanding truth, brevity and method, and said it was built half of marble and half of wood. D'Alembert compared it to a harlequin's coat, in which there is some good stuff but too many rags. Diderot was dissatisfied with it as a whole; much of it was compiled in haste; and carelessly written articles and incompetent contributors were admitted for want of money to pay good writers. Zedler's *Universal Lexicon* is on the whole much more useful for reference than its far more brilliant successor. The books attacking and defending the *Encyclopédie* are very many. No original work of the 18th century, says Lanfrey, has been more deprecated, ridiculed and calumniated. It has been called chaos, nothingness, the Tower of Babel, a work of disorder and destruction, the gospel of Satan and even the ruins of Palmyra.

THE ENCYCLOPÆDIA BRITANNICA

The *Encyclopædia Britannica or Dictionary of Arts and Sciences*, "by a society of gentlemen in Scotland, printed in Edinburgh for A. Bell and C. Macfarquhar, and sold by Colin Macfarquhar at his printing office in Nicolson street," was completed in 1771 in 3 vol. 4to, containing 2,670 pages, and 160 copperplates engraved by Andrew Bell. It was published in numbers, of which the first two were issued in Dec. 1768, "price 6d. each, or 8d. on a finer paper," and was to be completed in 100 weekly numbers. It was compiled, as the title-page says, on a new plan. The different sciences and arts were "digested into distinct treatises or systems," of which there are 45 with cross headings, *i.e.*, titles printed across the page, and about 30 other articles more than three pages long. The longest are "Anatomy," 166 pages, and "Surgery," 238 pages. "The various technical terms, etc., are explained as they occur in the order of the alphabet." "Instead of dismembering the sciences, by attempting to treat them intelligibly under a multitude of technical terms, they have digested the principles of every science in the form of systems or distinct treatises, and explained the terms as they occur in the order of the alphabet, with references to the sciences to which they belong." This plan, as the compilers say, differs from that of all the previous dictionaries of arts and sciences. Its merit and novelty consist in the combination of De Coetlogon's plan with that in common use—on the one hand keeping important subjects together, and on the other facilitating reference by numerous separate articles. It is doubtful to whom the credit of this plan is due. The editor, William Smellie, a printer (born in 1740, died on June 24, 1795), afterwards secretary and superintendent of natural history to the Society of Scottish Antiquaries, is said by his biographer to have devised the plan and written or compiled all the chief articles. Archibald Constable, who was interested in the work from 1788, and was afterwards intimately acquainted with Bell, says Colin Macfarquhar was the actual projector of the *Encyclopædia*, and the editor of the first two editions, while Smellie was merely "a contributor for hire." Dr. Gleig, in his preface to the third edition, says: "The idea had been conceived by him (Colin Macfarquhar) and his friend, Mr. Andrew Bell, engraver." Macfarquhar, according to Constable, was a person of excellent taste and very general knowledge, though at starting he had little or no capital, and was obliged to associate Bell, then the principal engraver in Edinburgh, as a partner in his undertaking.

The second edition was begun in 1776, and was published in numbers, of which the first was issued on June 21, 1777, and the last, No. 181, on Sept. 18, 1784, forming 10 vols, 4to, dated 1778 to 1783, and containing 8,595 pages and 340 plates. The pagination is continuous, ending with page 9,200, but 295 pages are inserted in various places, and page 7,099 is followed by 8,000. The number and length of the articles were much increased, 72 have cross headings, and more than 150 others may be classed as long articles. At the end is an appendix ("Abatement" to "Wood") of 200 pages, containing, under the heading Botanical Table, a list of the 931 genera included in the 58 natural orders of Linnaeus, and followed by a list of 526 books, said to have been the principal authorities used. All the maps are placed together under the article "Geography" (195 pages). Most of the long articles have numbered marginal titles; "Scotland," 84 pages, has 837. "Medicine," 309 pages, and "Pharmacy" have each an index. The plan of the work was enlarged by the addition of history and biography, which encyclopaedias in general had long omitted. Smellie was applied to by Bell to edit the second edition, and to take a share of one-third in the work; but he refused on the ground that the introduction of a system of general biography was inconsistent with the character of a dictionary of arts and sciences. James Tytler, M.A., seems to have been selected as the next most eligible compiler. Tytler (outlawed by the High Court of Justiciary in 1793, buried at Salem in Massachusetts in 1804, aged 58) "wrote," says Watt, "many of the scientific treatises and histories, and almost all the minor articles."

The Third Edition.—After about a year's preparation, the third edition was announced in 1787; the first number was published early in 1788, and the first volume in Oct. 1788. There were to be 300 weekly numbers, price 1s. each, forming 30 parts at 10s. 6d. each, and 15 volumes, with 360 plates. It was completed in 1797 in 18 vols. 4to, containing 14,579 pages and 542 plates. Among the multifarious articles represented in the frontispiece, which was required by the traditional fashion of the period, is a balloon. The maps are, as in subsequent editions, distributed among the articles relating to the respective countries. It was edited by Colin Macfarquhar as far as the article "Mysteries," when he died, in 1793 in his 48th year, "worn out," says Constable, "by fatigue and anxiety of mind." His children's trustees and Andrew Bell requested George Gleig of Stirling (consecrated on Oct. 30, 1808, assistant and successor to the bishop of Brechin), who had written about 12 articles, to edit the rest of the work. According to Kerr (*Smellie's Life*, i. 364–365), 10,000 copies were printed, and the profit to the proprietors was £42,000, besides the payments for their respective work as tradesmen in the conduct of the publication—Bell as engraver of all the plates, and Macfarquhar as sole printer. According to Constable, the impression was begun at 5,000 copies, and concluded with a sale of 13,000. James Hunter, "an active bookseller of no character," who had a shop in Middle Row, Holborn, sold the book to the trade, and on his failure Thomson Bonar, a wine merchant, who had married Bell's daughter, became the seller of the book. He quarrelled with his father-in-law, who would not see him during the ten years before his death. When the edition was completed, the copyright and remaining books were sold in order to wind up the concern, and "the whole was purchased by Bell, who gave £13 a copy, sold all the complete copies to the trade, printed up the odd volumes, and thus kept the work in the market for several years."

SUPPLEMENTS AND OTHER EDITIONS

The supplement of the third edition, printed for Thomson Bonar, and edited by Gleig, was published in 1801 in 2 vols., containing 1,624 pages and 50 copperplates engraved by D. Lizars. In the dedication to the king, dated Stirling, Dec. 10, 1800, Dr. Gleig says: "The French *Encyclopédie* had been accused, and

justly accused, of having disseminated far and wide the seeds of anarchy and atheism. If the *Encyclopædia Britannica* shall in any degree counteract the tendency of that pestiferous work, even these two volumes will not be wholly unworthy of your Majesty's attention." Dr. Thomas Thomson wrote "Chemistry," "Mineralogy" and other articles, in which the use of symbols was for the first time introduced into chemistry; and these articles formed the first outline of his *System of Chemistry*.

The fourth edition, printed for Andrew Bell, was begun in 1800 or 1801, and finished in 1810 in 20 vols. 4to, containing 16,033 pages, with 581 plates engraved by Bell. No articles were reprinted from the supplement, as Bell had not the copyright. Prof. Wallace's articles on mathematics were much valued, and raised the scientific character of the work. Dr. Thomas Thomson declined the editorship, and recommended Dr. James Millar, afterwards editor of the *Encyclopaedia Edinensis*. He was fond of natural history and a good chemist, but, according to Constable, slow and dilatory and not well qualified. The edition began with 1,250 copies and concluded at 4,000, of which two-thirds passed through the hands of Constable's firm. Early in 1804 Andrew Bell had offered Constable and his partner Hunter the copyright of the work, printing materials, etc., and all that was then printed of the fourth edition, for £20,000. This offer was in agitation in March 1804, when the two partners were in London. On May 5, 1804, after Lord Jeffrey's arrival in Edinburgh, as he relates to Francis Horner, they entrusted him with a design, on which he found that most of his friends had embarked with great eagerness, "for publishing an entire new encyclopaedia upon an improved plan. . . . W. Scott has embraced it with great affection. . . . The authors are to be paid at least as well as reviewers, and are to retain the copyright of their articles for separate publication if they think proper." It was then, perhaps, that Constable gave £100 to Bonar for the copyright of the supplement.

Andrew Bell died in 1809, and a fifth edition was begun immediately after the fourth as a mere reprint. Bell's trustees mismanaged the new edition so badly that, after the issue of five volumes, both the stock and the copyright were sold to Constable who paid between £13,000 and £14,000. Bonar, who lived next door to the printing office, thought he could conduct the book, and had resolved on the purchase. Having a good deal of money, he seemed to Constable a formidable rival, whose alliance was to be secured. After "sundry interviews" it was agreed that Constable should buy the copyright in his own name, and that Bonar should have one-third, and also one-third of the copyright of the supplement, for which he gave £200. Dr. James Millar corrected and revised the last 15 volumes. The edition dated 1817 was published in 20 vols., 16,017 pages, 582 plates, price £36.

Famous Contributors.—Soon after the purchase of the copyright, Constable began to prepare for the publication of a supplement, to be of four or, at the very utmost, five volumes. Dugald Stewart, in a letter to Constable, Nov. 15, 1812, though he declines to engage to execute any of his own suggestions, recommends that four discourses should "stand in front," forming "a general map of the various departments of human knowledge," similar to "the excellent discourse prefixed by D'Alembert to the French *Encyclopédie*," together with historical sketches of the progress since Bacon's time of modern discoveries in metaphysical, moral and political philosophy, in mathematics and physics, in chemistry, and in zoology, botany and mineralogy. He would only promise to undertake the general map and the first historical sketch, if his health and other engagements permitted. For the second he recommended Playfair, for chemistry Sir Humphry Davy. He received £1,000 for the first part of his dissertation (166 pages), and £700 for the second (257 pages), the right of publication being limited to the Supplement and *Encyclopædia*. Constable next contracted with Prof. Playfair for a dissertation "to be equal in length or not to Stewart's." He at first intended to have two editors, "one for the strictly literary and the other for the scientific department." He applied to Dr. Thomas Brown, who "preferred writing trash of poetry to useful and lucrative employment." At last he fixed on Macvey Napier (born 1777), whom he had known from 1798, and who "had been a hard student, and at college laid a good foundation for his future career, though more perhaps in general information than in what would be, strictly speaking, called scholarship." Napier went to London, and obtained the co-operation of many literary men. The supplement was published in half-volume parts from Dec. 1816 to April 1824. It formed six volumes 4to, containing 4,933 pages, 125 plates, 9 maps, three dissertations and 669 articles, of which a list is given at the end. The first dissertation, on the "progress of metaphysical, ethical and political philosophy," was by Stewart, who completed his plan only in respect to metaphysics. These historical dissertations were admirable and delightful compositions, and important and interesting additions to the *Encyclopædia*; but it is difficult to see why they should form a separate department distinct from the general alphabet. Among the distinguished contributors were James Mill, Ricardo, Malthus, Arago, Biot, Hazlitt and Sir Walter Scott, who, to gratify his generous friend Constable, laid aside *Waverley*, which he was completing for publication, and in April and May 1814 wrote "Chivalry." There were about 160 biographies, chiefly of persons who had died within the preceding 30 years. Signatures, on the plan of the *Encyclopédie*, were annexed to each article, the list forming a triple alphabet, A to XXX, with the full names of the 72 contributors arranged apparently in the order of their first occurrence. At the end of vol. vi. are Addenda and Corrigenda.

The sixth edition, "revised, corrected and improved," appeared in half-volume parts, price 16s. in boards, vol. xx. part ii. completing the work in May 1823. Constable, thinking it not wise to reprint so large a book year after year without correction, in 1820 selected Charles Maclaren (1782–1866), as editor. "His attention was chiefly directed to the historical and geographical articles. He was to keep the press going, and have the whole completed in three years." A new edition in 25 vols. was contemplated, not to be announced till a certain time after the supplement was finished; but Constable's house stopped payment on Jan. 19, 1826, and his copyrights were sold by auction. Those of the *Encyclopædia* were bought by contract, on July 16, 1828, for £6,150, by Thomas Allan, proprietor of the *Caledonian Mercury*, Adam Black, Abram Thomson, bookbinder, and Alexander Wight, banker, who, with the trustee of Constable's estate, had previously begun the seventh edition. Not many years later Black purchased all the shares and became sole proprietor.

The seventh edition, 21 vols. 4to (with an index of 187 pages), containing 17,101 pages and 506 plates, edited by Macvey Napier, assisted by James Browne, LL.D., was begun in 1827, and published from March 1830 to Jan. 1842. It was reset throughout and stereotyped. Mathematical diagrams were printed in the text from woodcuts. The dissertations of Stewart and others and their index of 30 pages, filled vol. i. As they did not include Greek philosophy, "Aristotle," "Plato" and "Socrates" were supplied by Dr. Hampden, afterwards bishop of Hereford. Among the numerous contributors of eminence, mention may be made of Sir David Brewster, Thomas De Quincey, Antonio Panizzi and Robert Stephenson. Zoology was divided into 11 chief articles, "Mammalia," "Ornithology," "Reptilia," "Ichthyology," "Mollusca," "Crustacea," "Arachnides," "Entomology," "Helminthology," "Zoophytes," and "Animalcule"—all by James Wilson.

The eighth edition, 1853–60, 21 vols. (and index of 239 pages, 1861), containing 17,957 pages and 402 plates, with many woodcuts, was edited by Dr. Thomas Steward Traill, professor of medical jurisprudence in Edinburgh university. The dissertations were reprinted, with one on the "Rise, Progress and Corruptions of Christianity" by Archbishop Whately. Lord Macaulay, Charles Kingsley, Robert Chambers, Rev. Charles Merivale, Dr. Hooker, Henry Austin Layard, Baron Bunsen, Sir John Herschel, Professors Owen, William Thomson and Blackie, were some of the many eminent new contributors found among the 344 authors, of whom an alphabetical list is given, with a key to the signatures. This edition was not wholly reset like the seventh, but many long articles were retained almost or entirely intact.

The publication of the ninth edition (A. and C. Black) was commenced in Jan. 1875, under the editorship of Thomas Spencer Baynes until 1880, and subsequently of W. Robertson Smith, and

completed in 1889, 24 vols., with index. This great edition retained a certain amount of the valuable material in the eighth, but was substantially a new work; and it was universally acknowledged to stand in the forefront of the scholarship of its time. Its contributors included the most distinguished men of letters and of science. In 1898 a reprint, sold at about half the original price, and on the plan of payment by instalments, was issued by *The Times* of London; and in 1902, under the joint editorship of Sir Donald Mackenzie Wallace, President Arthur T. Hadley of Yale university, and Hugh Chisholm, 11 supplementary volumes were published, forming, with the 24 vols. of the ninth edition, a tenth edition of 35 volumes. These included a volume of maps, and an elaborate index (vol. 35) of some 600,000 entries.

In May 1903 a start was made with the preparation of the 11th edition, under the general editorship of Hugh Chisholm and a staff of editorial assistants, the whole work of organization being conducted up to Dec. 1909 from *The Times* office. Arrangements were then made by which the copyright and control of the Encyclopædia Britannica passed to Cambridge university, for the publication at the University Press in 1910–11 of the 29 volumes (one being Index) of the 11th edition, a distinctive feature of this issue being the appearance of the whole series of volumes practically at the same time, though much of the material had been prepared some time in advance. The 12th edition, which appeared in 1922, consisted of the 11th edition, with three supplementary volumes, and was published in Great Britain by Encyclopædia Britannica Company Ltd., and in the United States by the Encyclopædia Britannica, Inc. This supplement to the 11th edition was rendered necessary by the convulsion of the World War. Hugh Chisholm was again the editor, while the New York branch of the editorial staff was under Franklin H. Hooper as American editor. It was soon realized, however, that while these three supplementary volumes were of great value as showing the state of the world, politically, geographically and intellectually, in the years immediately following the war, they were written too close to that gigantic struggle and lacked the cooperation of scholars from many of the Continental countries. Not long afterwards, therefore, under the editorship of J. L. Garvin, with Franklin H. Hooper as American editor, a further three-volume supplement, making the 13th edition (1926) was prepared, which gave a new survey of the march of events, the progress of knowledge and the innumerable changes of the world's aspect, thoughts and activities, in the years from 1910 to 1926. Marshal Foch, Lord Cecil, Albert Einstein, Commissar Trotsky, Mme. Curie, Dr. Stresemann, President Masaryk, Elihu Root and Emile Vandervelde were among the contributors whose names gave an international authority to the new volumes. The present edition, the 14th (1929), is again edited by J. L. Garvin, with Franklin H. Hooper as American editor, with the co-operation of over three thousand distinguished contributors from all countries of the world, and is a fresh and full survey of human knowledge in all its departments—a complete rebuilding of the entire work. It is unique in that it was all prepared and published at one time and is therefore a true cross section of the world's knowledge of to-day.

ENCYCLOPÉDIE AND CONVERSATIONS-LEXICONS

Later History of the Encyclopédie.—A new and enlarged edition of the *Encyclopédie* arranged as a system of separate dictionaries, and entitled *Encyclopédie méthodique ou par ordre de matières*, was undertaken by Charles Joseph Panckoucke (1736–98), a publisher of Paris. His privilege was dated June 20, 1780. The articles belonging to different subjects would readily form distinct dictionaries, although, having been constructed for an alphabetical plan, they seemed unsuited for any system wholly methodical. Two copies of the book and its supplement were cut up into articles, which were sorted into subjects. The division adopted was: 1, mathematics; 2, physics; 3, medicine; 4, anatomy and physiology; 5, surgery; and so on through 26 subjects—all forming distinct dictionaries entrusted to different editors. The first object of each editor was to exclude all articles belonging to other subjects, and to take care that there should be no omissions owing to doubts as to which editor should deal with certain words. In some words (such as air, which belonged equally to chemistry, physics and medicine) the methodical arrangement has the unexpected effect of breaking up the single article into several, widely separated. Each dictionary was to have an introduction and a classified table of the principal articles. History and its minor parts, as inscriptions, fables, medals, were to be included. Theology, which was neither complete, exact nor orthodox, was to be by the abbé Bergier, confessor to Monsieur. The whole work was to be completed and connected together by a *Vocabulaire Universel*, 1 vol., with references to all the places where each word occurred, and a very exact history of the *Encyclopédie* and its editions of Panckoucke. The prospectus, issued early in 1782, proposed three editions—84 vols. 8vo, 43 vols. 4to, and 53 vols. 4to, each edition having 7 vols. 4to of 250 to 300 plates each. It was to be issued in livraisons of 2 vols. each, the first to appear in July 1782, and the whole to be finished in 1787. The number of subscribers, 4,072, was so great that the "special-terms" subscription list was closed on April 30. Twenty-five printing offices were employed, and in Nov. 1782 the 1st livraison was issued. A Spanish prospectus was sent out, and obtained 330 Spanish subscribers, with the inquisitor-general at their head. The complaints of the subscribers and his own heavy advances induced Panckoucke, in Nov. 1788, to appeal to the authors to finish the work. Those *en retard* made new contracts, giving their word of honour to put their parts to press in 1788, and to continue them without interruption, so that Panckoucke hoped to finish the whole, including the vocabulary (4 or 5 vols.), in 1792. Whole sciences, as architecture, engineering, hunting, police, games, etc., had been overlooked in the prospectus; a new division was made in 44 parts, to contain 51 dictionaries and about 124 volumes. Permission was obtained on Feb. 27, 1789, to receive subscriptions for the separate dictionaries. Two thousand subscribers were lost by the Revolution. The 50th livraison appeared on July 23, 1792, when all except seven of the dictionaries eventually published had been begun. The publication was continued by Henri Agasse, Panckoucke's son-in-law, from 1794 to 1813, and then by Mme. Agasse, his widow, to 1832, when it was completed in 102 livraisons or 337 parts, forming 166½ vols. of text, and 51 parts containing 6,439 plates. Pharmacy, minerals, education, *ponts et chaussées* had been announced but were not published. The original parts have been so often subdivided or added to that an exact account cannot be given of the work, which contains 88 alphabets, with 83 indexes, and 166 introductions, discourses, etc. The largest dictionaries are medicine, 13 vols., 10,330 pages; zoology, 7 dictionaries, 13,645 pages, 1,206 plates; botany, 12,002 pages, 1,000 plates. The whole is as unmanageable as Migne's *Encyclopédie théologique* (1844–75), 119,059 pages.

The "Conversations-Lexicon."—No work of reference has been more useful and successful, or more frequently copied, imitated and translated, than that known as the *Conversations-Lexikon* of Brockhaus. It was begun as *Conversations-Lexikon mit vorzüglicher Rücksicht auf die gegenwärtigen Zeiten*, Leipzig, 1796 to 1808, 6 vols., 2,762 pages, by Dr. Gotthelf Renatus Löbel (1767–99), who intended to supersede Hübner, and included geography, history, and some biography, besides mythology, philosophy, natural history, etc. Vols. i.–iv. (A to R) appeared 1796 to 1800, vol. v. in 1806. Friedrich Arnold Brockhaus (*q.v.*) bought the work with its copyright in 1808, for 1,800 thalers from the printer, who seems to have got it in payment of his bill. The editor, Christian Wilhelm Franke, by contract dated Nov. 16, was to finish vol. vi. by Dec. 5, and the already projected supplement, 2 vols., by Michaelmas 1809, for 8 thalers a printed sheet. No penalty was specified, but, says his grandson, Brockhaus was to learn that such contracts, whether under penalty or not, are not kept, for the supplement was finished only in 1811. Brockhaus issued a new impression as *Conversations-Lexikon oder kurzgefasstes Handwörterbuch*, etc., 1809–11, and on removing to Altenburg in 1811 began himself to edit the 2nd edition (1812–19, 10 vols.), and, when vol. iv. was published, the 3rd (1814–19). He carried on both editions together until 1817, when he removed to Leipzig, and began the 4th edition as *Allgemeine deutsche Realencyclopädie für die gebildeten Stände: Conversations-Lexikon.* This

title was, in the 14th edition, changed to that of *Brockhaus' Konversations-Lexicon*. The 5th edition was at once begun, and was finished in 18 months. Edition succeeded edition until the appearance of the 14th (1901–03) in 16 vols. with a supplementary volume in 1904. The *Konversations-Lexicon* is intended, not for scientific use, but to promote general mental improvement by giving the results of research and discovery in a simple and popular form without extended details. The articles, often too brief, are excellent and trustworthy, especially on German subjects, give references to the best books, and include biographies of living men.

One of the best German encyclopaedias is that of Meyer, *Neues Konversations-Lexicon*. The first edition, in 37 vols., was published in 1839–52. Later editions, following the arrangement of Brockhaus, are the 4th (1885–90, 17 vols.), the 5th (1894–98, 18 vols.), the 6th (1902–04), and the 7th (1924–28).

The most copious German encyclopaedia is Ersch and Gruber's *Allgemeine Enzyklopädie der Wissenschaften und Künste*, Leipzig. It was designed and begun in 1813 by Prof. Johann Samuel Ersch to satisfy the wants of Germans, only in part supplied by foreign works. It was stopped by the Napoleonic war until 1816, when Prof. Hufeland joined, but he died in 1817 while the specimen part was at press. The editors of the different sections at various times have been some of the best-known men of learning in Germany, including J. G. Gruber, M. H. E. Meier, Hermann Brockhaus, W. Müller and A. G. Hoffmann of Jena. The work is divided into three sections (1) A–G, of which 99 vols. have appeared since 1890, (2) H–N, 43 vols., (3) O–Z, 25 vols. Another valuable German work of an encyclopaedic character is *Handwörterbuch der Staatswissenschaften*, edited by J. Conrad, the last edition of which was published in 1923.

Among British encyclopaedias not previously mentioned, we may refer to Brewster's *Edinburgh Encyclopaedia* (1810–1830), and Wilks's *Encyclopaedia Londinensis* (1810–29). The *Encyclopaedia Metropolitana* (1845, 28 vols.) professed to give sciences and systematic arts entire and in their natural sequence, as shown in the introductory treatise on method by S. T. Coleridge. "The plan was the proposal of the poet Coleridge, and it had at least enough of a poetical character to be eminently unpractical." However defective the plan, the excellence of many of the treatises by Archbishop Whately, Sir John Herschel, Prof. Barlow, Peacock, de Morgan, etc., is undoubted. It is in four divisions, the last only being alphabetical:—I. *Pure Sciences*; II. *Mixed and Applied Sciences*; III. *History and Biography*; IV. *Miscellaneous*, including geography, a dictionary of English (the first form of Richardson's) and descriptive natural history. A re-issue in 38 vols. was announced in 1849.

The very excellent and useful *English Cyclopaedia* (1854–62; supplements, 1869–73), conducted by Charles Knight, based on the *Penny Cyclopaedia* (1833–46, 29 vols.), of which he had the copyright, is in four divisions, all alphabetical, and evidently very unequal as classes:—1, geography; 2, natural history; 3, biography (with 703 lives of living persons); 4, arts and sciences.

Chambers's Encyclopaedia (1860–68, 10 vols.), edited in part by the publishers, but under the charge of Dr. Andrew Findlater as "acting editor" throughout, was founded on the 10th edition of *Brockhaus*. A revised edition appeared in 1874. In the list of 126 contributors were J. H. Burton, Emmanuel Deutsch, Prof. Goldstücker, etc. The articles were generally excellent, more especially on Jewish literature, folk-lore and practical science; but, as in *Brockhaus*, the scope of the work did not allow extended treatment. A further revision took place, and in 1888–92 an entirely new edition was published, in 10 vols., still further new editions being issued in 1895, in 1901 and in 1923–27.

A brief compilation, the *Harmsworth Encyclopaedia* (1905), was published in 40 fortnightly parts (sevenpence each) in England, and as *Nelson's Encyclopaedia* (revised) in 12 vols. (1906) in America. In 1909 *Nelson's Perpetual Loose-Leaf Encyclopaedia* in 12 vols. appeared.

In the United States various encyclopaedias have been published, but without rivaling there in reputation and volume of sales the *Encyclopædia Britannica*.

The *New American Cyclopaedia* (1858–63, 16 vols.) was the work of the editors, George Ripley and Charles Anderson Dana, and 364 contributors, chiefly American. A supplementary work, the *American Annual Cyclopaedia*, a yearly vol. of about 800 pages, was started in 1861, but ceased in 1902. A new edition of the *American Cyclopaedia* (1873–76, 16 vols.) was prepared by the same editors.

Other American encyclopaedias are Alvin J. Johnson's *New Universal Cyclopaedia* (1875–77, 4 vols.), a new edition of which (excellently planned) was published in 8 vols., 1893–95, under the name of *Johnson's Universal Cyclopaedia*; the *Encyclopaedia Americana*, edited by Francis Lieber, which appeared in 1839–47 in 14 vols.; a new work under the same title, published in 1903–04 in 16 vols.; second edition (1906) in 20 vols.; third edition (1910) in 22 vols.; a new and enlarged edition (1918) in 30 vols. (revised 1923), and a later edition (1927–28) in 30 vols.; the *International Cyclopaedia*, partly based on *Chambers's Encyclopaedia* of 1868 and 1880, first appeared in 1884 (revised in 1891, 1894 and 1898). It was superseded in 1902 by the *New International Encyclopaedia* in 17 vols.; second edition (1914–16) in 24 vols.; in 1925 two supplementary vols. appeared.

In Europe a great impetus was given to the compilation of encyclopaedias by the appearance of Brockhaus' *Konversations-Lexicon* (*see* above), which, as a begetter of these works, must rank, in the 19th century, with the *Cyclopaedia* of Ephraim Chambers in the 18th. The following, although in no sense an exhaustive list, may be here mentioned. In France, *Le Grand Dictionnaire universel du XIX^e siècle*, of Pierre Larousse (15 vols., 1866–76), with supplementary volumes in 1877, 1887 and 1890; the *Nouveau Larousse illustré, dictionnaire universel encyclopédique* (7 vols., 1901–04), (this is in no way a re-issue or an abridgment of *Le Grand Dictionnaire* of Pierre Larousse); *La Grande Encyclopédie, inventaire raisonné des sciences, des lettres, et des arts*, in 31 vols. (1886–1903). In Italy we have the *Nuova Enciclopedia Italiana* (14 vols., 1841–51, and in 25 vols., 1875–88); and Senatore Giovanni Gentile has been appointed chief editor of the great post-War undertaking, the *Enciclopedia Italiana Fondazione Treccani*. In Spain, the *Diccionario enciclopedico Hispano-Americano de litteratura, ciencias y artes* was published at Barcelona (25 vols., 1877–99). The Russian encyclopaedia, *Russki Entsiklopedicheski Slovar* (41 vols., 1905, 2 supplementary vols., 1908) was begun in 1890 as a Russian version of Brockhaus' *Konversations-Lexicon*, but became a monumental encyclopaedia to which all the best Russian men of science and letters contributed. A new Russian encyclopaedia *Bolshaya Sovietskaya Entsiklopediya*, under the general editorship of O. V. Schmidt, will, when complete, fill 30 volumes. The names of the contributors occupy 60 pages. Sixty thousand copies are being printed by the publishers, the Communist Academy of the S.S.R. Elaborate encyclopaedias have also appeared in the Polish, Hungarian, Bohemian and Rumanian languages. Of Scandinavian encyclopaedias there have been re-issues of the *Nordësk Conversations-Lexicon*, first published in 1858–63, and of the *Svenskt Conversations-Lexicon*, first published in 1845–51. Among post-War additions of encyclopaedias is *The Illustrated Australian Encyclopaedia*, occupying two volumes and edited by A. W. Jose and H. J. Carter (Sydney, 1925–26).

"ENDEAVOUR," THE, the ship in which Captain Cook made his famous voyages of discovery (1769–70), for the purpose of observing the transit of Venus, and exploring the Southern Pacific. It was a small well-built craft of 370 tons carrying 22 guns, chosen and manned by Cook himself. After making certain astronomical observations on the island of Tahiti, the "Endeavour" progressed through the Pacific. On Oct. 6, 1789 the eastern coast of New Zealand was sighted, followed by the discovery of Australia at a point now identified as Cape Everard.

ENDECOTT, JOHN (*c.* 1588–1665), English colonial governor in America, was born probably at Dorchester, Dorsetshire, England, about 1588. Little is known of him before 1628, when he was one of the six "joint adventurers" who purchased from the Plymouth Company a strip of land about 60 m. wide along the Massachusetts coast and extending westward to the Pacific Ocean. By his associates Endecott was entrusted with the respon-

sibility of leading the first colonists to the region, and with some 60 persons proceeded to Naumkeag (later Salem) where Roger Conant, a seceder from the colony at Plymouth, had begun a settlement two years earlier. He was the local governor of the Massachusetts Bay colony from April 30, 1629, to June 12, 1630, when John Winthrop brought the charter to Salem and became governor of the colony. Endecott continued to take a prominent part in the affairs of the colony, commanding an expedition against the Pequots in 1636. At Salem he was a member of the congregation of Roger Williams, whom he resolutely defended in his trouble with the New England clerical hierarchy. He was deputy-governor in 1641–44, and governor in 1644–45, and served also as commander-in-chief of the militia and as one of the commissioners of the United Colonies of New England, of which in 1658 he was president. On the death of John Winthrop in 1649 he became governor, and by annual re-elections served continuously until his death, with the exception of two years (1650–51 and 1654–55), when he was deputy-governor. Under his authority the colony of Massachusetts Bay made rapid progress, and except in the matter of religious intolerance—he showed great bigotry and harshness, particularly towards the Quakers—his rule was just and praiseworthy. Of him Edward Eggleston says: "A strange mixture of rashness, pious zeal, genial manners, hot temper, and harsh bigotry, his extravagances supply the condiment of humour to a very serious history—it is perhaps the principal debt posterity owes him." He died on March 15, 1665.

See C. M. Endicott, ***Memoirs of John Endecott*** (Salem, 1847), and a "Memoir of John Endecott" in ***Antiquarian Papers*** of the American Antiquarian Society (Worcester, Mass., 1879).

A lineal descendant, WILLIAM CROWNINSHIELD ENDICOTT (1826–1900), graduated at Harvard in 1847, was a justice of the Massachusetts supreme court in 1873–82, and was secretary of War in President Cleveland's cabinet in 1885–89. His daughter, Mary Crowninshield Endicott, was married to the English statesman Joseph Chamberlain in 1888.

ENDEMIC. An adjective signifying that a given infectious disease is constantly present in a population in the sense that a few cases may always be detected on careful search. An endemic disease is liable to assume epidemic proportions (*see* EPIDEMIC) under conditions that are not fully understood. No doubt in endemic diseases, as in the occurrence of epidemics, the existence of chronic carriers of the disease amongst the population (*see* CARRIERS) is of fundamental importance, but the factors of susceptibility and immunity amongst the healthy (*see* IMMUNITY) are equally important and far more difficult to determine. (*See* EPIDEMIOLOGY.)

Subject to the general conditions mentioned above the importance of endemic disease to a community can best be illustrated by a few specific examples.

Diphtheria.—It is certain that in the throats of some apparently normal individuals bacilli are present from time to time, or constantly, which are indistinguishable (except perhaps in some cases or occasions on bacteriological examination) from B. diphtheria. That the individual does not suffer from the clinical disease known as diphtheria depends upon the fact that his active immunity is kept up by reason of his repeated re-inoculation with small doses of the bacteria in his own throat and the toxin they produce. So far the condition concerns the individual alone, but suppose he be a child attending school and that the weather be cold and wet so that the children are confined to close quarters and many of them are afflicted with slight "colds and coughs." Under these conditions the chance of some of these diphtheria bacilli exhaled or expectorated by the "carrier" finding lodgement in the throats of other children is enormously increased. Moreover it is probable under the given conditions that the resistance of these other children to infectious disease will be below normal, and that quite apart from their specific reaction towards B. diphtheria as can be determined by the Schick test. The conditions are eminently favourable for an outbreak (local epidemic) of diphtheria.

Typhoid and Paratyphoid Fevers.—In the case of these diseases the "carrier" side of the problem is similar to that obtaining in diphtheria, but in addition the cultural characteristics of the offending micro-organism play a large part. Not only are the bacteria expelled in enormously larger numbers, but also they contaminate sewage and may, by leakage, contaminate the water supply. Moreover they multiply under saprophytic conditions to a far greater degree than B. diphtheria, for example. Hence the differences between various endemic diseases, though perhaps relatively unimportant so far as concerns the individual, may be of great importance to the community.

Plague.—In this bacterial disease the endemic condition really concerns rats and the fleas they harbour. Actual cases of human plague may be wanting for a time in a community liable to outbreaks and it is only when mortality among the rats causes their parasitic fleas to leave the rodents and attack man that human cases of bubonic or pneumonic plague arise. Hence endemicity in the case of plague is not quite the same phenomenon as in the case of the other diseases we have considered.

Typhus Fever; Malaria.—*Mutatis mutandis*, endemic conditions in these diseases resemble those in bubonic plague. That is to say, the environmental conditions influencing the life-history of the body-louse and the anopheline mosquito, respectively, play dominant parts in the occurrence and dissemination of the two diseases. Nevertheless these factors could not lead to epidemics were it not for the existence of sporadic human cases in the community. And were it not for density of population, need of warmth, conditions of poverty, facility of transport in the case of typhus and for warmth and moisture favouring the multiplication of mosquitoes in the case of malaria, sporadic cases of these two diseases might occur in the community, or even the diseases might be endemic but epidemics would not arise.

Filter-passing Viruses.—In the case of some diseases believed to be due to the action of filter-passing viruses (*q.v.*), *e.g.*, varicella, dengue, distemper, foot-and-mouth disease, some varieties of herpes, there is evidence from the more or less frequent occurrence of epidemics and the outbreak of disease in new-comers into the district that on occasions the respective diseases may be endemic. The conditions underlying these outbreaks of disease are even less well understood than those described, mainly because the nature of the aetiological factor is unknown.

ENDIVE, *Cichorium Endivia*, an annual esculent plant of the family Compositae, commonly reputed to have been introduced into Europe from the East Indies, but, according to some authorities, more probably indigenous to Egypt. It has been cultivated in England for more than 300 years. There are numerous varieties of the endive, forming two groups, the curled or narrow-leaved (var. *crispa*), and the Batavian or broad-leaved (var. *latifolia*), the leaves of which are not curled. The former varieties are those most used for salads, the latter for culinary purposes. The plant requires a light, rich and dry soil, in an unshaded situation. In England sowing for the main crop should begin about the second or third week in June; but for plants required to be used young it may be as early as the latter half of April, and for winter crops up to the middle of August. Transplantation, where early crops are required, has been found inadvisable. The bleaching of endive, to prevent the development of the natural bitter taste of the leaves, is begun about three months after the sowing, and is best effected either by tying the outer leaves around the inner, or by the use of the bleaching-pot. The bleaching may be completed in about ten days in summer, but in winter it takes three or four weeks.

ENDOCRINOLOGY. This science deals with the structure and function of the organs of internal secretion (*endocrine* or *incretory organs*), in health and disease, and has been vigorously developed since 1910. Through observations upon man in private clinics and in university hospitals, and through experimentation upon animals in laboratories, many important new facts have been accumulated concerning these organs, their products (*increta*) and their functions during different periods of the life-cycle of individual organisms. Attempts are being made to co-ordinate these recent discoveries with what was known before, in order that knowledge in this domain may be better systematised and formulated and that the diagnosis and treatment of endocrine

disturbances in man may find securer foundations than the speculative suppositions, often groundless, that have been advanced in a period of expanding research to eke out a store of facts that was felt to be lamentably meagre.

Limitation of the Field.—There is, as yet, no general agreement as to the limits to be set to the field of endocrinology[1]. (The figures throughout the text refer to the bibliography at the end of the article.) Some would include all parts of the body in the category of organs of internal secretion, on the ground that all organs give off chemical substances to the blood and lymph; others would limit membership in the class to a few organs—(*a*) the ductless glands and (*b*) certain glands that, despite the possession of ducts and the production of an external secretion, yield to the blood directly (or through the lymph) materials that are of profound significance either for the growth and differentiation of distant parts or for the automatic regulation of the physiological functions of those parts. In this latter and more restricted sense, the endocrine organs include the thyroid gland, the parathyroid glands, the hypophysis cerebri (or pituitary gland), the suprarenal glands, the islands of Langerhans of the pancreas, and, perhaps, the endocrine portions of the sex glands or gonads. Organs, the products of which serve merely the nutrition of the body or are mere waste substances to be excreted from the body by other organs, would not be so included.

Even with this restriction there is doubt as to just how many organs should be classed as "incretory" and, particularly, as to whether the pineal gland, the posterior lobe of the hypophysis cerebri, the thymus, the liver and the chromaffin tissues should, or should not, be so classed. For practical reasons it would seem better to regard endocrinology, for the present at least, as limited in its field to the structure and functions of the organs of internal secretion in the narrower sense mentioned above rather than to extend its scope so as to include all the organs of the body whose products on entering the blood play any part in chemical regulation. The science which deals with the "hormones" or "chemical messengers" (*cf.* E. H. Starling) in general within the body has been called "hormonology"; endocrinology in the narrower sense would appear to represent an important part or domain of that more comprehensive subject.

Histology and Embryology of the Endocrine Organs.—The gross and microscopic appearances of the principal ductless glands are described elsewhere (*see* DUCTLESS GLANDS). Recent advances in the morphology of these glands have consisted (*a*) of intensive studies of their finer structure by means of more delicate histological technique and (*b*) of more accurate determinations of the mode of origin and the chronological development of these structures in the embryos. Systematic (and quantitative) statistical studies of the normal variations of these organs and their relations to the body as a whole have been undertaken for certain animal species (*e.g.*, the rat). An attempt is also being made to determine precisely the evolutionary processes responsible for the organogenesis and histogenesis of the structures that manufacture the internal secretions, a phase of research regarded as important by biologists and especially by embryologists[2].

Physiology of the Endocrine Organs.—The increta produced by the endocrine organs and delivered to the blood, either directly, or by way of the lymph, appear to be of great importance for the organism as a whole in all phases of the life-cycle (evolution, maturity and involution). During the ***period of evolution***, the progressive phases of the life-cycle (that is, during the development of the individual), these increta play a rôle in the processes of growth, of organ formation and of tissue differentiation[3]. The endocrine substances that participate in the building of the bodily organs and are of significance in the initiation and the continuance of the metamorphoses that occur during growth have been called "harmozones." It is believed that they react with the autochthonous chromosomal substances of the cells of different regions of the body, perhaps in an enzyme-like way, and so form a part of the stimulative and assimilative processes concerned in normal growth and differentiation.

The endocrine organs themselves undergo changes during growth and development; the several organs appear at somewhat different times in the embryo, and vary somewhat in size, in structure, and doubtless, too, in function, at different stages of an organism's unfolding. That the functions of these organs are correlatively connected is certain; and that there are individual, racial and generic variations in these correlations seems very probable. The different varieties of habitus (pyknic, asthenic, athletic) met with inside the limits of normal variation in a single human race, and the skeletal and other somatic peculiarities that characterise the different races of man (*e.g.*, Nordic, Mediterranean, negro, etc.) or of any other animal, say the dog (*e.g.*, bulldog, dachshund, greyhound), though dependent in part on regional chromosomal specificities, are believed to be also in part determined by the differing endocrine "formulae" or "constellations" of their bearers, the hypophysis being dominant, perhaps in one, the thyroid in another, the gonads in a third and so forth. The different combinations and permutations of the incretory influences that are possible are interesting and at the same time appalling to the student of human and animal constitutions[4].

Function of Hormones.—During the period of maturity the hormones from the incretory organs are believed to subserve many important functions, particularly those concerned with automatic adjustments within the organism when disturbances endanger equilibrium[5]. Thus a hormone from the thyroid gland participates in the control of the basal metabolic rate, one from the parathyroid in the control of calcium metabolism, and one from the islands of the pancreas in the control of sugar metabolism. These hormones may act, as is gradually being found out, through the utilisation of various mechanisms; sometimes they exert their influence through affecting other endocrine organs than those by which they are produced, sometimes through the vegetative nervous system and sometimes through direct attack upon the body cells in general. Ignorance here is as yet profound. Slowly, however, facts are emerging, as a result of clinical-pathological studies, of experimental removal of an endocrine organ and observing what follows, of transplantation experiments and of experiments in which substances derived from endocrine organs are fed to, or injected into, healthy or diseased organisms.

Senescence and Rejuvenation.—During the period of involution of an organism, the incretory organs change as do all the other parts of the body. In the ageing process of normal involution, there may be steady general decline through a long series of regressive phases to physiological death. But premature senescence, partial or general, may appear as a result of abnormalities of one or more endocrine organs (gonads, thyroid, etc.), for such abnormalities lead to disturbances of equilibrium of the correlating systems of the body. To a certain extent, "rejuvenescence" can be experimentally achieved by injection or transplantation of certain endocrine tissues (*see* REJUVENATION). It is possible that the appearance of certain malignant growths may come to be correlated with changes in the incretory glands, for in man, alterations in the thymus, thyroid, hypophysis and suprarenals have been found in association with neoplastic growths and, in experimental animals, definite influences of incretory conditions upon the "taking" and growth of neoplastic grafts, have been demonstrated[6]. Adenocarcinomata, for example, are transplantable to certain normal mice but not to castrates of the same species, though if a young testis be also grafted into the castrate, the neoplastic graft can then be made to grow.

Isolation of Chemical Substances.—Physiological chemists have made progress in isolating various potent chemical substances from the organs of internal secretion. Among the more important of these may be mentioned ***epinephrin*** (or *adrenalin*) from chromaffin tissues, ***thyroxin*** from the thyroid gland, *pituitrin* and *antuitrin* from the hypophysis cerebri, *lutein* from corpora lutea of the ovary and insulin (*q.v.*) from the islets of the pancreas. Recently, from the parathyroid glands has been extracted a *parathyroid hormone* that will prevent or control tetany due to parathyroid insufficiency and will regulate the level of the calcium content of the blood; from pituitrin has been isolated an active principle of great potency that will in extremely dilute solutions

cause contraction of uterine muscle; and from ovarian follicular fluid has been separated a hormone that will, on injection, induce a sexually mature condition in immature females[7].

Clinical Endocrinology.—Knowledge of clinical syndromes due to disorders of the endocrine organs has also made rapid strides since 1910, and the symptomatology of the endocrine disorders has been extended and made more precise. Thus the principal endocrine disturbances manifested as Graves' disease, myxoedema, tetany, acromegaly, adiposogenital dystrophy, eunuchism and eunuchoidism, Addison's disease, suprarenal virilism and hirsutism and diabetes mellitus are now far better understood than ever before. There has been a tendency, however, to attempt to push the clinical applications of the scientific advances in endocrinology further than is warranted, and much confusion has arisen both in the profession and among laymen because of failure to distinguish between mere speculations and well-established facts[8]. Fortunately, warnings have been sounded, and more careful workers emphasise the necessity of a more rigidly critical approach to the solution of clinical endocrine problems. This is particularly true of endocrine therapy, which has recently almost run riot. The wishful thinking of unskilled practitioners and their uncontrolled impulses therapeutically to act by administering endocrine products singly and in the form of divers "polyglandular formulae" bade fair, for a time, to become scandalous, aided and abetted as such ill-founded therapy was by ignorant or unscrupulous vendors of endocrine products. Organotherapy and hormonotherapy have scored genuine triumphs; it is unfortunate that their reputation should be sullied by uncritical extravagances[9]. The effects of thyroid extract or thyroxin in myxoedema, of iodine in the prevention of colloid goitre (*q.v.*), of surgical removal of part of the thyroid gland in exophthalmic goitre and of insulin (*q.v.*) in diabetes (*q.v.*) are brilliant examples of therapeutic successes in endocrine domains. The utilisation of certain hormones for their pharmacodynamic effects in disorders not primarily of endocrine origin is proving profitable; the control of paroxysms of bronchial asthma by injections of epinephrin and the restriction of water-excretion through the kidneys in diabetes insipidus by injections of pituitrin, and the use of pituitrin in obstetrics and surgery, of adrenalin in local anaesthesia and of lutein in ovarian dysfunction are notable examples. Organotherapy and hormonotherapy undoubtedly have an important future, but genuine success in these fields can be achieved only by thoughtful, painstaking, rigidly controlled work; progress is only too likely to be retarded and science to be discredited by the rash enthusiast and the credulous ignoramus.

In the United States the Association for the study of Internal Secretions and its journal, *Endocrinology*, are doing much to foster the development of endocrine research.

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(3) *cf.* Harms, "Das Wesen der Inkretion und ihre Bedeutung für das normale und experimentell beeinflusste Geschehen innerhalb der Lebensphasen der Tiere," *Deutsche Med. Wchnschr.*, 1925, 51, 631–633.

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(8) *cf.* H. A. Christian, "The Use and Abuse of Endocrinology," *Canada M. Assn. J.*, 1924, 14, 102–106.

(9) *cf.* H. Lisser, "Organotherapy; Present Achievements and Future Prospects," *Endocrinology*, 1925, 9, 1–20. (L. F. B.)

ENDOCRINOLOGY IN ANIMALS

Since the term "internal secretion" has been used by some authors so indefinitely as to cover the whole realm of chemical exchange in the animal body, it is necessary for the purpose of this definition to restrict it to the production of substances which are liberated into the body fluids by the specific activity of particular structures, and may thus evoke responses in more remote parts. In practically all familiar animals, visible manifestations of activity involve a receptive surface on which the stimulus operates, *e.g.*, *retina* a structure specialized for the performance of the appropriate response (*e.g.*, muscle or gland), and intervening between these two a mechanism of co-ordination. Co-ordination in animals is of two kinds. Cellular animals in general possess tissues endowed with special powers for the conduction of disturbances from the receptive surface to the seat of response. Such tissues constitute the nervous system. But in animals possessing a circulatory system, the latter also provides an avenue through which, not only the chemical equilibrium of the body, but the active responses of the organism, too, can be regulated. Thus, in addition to nervous, there is chemical or endocrine co-ordination. Knowledge of endocrine co-ordination at present is wholly confined to vertebrate species. This is partly because the study of endocrinology has centred round the attempt to define the role of certain organs of an apparently secretory structure, though lacking any connection by duct with the exterior, with the alimentary tract, or with the cavities of the reproductive and excretory organs. The chief of these so-called ductless glands is the *pituitary*, which lies attached to the floor of the brain; the *adrenals*, which lie in close propinquity to the kidneys; the *thyroid* in the ventral aspect of the pharyngeal region; and finally certain masses of cells amid the enzyme-secreting tubules of the pancreas, named *islets of Langerhans* after their discoverer. The islets of Langerhans in certain bony fishes are separate glandular structures unconnected with the pancreas.

The pituitary and adrenal glands are microscopically complex structures. The former consists of three distinct glandular portions with different histological characteristics, the anterior lobe, the *pars tuberalis*, and the *pars intermedia*—the last two, together with a mass of nervous tissue developed from the floor of the embryonic brain, constituting the posterior lobe. The adrenals of land vertebrates consist of two kinds of cells. One type, which forms the core of the gland in mammals, is distinguished by its very specific reaction to chromium compounds, hence called the *chromaphil* or *chromaffine* tissue. The chromaphil tissue of fishes is diffuse. The tissue corresponding to the cortical portion of the mammalian adrenal is an entirely separate entity (interrenal body) in the cartilaginous fishes. The thyroid in all vertebrates, including the lampreys and hagfishes, has a very definite and characteristic microscopic structure, consisting of vesicles of epithelial cells surrounding a jellyish mass (colloid).

In the closing years of the 19th century Oliver and Schafer showed that watery extracts of the adrenal (chromaphil portion) and pituitary (posterior lobe) glands have highly specific and potent effects on the circulatory system of the mammal. Murray demonstrated the efficacy of administration of sheep's thyroids in connection with clinical manifestations (*myxoedema* and *cretin-*

ism) associated with atrophy or under-development of the thyroid gland. But it was not till 1902 that the conception of chemical co-ordination became clarified through the work of Bayliss and Starling, who first clearly demonstrated the reality of internal secretion as a means of regulating active responses in the normal animal. It had been known, previous to their researches, that by the introduction of acid alone into the intestine, intermittent activity of the pancreas, which normally occurs in response to the passage of acid food into the former, could be brought into play, even after all the nervous connections of the gut had been severed. Bayliss and Starling showed that an acid concoction of the mucous membrane of the intestine will, if injected into the blood stream, evoke an immediate flow of pancreatic juice. These and other experiments showed that liberation, by the acid food, of a soluble product, whose precursor is present in the enteric mucosa, provides the signal for pancreatic secretion. Diffusing into the blood stream, this product, called by its discoverers, *secretin*, possesses the specific property of stimulating the pancreatic cells to secrete: thus the production and translocation of secretin is a mechanism by which the outpouring of one of the most important of the digestive juices is co-ordinated with the entry of food into the portion of the gut into which it is discharged. To substances of such a kind Bayliss and Starling applied the term *hormone*. Schafer has also used the word *autacoid* for specific physiologically active, *i.e.*, drug-like substances which can be extracted from different organs of the body; as there are several autacoids whose role in the intact animal has not as yet been ascertained, the distinction is a valuable one.

Properties of Autacoids.—Of the specific physiologically active constituents of extracts in the ductless glands, adrenaline claims prior attention, since it was isolated in chemically pure form as early as 1902. Adrenaline is the active constituent of the chromaphil tissues of vertebrates; it also appears to be present in certain invertebrates, such as the mollusc *Purpura* and in the nerve ganglia of leeches. It is the only autacoid known with certainty to be present in the body of animals outside the vertebrate series. Injection into the circulation in all land vertebrates produces a marked rise of blood pressure due to arterial constriction. In the pupillary muscles it produces dilation. It produces contraction of the melanophores or black pigment cells in the skin of reptiles, amphibia and fishes. It causes stoppage of movement and loss of tone in intestinal muscle, generally inhibition of the bladder, acceleration of the heart in land vertebrates, and either inhibition or excitation of uterus muscle in mammals, depending on the species. The intestinal response is especially diagnostic and sensitive, being obtainable in dilutions from 1:20,000,000 to 1:800,000,000. In general there is a noteworthy parallelism between the effect of adrenaline and of sympathetic stimulation on the same structure; drugs which block the sympathetic impulse at the nerve-muscle junction antagonize the action of adrenaline. The pharmacological properties of the extracts of the pituitary body of vertebrates are manifold. The three most specific are: (a) Pressor activity, *i.e.*, prolonged rise of blood pressure followed by tolerance to successive injections in the mammal, as described by Oliver and Schafer; (b) Oxytocic activity, *i.e.*, powerful constrictor activity on the mammalian uterus discovered by Dale; (c) Pigmentary effector activity, *i.e.*, power to evoke expansion of amphibian melanophores studied by Hogben and Winton. The first of these is common to the pituitaries of all land vertebrates and bony fishes; the last two to extracts of the posterior lobe of all vertebrates. The activity of other organ extracts may be deferred to a consideration of the role of chemical co-ordination (*vide infra*).

Chemical Constitution of Autacoids.—Adrenaline was isolated in pure form independently by Takamine and Aldrich in 1902. It has since been synthesized, and an iodine compound first isolated in pure form by Kendall (1917) and later by Harrington (1927). Highly concentrated extracts of the pituitary (posterior lobe) have been prepared by Dudley and by Abel and his colleagues. The latter has obtained a preparation which constricts the mammalian uterus in a dilution of 1:1,250,000,000. Like insulin, the active constituents of the islets of Langerhans, and like secretin they are crystalloidal substances destroyed by trypsin; they are, therefore, possibly polypeptides.

Methods of Investigation.—Suggestive indications that an organ is one of internal secretion, in the sense defined above, is provided by a study of the biological action of these drug-like substances or autacoids extracted from certain tissues. Characteristic clinical or post operative consequences of disease, atrophy and removal also suggest lines of investigation. But either of these alone is inadequate as a criterion of endocrine activity. Fresh extracts of the pituitary gland of vertebrates have the property of raising the blood pressure. This is an important fact in pharmacology, since extracts of the pituitary have been used to ameliorate the condition of surgical shock, and the existence of this property of pituitary extracts naturally prompts investigation into the possible relation of the pituitary gland to the regulation of blood pressure in the mammal; but there is no justification for assuming without further evidence that such a relation exists. It is contrary to the principles of scientific method to assume that every chemical entity found in the body must necessarily be propitious to its efficient working. Again the fact that removal of the testis in the mammal prevents the assumption of the male secondary sexual characters does not of itself justify the common references in medical literature to an internal secretion of the testis. On this evidence alone, no economy of hypothesis is effected by assuming that the testis discharges specific exciting substances into the circulation in preference to the equally plausible alternative that it removes or neutralizes something.

The question of the regulation of active responses by chemical co-ordination is more accessible to experimental study. If it is known that an organ contains a substance which evokes a specific local reaction in some organ or response (muscle, gland, pigment cell, etc.) its endocrine function is sufficiently established by applying one of two methods. In some cases it is possible to show that reactions which follow administration of the organ extract are associated in the intact animal with the appearance of some substance in the blood, having similar chemical and biological properties to the active constituent of the extract. This line was pursued with the study of the adrenals, and it was formerly thought that the dilation of the pupil, quickening of the pulse, etc., characteristic of fright in the mammal, were not wholly of nervous origin but in part reinforced by liberation of adrenaline into the circulation. This view has been quoted widely and accepted by many psychologists. It appears, however, from later more quantitative observations of Stewart and his colleagues that the evidence of previous investigators was founded on inadequate technique. Stewart's work shows that small quantities of adrenaline do make their way into the circulation more or less continuously. Whether such small quantities are really significant to the efficient neuromuscular activity of the animal, and whether special conditions exist in which a large outpouring of adrenaline into the blood stream occurs is still uncertain. The method which has been applied in the study of adrenaline secretion is essentially similar to that which has been adopted in the study of pancreatic regulation by secretin formation, as mentioned above. An alternative method of investigation consists in compensating for the effects of removal of a supposedly endocrine organ by introducing its extract into the circulation. In the case of amphibia (frogs and salamanders), the black pigment cells responsible for the colour responses can be induced to expand after the injection of exceedingly minute traces of extract of the pituitary gland. Removal of the gland (posterior lobe) on the other hand results in a state of permanent pallor due to complete contraction of the pigment cells. Here the immediate agency involved in co-ordinating the synchronous response of the pigmentary effector organs of the skin with the external conditions that evoke colour response is evidently the secretion of the pituitary gland. In frogs removal of the gland results in the dilatation of the minute vessels (*capillaries*) of the skin, and Krogh has shown that perfusion of these vessels with a fluid containing a trace of pituitary extract results in their constriction. It is possible that the rise of blood pressure following injection in the mammal arises from the same reaction, and Krogh has obtained some evidence that pituitary secretion

regulates capillary tone in mammals as well as amphibia.

With regard to the part played by internal secretions in relation to chemical equilibrium and development, the attempt to harmonize the effects of removal of organs and of injecting their autacoids into the circulation has yielded the only significant data. First and foremost comes the thyroid. In man, under-development of the gland is associated with the infantile condition known as cretinism, and in later life with the disease known as myxoedema. Both of these are characterized among other things with a lower respiratory activity of the tissues, which is remedied with the clinical manifestations by injection of thyroxine. In frogs and salamanders the *larval* or tadpole stage can be induced to develop into the adult with amazing precocity by thyroid feeding or injection, and the total elimination of iodine from the water or removal of the thyroid gland prevent the larval form from assuming the adult condition, so that it remains permanently in the aquatic form. A few larval forms in nature such as the axolotl larva of the Mexican salamander become sexually mature and never ordinarily assume the adult form if kept in aquaria. The axolotl will develop into a land salamander within ten days of thyroid feeding. Removal of the anterior lobe of the pituitary gland in frog tadpoles has also been shown by P. E. Smith and Bennet Allen to prevent metamorphosis. In this case the thyroid remains underdeveloped. Thyroid feeding causes the tadpoles to mature, as does also injection of pituitary anterior lobe extracts, which induce the thyroid to attain its normal development. Thus pituitary secretion stimulates the development of the thyroid just as thyroid secretion promotes the assumption of the adult characters, and this interrelationship makes it easier to form a picture of the way in which the orderly chronological sequence in which new systems of organs make their appearance in the course of development is brought about. In man, disorders of the anterior lobe are associated with clinical abnormalities of development (acromegaly, etc.), which at present remain obscure. In regard to sexual development the main positive results have arisen in connection with ovarian extracts prepared first by Allen and his associates. Removal of the ovaries brings about cessation of the oestrous phenomena. Injection of ovarian extracts evokes oestrous activity, and Parkes has shown that menstruation in the human subject can be induced in this way. A great deal of interest has recently centred round the internal secretion of the pancreas. It has long been known that removal of the pancreas results in diabetes. In 1922 Banting and Best showed that the fatal results of removal of the pancreas can be prevented by specially prepared extracts of the gland, the active constituent of which has the power of lowering the sugar content of blood and urine. Collip has recently claimed that the lowered calcium content of the blood associated with clinical disorders of the parathyroid glands, or operative removal of the same, can be compensated by the injection of an extract of the gland.

Practical Results.—The successful use of thyroid extracts for myxoedema and cretinism, the application of pituitary extracts to promote contraction of the womb in obstetrical practice, and to raise blood pressure in cases of surgical shock, the use of adrenaline in superficial haemorrhage, and finally the importance of insulin in relation to diabetes represent genuine positive achievements of no mean value in modern scientific medicine. The manufacture of glandular preparations, however, has been abused for commercial purposes, and a great deal of what is called glandular therapy or organotherapy is based on no proper information. So-called polyglandular preparations are sold by a number of firms, and are extensively employed by medical men who have insufficient information at their disposal to sift the wheat from the chaff. Side by side with these abuses, descriptions of clinical manifestations, uncontrolled by critical experiment, has led to a large amount of speculation about the role of the ductless glands in determining differences of temperament. Much of this is passing into psychological and sociological works. It cannot be too strongly emphasized that, while such speculation may serve a useful purpose by stimulating further enquiry, it is for the most part entirely premature and often without any valid justification.

See L. T. Hogben, *The Comparative Physiology of Internal Secretion* (1927); E. Schafer, *The Endocrine Organs* (1924–26); S. Vincent, *Internal Secretion and the Ductless Glands* (1924). (L. T. H.)

ENDOEUS, an early sculptor, who worked at Athens in the middle of the 6th century B.C. We are told that he made an image of Athena dedicated by Callias, the contemporary of Pisistratus, at Athens about 564 B.C. An inscription bearing his name has been found at Athens, written in Ionian dialect. The tradition which made him a pupil of Daedalus is apparently misleading, since Daedalus had no connection with Ionic art.

ENDOGAMY. The law of endogamy prohibits the marriage of an individual outside his or her social group. It concerns itself with marriage only, not with extra-marital relations. The most famous example is among the Hindus who do not permit men and women of different castes to marry. (*See* CASTE.) Among primitive peoples it is rare, though in many parts of Africa the smiths do seem to form an endogamous occupational unit and the Santals of India punish breaches of the law. Where society is an hierarchy the disapproval of marriages between individuals of different classes may assume the form of a definite regulation, and this is true also of the feeling against a woman marrying outside her own tribe or local group, but such unions can generally be condoned, and diplomatic marriages between different tribes do take place.

Exogamy and endogamy are by no means mutually exclusive. In any community there may be one type of social group, *e.g.*, the clan, which is exogamous, and another type, *e.g.*, the occupational class, which is endogamous. This condition is actually found in India where the endogamous castes are composed of exogamous clans. Thus, exogamy and endogamy are often found together, supplementing one another. (*See* EXOGAMY.)

BIBLIOGRAPHY.—E. A. Westermarck, *The History of Human Marriage* (1921); Sir J. G. Frazer, *Totemism and Exogamy* (4 vols. 1910); W. H. R. Rivers, *Social Organization* (1924); R. H. Lowie, *Primitive Society* (1921). (C. H. W.)

ENDOR, an ancient town of Palestine, situated in the territory of Issachar, and a place from which the Manassites could not expel the Canaanites (Josh. xvii. 11). It was the scene of the rout of Jabin and Sisera (Ps. lxxxiii. 9), but is chiefly memorable as the abode of the sorceress whom Saul consulted on the eve of the battle of Gilboa (I Sam. xxviii.). In the fourth century A.D. it is described as a large village four Roman miles south of Tabor. There is a village 'Endur (not 'Endur) in the locality indicated on the slope of Jebel Dhāhi, with burial caves, grain pits and rock-cut cisterns to attest to its ancient importance. From a cave a spring flows which waters the village gardens. (E. Ro.)

FIG. 1.—ENDOTHELIAL COVERING OF THE PERITONEAL MEMBRANE

ENDOTHELIUM. Lining the blood-vessels, the lymphatics and lymph spaces, and the pleural, pericardial, and peritoneal cavities are found flattened cells (endothelial cells) joined at their edges to form an extremely thin membrane.

An endothelial cell is very flattened and possesses a protoplasm with faint granules and an oval or round nucleus (figs. 1 and 2). The cells are irregularly polyhedral and united at the edges by cement substance which, though scanty, stains with silver nitrate when the appearance reproduced in the figure is seen. By being thus united together the cells form a continuous layer. In serous cavities this layer is pierced by small openings (stomata), which bring the cavity into communication with lymph spaces or vessels lying beneath the membrane. The stomata are surrounded by a special layer of cubical and granular cells.

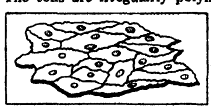


FIG. 2.—ENDOTHELIAL CELLS FROM INTERIOR OF AN ARTERY, STAINED BY NITRATE OF SILVER

By means of endothelial membranes the surfaces of the parts covered by them are rendered very smooth. Thus the abdominal organs can glide easily over one another within the peritoneal cavity; the blood or lymph experiences the least amount of fric-

tion, and friction is reduced to a minimum between a tendon and its sheath or in the joint cavities. The cells forming these membranes also possess further physiological properties. Thus it is most probable that they play an active part in the blood capillaries in transmitting substances from the blood into the tissue spaces, or conversely in preventing the passage of materials from blood to tissue space or from tissue space to blood. Hence the fluid of the blood and that of the tissue space need not be of the same chemical composition. Endothelial cells also may be phagocytic (*see* PHAGOCYTOSIS).

ENDOWMENT INSURANCE: *see* LIFE INSURANCE.

ENDYMION, in Greek mythology, son of Aëthlius and king of Elis. He was loved by Selene, goddess of the moon, by whom he had 50 daughters. Otherwise, he was a beautiful youth, a shepherd or hunter whom Selene visited every night while he lay asleep in a cave on Mount Latmus in Caria (Pausanias v., 1, 3; Ovid, *Ars am.* iii. 83). Zeus offered him anything he might desire, and he chose an everlasting sleep, in which he might remain youthful for ever (Apollodorus i. 56). According to others, Endymion's eternal sleep was a punishment inflicted by Zeus upon him because he ventured to fall in love with Hera (Schol. Theocritus iii. 49). The usual form of the legend, however, represents Endymion as having been put to sleep by Selene herself in order that she might enjoy his society undisturbed (Cicero, *Tusc. disp.* i. 92).

ENERGETICS may be defined as the science of energy. In systems whose state is changing so slowly that the reactions arising from changing motions can be neglected, whether these systems are in a stationary condition or in a state of steady motion, the energy depends upon the configuration alone, and its mathematical expression can be determined from measurement of the work required for a sufficient number of single transformations. Once it is found, all statical relations of the system are implicitly determined along with it, and results of all other transformations can be predicted. The general development of such relations are conveniently classed as a separate branch of physics under the name *Energetics* first proposed by J. M. Rankine. (*See* THERMODYNAMICS.)

ENERGICI or ENERGUMENS (Gr. "possessed by a spirit"), the name given in the early Church to those suffering from different forms of insanity, who were popularly supposed to be under the control of some indwelling spirit other than their own. Among primitive races everywhere disease is explained in this way, and its removal supposed to be effected by priestly prayers and incantations. They were sometimes called χειμαζόμενοι, as being "tossed by the waves" of uncontrollable impulse. Persons afflicted thus were forbidden to enter the church, but were daily fed and prayed for over by the exorcists, and, in case of recovery, after a fast of from 20 to 40 days, were admitted to the Eucharist, and their names and cures entered in the church records.

A note on the New Testament use of the word ἐνεργεῖν and its cognates will be found in J. A. Robinson's edition of *The Epistle to the Ephesians*, pp. 241–247; an excursus on "The Conflict with Demons" in A. Harnack, *The Expansion of Christianity*, i. 152–180. *Cf.* EXORCISM.

ENERGISM, a term introduced by F. Paulsen (*Introduction to Philosophy*, 1898) to express his conception of the moral ideal as consisting not in a condition of mere state of feeling (like happiness) but in a life devoted to a certain kind of activity or work. The term energism is also used sometimes to designate the ontological view which identifies ultimate reality, or the primal stuff or substance, with some kind of energy.

ENERGY, in physical science, a term which may be defined as accumulated mechanical work, which, however, may be only partially available for use (from the Gr. ἐνέργεια: ἐν, in ἔργον, work). A bent spring possesses energy, for it is capable of doing work in returning to its natural form; a charge of gunpowder possesses energy, for it is capable of doing work in exploding; a Leyden jar charged with electricity possesses energy, for it is capable of doing work in being discharged; a magnet is capable of attracting certain bodies (*e.g.*, iron) and doing work during their approach. The motions of bodies, or of the ultimate parts of bodies, also involve energy, for stopping them would be a source of work.

Measurement.—All kinds of energy are ultimately measured in terms of work. If we raise 1 lb. of matter through a foot we do a certain amount of work against the earth's attraction; if we raise 2 lb. through the same height we do twice this amount of work, and so on. Also, the work done in raising 1 lb. through 2 ft. will be double of that done in raising it 1 ft. Thus we recognize that the work done varies conjointly as the resistance overcome and the distance through which it is overcome.

Now, we may select any definite quantity of work we please as our unit, as, for example, the work done in lifting a pound a foot high from the sea-level in the latitude of London, which is the unit of work generally adopted by British engineers, and is called the "foot-pound." The most appropriate unit for scientific purposes is one which depends only on the fundamental units of length, mass and time, and is hence called an absolute unit. Such a unit is independent of gravity or of any other quantity which varies with the locality. Taking the centimetre, gramme and second as our fundamental units, the most convenient unit of force is that which, acting on a gramme for a second, produces in it a velocity of a centimetre per second; this is called a Dyne. The unit of work is that which is required to overcome a resistance of a dyne over a centimetre, and is called an Erg. In the latitude of Paris the dyne is equal to the weight of about $\frac{1}{981}$ of a gramme, and the erg is the amount of work required to raise $\frac{1}{981}$ of a gramme vertically through one centimetre.

Energy is commonly defined as the capacity for doing work. Since, however, we cannot always bring about the change the term capacity is somewhat misleading; it is better to define energy as that which diminishes when work is done by an amount equal to the work so done. The unit of energy should therefore be the same as that of work, and the centimetre-gramme-second (C.G.S.) unit of energy is the erg.

It will be seen from that which has been stated that energy may become manifest in many ways; or, in other words there are many forms of energy.

Forms.—The forms of energy which are most readily recognized are of course those in which the energy can be most directly employed in doing mechanical work; and it is manifest that masses of matter which are large enough to be seen and handled are more readily dealt with mechanically than are smaller masses. Hence when useful work can be obtained from a system by simply connecting visible portions of it by a train of mechanism, such energy is more readily recognized than is that which would compel us to control the behaviour of molecules before we could transform it into useful work. This leads up to the fundamental distinction, introduced by Lord Kelvin, between "available energy," which we can turn to mechanical effect, and "diffuse energy," which is useless for that purpose.

Potential Energy.—If a pound weight be suspended by a string passing over a pulley, in descending through 10 ft. it is capable of raising nearly a pound weight attached to the other end of the string, through the same height, and thus can do nearly 10 foot-pounds of work. The smoother we make the pulley the more nearly does the amount of useful work which the weight is capable of doing approach 10 foot-pounds, and if we take into account the work done against the friction of the pulley, we may say that the work done by the descending weight is 10 foot-pounds, and hence when the weight is in its elevated position we have at disposal 10 foot-pounds more energy than when it is in the lower position. It should be noticed, however, that this energy is possessed by the system consisting of the earth and pound together, in virtue of their separation, and that neither could do work without the other to attract it. The system consisting of the earth and the pound therefore possesses an amount of energy which depends on the relative positions of its two parts, on account of the latent physical connection existing between them. In most mechanical systems the working stresses acting between the parts can be determined when the relative positions of all the parts are known; and the energy which a system possesses in virtue of the relative positions of its parts, or its *configuration*, is classified as "potential energy," to distinguish it from energy of motion which

we shall presently consider. The word potential does not imply that this energy is not real; it exists in potentiality only in the sense that it is stored away in some latent manner; but it can be drawn upon without limit for mechanical work.

Kinetic Energy.—It is a fundamental result in dynamics that, if a body be projected vertically upwards *in vacuo*, with a velocity of v centimetres per second, it will rise to a height of $v^2/2g$ centimetres, where g represents the numerical value of the acceleration produced by gravity in centimetre-second units. Now, if m represent the mass of the body in grammes its weight will be mg dynes, for it will require a force of mg dynes to produce in it the acceleration denoted by g. Hence the work done in raising the mass will be represented by $mg{\cdot}v^2/2g$, that is, $\frac{1}{2}mv^2$ *ergs*. Now, whatever be the direction in which a body is moving, a frictionless constraint, like a string attached to the body, can cause its velocity to be changed into the vertical direction without any change taking place in the magnitude of the velocity. Thus it is merely in virtue of the velocity that the mass is capable of rising against the resistance of gravity, and hence we recognize that on account of its motion the body possessed $\frac{1}{2}mv^2$ units of energy. Energy of motion is usually called "kinetic energy."

A simple example of the transformation of kinetic energy into potential energy, and vice versa, is afforded by the pendulum. When at the limits of its swing, the pendulum is for an instant at rest, and all the energy of the oscillation is static or potential. When passing through its position of equilibrium, since gravity can do no more work upon it without changing its fixed point of support, all the energy of oscillation is kinetic. At intermediate positions the energy is partly kinetic and partly potential.

Available kinetic energy is possessed by a system of two or more bodies in virtue of the relative motion of its parts. Since our conception of velocity is essentially relative, it is plain that any property possessed by a body in virtue of its motion can be effectively possessed by it only in relation to those bodies with respect to which it is moving. If a body whose mass is m grammes be moving with a velocity of v centimetres per second relative to the earth, the available kinetic energy possessed by the system is $\frac{1}{2}mv^2$ ergs if m be small relative to the earth. But if we consider two bodies each of mass m and one of them moving with velocity v relative to the other, only $\frac{1}{4}mv^2$ units of work is available from this system alone. Thus the estimation of kinetic energy is intimately affected by the choice of our base of measurement.

Conservation of Energy.—When the stresses acting between the parts of a system depend *only* on the relative positions of those parts, the sum of the kinetic energy and potential energy of the system is always the same, provided the system be not acted upon by anything outside it. Such a system is called "conservative," and is well illustrated by the swinging pendulum above referred to. But there are stresses which depend on the relative *motion* of the visible bodies between which they appear to act. When work is done against these forces no full equivalent of potential energy may be produced; this applies especially to frictional forces, for if the motion of the system be reversed the forces will be also reversed and will still oppose the motion. It was long believed that work done against such forces was lost, and it was not till the 19th century that the energy thus transformed was traced; the conservation of energy has become the master-key to unlock the connections in inanimate nature.

The conception of work and of energy was originally derived from observation of purely mechanical phenomena, that is to say, phenomena in which the relative positions and motions of visible portions of matter were all that were taken into consideration. Hence it is not surprising that, in those more subtle forms in which energy cannot be readily or completely converted into work, the universality of the principle of energy, its conservation, as regards amount, should for a long while have escaped recognition after it had become familiar in pure dynamics.

It was pointed out by Thomson (Lord Kelvin) and P. G. Tait that Newton had divined the principle of the conservation of energy, so far as it belongs purely to mechanics. But what became of the work done against friction and such non-conservative forces remained obscure, while the chemical doctrine that heat was an indestructible substance afterwards led to the idea that it was lost. There was, however, even before Newton's time, more than a suspicion that heat was due to the motions of the ultimate parts of which bodies are built up. Francis Bacon expressed his conviction that heat consists of a kind of motion or "brisk agitation" of the particles of matter. In the *Novum Organum*, after giving a long list of the sources of heat, he says: "From these examples, taken collectively as well as singly, the nature whose limit is heat appears to be motion. . . . It must not be thought that heat generates motion or motion heat (though in some respects this is true), but the very essence of heat, or the substantial self of heat, is motion, and nothing else." It must not be forgotten, however, that early writers make no distinction between heat and temperature. No definiteness therefore can be attributed to such anticipations as this. It was only when Joseph Black showed that heat was something (distinct from temperature) which could be measured that the ground was cleared for bringing it into the mechanical scheme.

Rumford's Investigations.—The first vigorous effort to restore the universality of the doctrine of energy was made by Benjamin Thompson, Count Rumford, and was published in the *Phil. Trans.* for 1798. Rumford was engaged in superintending the boring of cannon in the military arsenal at Munich, and was struck by the amount of heat produced by the action of the boring bar upon the brass castings. In order to see whether the heat came out of the chips he compared the capacity for heat of the chips abraded by the boring bar with that of an equal quantity of the metal cut from the block by a fine saw, and obtained the same result in the two cases, from which he concluded that "the heat produced could not possibly have been furnished at the expense of the latent heat of the metallic chips."

Rumford then turned up a hollow cylinder which was cast in one piece with a brass six-pounder, and having reduced the connection between the cylinder and cannon to a narrow neck of metal, he caused a blunt borer to press against the hollow of the cylinder with a force equal to the weight of about 10,000 lb., while the casting was made to rotate in a lathe. By this means the mean temperature of the brass was raised through about 70° Fahr., while the amount of metal abraded was only 837 grains.

In order to be sure that the heat was not due to the action of the air upon the newly exposed metallic surface, the cylinder and the end of the boring bar were immersed in 18·77 lb. of water contained in an oak box. The temperature of the water at the commencement of the experiment was 60° F and after two horses had turned the lathe for 2½ hours the water boiled. Taking into account the heat absorbed by the box and the metal, Rumford calculated that the heat developed was sufficient to raise 26·58 lb. of water from the freezing to the boiling point, and in this calculation the heat lost by radiation and conduction was neglected. Since one horse was capable of doing the work required, Rumford remarked that one horse can generate heat as rapidly as nine wax candles burning in the ordinary manner.

Finally, Rumford reviewed all the sources from which the heat might have been supposed to be derived, and concluded that it was simply produced by the friction, and that the supply was inexhaustible. "It is hardly necessary to add," he remarks, "that anything which any insulated body or system of bodies can continue to furnish *without limitation* cannot possibly be *a material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner that heat was excited and communicated in these experiments, except it be *motion*."

Transformation of Energy.—About the same time Davy showed that two pieces of ice could be melted by rubbing them together in a vacuum, although everything surrounding them was at a temperature below the freezing point. He did not, however, infer that since the heat could not have been supplied by the ice, for ice absorbs heat in melting, this experiment afforded conclusive proof against the substantial nature of heat.

Though we may allow that the results obtained by Rumford and Davy demonstrate satisfactorily that heat is in some way due to

motion, yet they do not tell us to what particular dynamical quantity heat corresponds. For example, does the heat generated by friction vary as the friction and the time during which it acts, or is it proportional to the friction and the distance through which the rubbing bodies are displaced—that is, to the work done against friction—or does it involve any other conditions? If it can be shown that, however the duration and all other conditions of the experiment may be varied, the same amount of heat can in the end be always produced when the same amount of *energy* is expended, then, and only then, can we infer that heat is a form of energy, and that the energy consumed has been really transformed into heat. This was left for J. P. Joule to achieve; his experiments conclusively prove that heat and energy are of the same nature, and that all other forms of energy can be transformed into an equivalent amount of heat.

Mechanical Equivalent of Heat.—The quantity of energy which, if entirely converted into heat, is capable of raising the temperature of the unit mass of water from 0° C to 1° C is called the mechanical equivalent of heat.

In 1842 R. Mayer, a physician at Heilbronn, published an attempt to determine the mechanical equivalent of heat from the heat produced when air is compressed. Mayer made an assumption that the whole of the work done in compressing the air was converted into heat, and neglecting the possibility of heat being consumed in doing work within the air itself or being produced by the transformation of internal potential energy. Joule afterwards proved (*see* below) that Mayer's assumption was nearly in accordance with fact, so that his method was a sound one as far as experiment was concerned; and it was only on account of the values of the specific heats of air at constant pressure and at constant volume employed by him being very inexact that the value of the mechanical equivalent of heat obtained by Mayer was very far from the truth.

Joule's Researches.—Passing over L. A. Colding, who in 1843 presented to the Royal Society of Copenhagen a paper entitled *Theses concerning Force*, we come to Dr. James Prescott Joule of Manchester, to whom we are indebted more than to any other for the establishment of the principle of the conservation of energy on the broad basis on which it has since stood. The best-known of Joule's experiments was that in which a brass paddle consisting of eight arms rotated in a cylindrical vessel of water containing four fixed vanes, which allowed the passage of the arms of the paddle but prevented the water from rotating as a whole. The paddle was driven by weights, and the temperature of the water was observed by thermometers which could indicate $\frac{1}{200}$ of a degree Fahrenheit. Special experiments were made to determine the work done against resistances outside the vessel of water, which amounted to about ·006 of the whole, and corrections were made for the loss of heat by radiation, the buoyancy of the air affecting the descending weights, and the energy dissipated, *i.e.*, converted into heat, when the weights struck the floor with a finite velocity. From these experiments Joule obtained 72·692 foot-pounds in the latitude of Manchester as equivalent to the amount of heat required to raise 1 lb. of water through 1° Fahr., from the freezing point. Adopting the centigrade scale, this gives 1,390.846 foot-pounds.

With an apparatus similar to the above, but smaller, made of iron and filled with mercury, Joule obtained results varying from 772·814 foot-pounds when driving weights of about 58 lb. were employed to 775·352 foot-pounds when the driving weights were only about 19½ lb. By causing two conical surfaces of cast-iron immersed in mercury and contained in an iron vessel to rub against one another when pressed together by a lever, Joule obtained 776·045 foot-pounds for the mechanical equivalent of heat when the heavy weights were used, and 774·93 foot-pounds with the small driving weights. In this experiment a great noise was produced, corresponding to a loss of energy, and Joule endeavoured to determine the amount of energy necessary to produce an equal amount of sound from the string of a violoncello and to apply a corresponding correction.

The close agreement between the results at least indicated that "the amount of heat produced by friction is proportional to the work done and independent of the nature of the rubbing surfaces." Joule inferred from them that the mechanical equivalent of heat is probably about 772 foot-pounds, or, employing the centigrade scale, about 1,390 foot-pounds.

In 1840 he further showed that when an electric current was produced by means of a dynamo-magneto-electric machine the heat generated in the conductor, when no external work was done by the current, was the same as if the energy employed in producing the current had been converted into heat by friction, thus showing that electric currents conform to the principle of the conservation of energy, since energy can neither be created nor destroyed by them. He also determined a roughly approximate value for the mechanical equivalent of heat from the results of these experiments. He also extended his investigations to the currents produced by batteries.

In 1844 and 1845 Joule published a series of researches on the compression and expansion of air. A metal vessel was placed in a calorimeter and air forced into it, the amount of energy expended in compressing the air being measured. Assuming that the whole of the energy was converted into heat, when the air was subjected to a pressure of 21·5 atmospheres Joule obtained for the mechanical equivalent of heat about 824·8 foot-pounds, and when a pressure of only 10·5 atmospheres was employed the result was 796·9 foot-pounds.

In the next experiment the air was compressed as before, and then allowed to escape through a long lead tube immersed in the water of a calorimeter, and finally collected in a bell jar. The amount of heat absorbed by the air could thus be measured, while the work done by it in expanding could be readily calculated. In allowing the air to expand from a pressure of 21 atmospheres to that of 1 atmosphere the value of the mechanical equivalent of heat obtained was 821·89 foot-pounds. Between 10 atmospheres and 1 it was 815·875 foot-pounds, and between 23 and 14 atmospheres 761·74 foot-pounds.

But, unlike Mayer, Joule was not content with assuming that when air is compressed or allowed to expand the heat generated or absorbed is the equivalent of the work done and of that only, no change being made in the internal energy of the air itself when the temperature is kept constant. To test this two vessels similar to that used in the last experiment were placed in the same calorimeter and connected by a tube with a stop-cock. One contained air at a pressure of 22 atmospheres, while the other was exhausted. On opening the stop-cock no work was done by the expanding air against external forces, since it expanded into a vacuum, and it was found that no heat was generated or absorbed. This showed that Mayer's assumption was practically true. The subsequent researches of Dr. Joule and Lord Kelvin (*Phil. Trans.*, 1853, p. 357, 1854, p. 321, and 1862, p. 579) showed that the statement that no *internal work* is done when a gas expands or contracts is not quite true, but the amount is very small in the cases of those gases which, like oxygen, hydrogen and nitrogen, can only be liquefied by intense cold and pressure. (*See* LIQUEFACTION OF GASES.)

Subsequent Determinations.—For a long time the final result deduced by Joule by these varied and careful investigations was accepted as the standard value of the mechanical equivalent of heat. Recent determinations by H. A. Rowland and others, necessitated by modern requirements, have shown that it is in error, but by less than 1%. The writings of Joule, which thus occupy the place of honour in the practical establishment of the conservation of energy, have been collected into two volumes published by the Physical Society of London. On the theoretical side the greatest stimulus came from the publication in 1847, without knowledge of Mayer or Joule, of Helmholtz's great memoir, *Über die Erhaltung der Kraft*, followed immediately (1848–1852) by the establishment of the science of thermodynamics (*q.v.*), mainly by R. Clausius and Lord Kelvin on the basis of "Carnot's principle" (1824), modified in expression so as to be consistent with the conservation of energy.

The general equation of thermodynamics consistent with the above investigations may be written: Heat entering a system = Increase of energy of the system plus the external work done by

the system during the entry. It is clear from this that it is erroneous to speak of the heat *in* a body. Heat can pass inwards or outwards but the amount so passing is not a measure of the change of energy of the body for some of it passes out simultaneously as external work. The language in common use is an inheritance from the old caloric theory according to which heat was regarded as a substance. When heat passes into a solid or liquid very little external work is done and the usual nomenclature is fairly satisfactory. But it is essential to an understanding of thermodynamics to realize that it is not satisfactory in general. This subject is further considered in THERMODYNAMICS (*q.v.*).

Tendency of Transformations.—It may, however, be added here that in all cases there is a general tendency for other forms of energy to be transformed into heat on account of the friction of rough surfaces, the resistance of conductors, or similar causes, and thus to lose availability. In some cases, as when heat is converted into the kinetic energy of moving machinery or the potential energy of raised weights, there is an ascent of energy from the less available form of heat to the more available form of mechanical energy, but in all cases this is accompanied by the transfer of other heat from a body at a high temperature to one at a lower temperature, thus losing availability to an extent that more than compensates for the rise.

Recent theoretical developments in physics have given rise to the presumption that the law of conservation of energy as usually understood is valid only for small motions such as are met with in engineering problems. For the modifications necessary to obtain a general theory applicable to all cases reference must be made to the article on RELATIVITY (*q.v.*). (W. GAR.; J. LA.)

ENFANTIN, BARTHÉLEMY PROSPER (1796–1864), French social reformer, one of the founders of the Saint-Simonian School, was born at Paris on Feb. 8, 1796. He was the son of a banker of Dauphiny, and after receiving his early education at a lyceum, was sent in 1813 to the École Polytechnique. In 1821 he entered a banking-house newly established at St. Petersburg, but returned two years later to Paris, where he was appointed cashier to the Caisse Hypothécaire. At the same time he became a member of the secret society of the Carbonari. In 1825 a new turn was given to his thoughts and his life by the friendship which he formed with Olinde Rodriguez, who introduced him to Saint-Simon. He embraced the new doctrines with ardour, and by 1829 had become one of the acknowledged heads of the sect (*see* SAINT-SIMON).

After the revolution of 1830 Enfantin devoted himself wholly to his cause. Besides contributing to the *Globe* newspaper, he made appeals to the people by systematic preaching, and organized centres of action in some of the principal cities of France. The headquarters in Paris were removed from the modest rooms in the rue Taranne, and established in large halls near the boulevard Italien. Enfantin and Bazard (*q.v.*) were proclaimed "Pères Suprêmes." A hopeless antagonism arose between them, which was widened by Enfantin's announcement of his theory of the relation of man and woman, which would substitute for the "tyranny of marriage" a system of "free love." Bazard now separated from his colleague, and in his withdrawal was followed by all those whose chief aim was philosophical and political. Enfantin thus became sole "father," and the few who were chiefly attracted by his religious pretensions and aims still adhered to him. New converts joined them, and Enfantin declared that his followers in France numbered 40,000. In May 1832 the halls of the new sect were closed by the government, and the "father," with some of his followers, appeared before the tribunals. He now retired to his estate at Menilmontant, near Paris, where with 40 disciples, all of them men, he continued to carry out his socialistic views. In August of the same year he was again arrested, and sentenced to a year's imprisonment with a small fine.

Enfantin was released in a few months, and then, accompanied by some of his followers, he went to Egypt where he spent two years. On his return to France he became first a postmaster near Lyons, and in 1841 was appointed member of a scientific commission on Algeria. In 1845 he was appointed a director of the Paris and Lyons railway. Three years later he established, in conjunction with Duveyrier, a daily journal, entitled *Le Crédit*, which was discontinued in 1850. He died suddenly at Paris on Sept. 1, 1864.

Amongst his works are: *Doctrine de Saint-Simon* (written in conjunction with several of his followers), published in 1830, and several times republished; *Économie politique et politique Saint-Simonienne* (1831); *Correspondance politique* (1835–1840); *Corresp. philos. et religieuse* (1843–1845); *Colonisation de l'Algérie* (1843), a learned and original work; and *La Vie éternelle passée, présente, future* (1861). *See* G. Weill, *L'École Saint-Simonienne, son histoire, son influence, jusqu' à nos jours* (Paris, 1896).

ENFIDAVILLE [*Dar-el-Bey*], a town of Tunisia, on the railway between Tunis and Susa, 30 m. N.E. of the last-named place and 5 m. inland from the Gulf of Hammamet. Enfidaville is the chief settlement on the Enfida estate, a property of over 300,000 acres in the Sahel district of Tunisia, forming a rectangle between the towns of Hammamet, Susa, Kairawan and Zaghwan. On this estate, devoted to the cultivation of cereals, olives, vines and to pasturage, are colonies of Europeans and natives.

The Enfida estate was granted by the bey Mohammed-es-Sadok to his chief minister Khaireddin Pasha (*q.v.*) in return for the confirmation by the sultan of Turkey in 1871, through the instrumentality of the pasha, of the right of succession to the beylik of members of Es-Sadok's family. When, some years later, Khaireddin left Tunisia he sold the estate to a Marseilles company, which resold it to the Société Franco-africaine.

ENFIELD, a market town and urban district in the Enfield parliamentary division of Middlesex, England, 11 m. N. of London Bridge, with stations on the Great Northern and Great Eastern sections of the L.N.E. railway. Pop. of urban district (1921) 60,738. Enfield lies at the northern extremity of the county, extending westward from the Lea and Stort Navigation, and comprises the four local divisions known as the Town, in the centre, with the Chase on the west, and Green Street and Bull's Cross (with Ponders End, Enfield Highway and Enfield Lock) along the Old North Road on the east. It has grown rapidly as a residential and industrial area; many of the inhabitants are employed in the Royal Small Arms factory at Enfield Lock. The church of St. Andrew, mainly Perpendicular, with Early English portions, contains several ancient monuments and brasses. Enfield Palace, fronting the High Street, retains portions of the building of Edward VI. The grammar school for boys, founded in 1557, is now enlarged and modernized, with the county school for girls, under the joint control of the county and district councils. The New River flows through the parish, and Sir Hugh Myddleton, its projector, was for some time resident here. Enfield Chase, once a royal preserve, was disafforested in 1777, and largely enclosed thereafter. Several fine mansions in splendidly timbered parks remain, as Trent Park, Forty Hall and White Webbs. Forty Hall is from the designs of Inigo Jones; White Webbs was suspected as the scene of the hatching of the Gunpowder Plot. The urban council has control of over 200 ac. of parks and open spaces, including Hilly-fields (65 ac.), Bush Hill (27 ac.) and Enfield Town (23 ac.) parks.

An Anglo-Saxon derivation, signifying "forest clearing," is indicated for the name. The principal manor of Enfield, which was held by Asgar, Edward the Confessor's master of horse, was in the hands of Geoffrey de Mandeville at the time of Domesday, and belonged to the Bohun family in the 12th and 13th centuries. It came, by succession and marriage, into the possession of the crown under Henry IV., and was included in the duchy of Lancaster. Of the other manors, Worcesters came to the crown in the time of Henry VIII., whose children resided at the manor-house, Elsynge Hall. Edward VI., settling both manors upon the princess Elizabeth, rebuilt Enfield Palace for her. She was a frequent resident here before and after her accession to the throne. About 1664 the palace was occupied as a school by Robert Uvedale (1642–1722), who was also an eminent horticulturist. The town received grants of markets from Edward I. and James I.

ENFIELD, a town of Hartford county, Connecticut, U.S.A., on the east bank of the Connecticut river, 20m. N. of Hartford; served by the New York, New Haven and Hartford railroad. The population in 1920 was 11,719. The town has an area of

35 sq.m. and embraces several villages, of which Thompsonville is the largest and most important. Tobacco is grown, and there are various manufactures, notably carpets (the largest plants in the country) and casket hardware. Enfield was settled in 1679, and was included in the town of Springfield until 1683. In 1749 it became part of Connecticut. At a town meeting on July 11, 1774, a resolution was adopted in favour of breaking off "all commercial intercourse with Great Britain and the West Indies until these oppressive acts for raising a revenue in America are repealed." A Shaker community was established in 1781 at what is now Shaker Station.

ENFILADE, a military term used to express the direction of fire along an enemy's line from its flank. (A French word, from *enfiler*, to thread, and so to pass through from end to end.) This species of fire is most demoralizing and destructive as it rakes the greatest length of a position or body of troops, while only a fraction of the latter can reply to it. If any considerable body of men changes front, it immediately lays itself open to enfilade from the enemy whom it originally faced. Against entrenchments, or the parapets of fortifications, enfilade is still more effective, as the enemy is deprived of the protection given by his works and is no better covered than if he were in the open. Banks of earth (called *traverses*), built at right angles to the line of defence, are usually employed to protect parapets or trenches against enfilade.

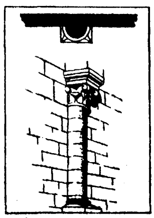
ENGADINE (Ger. *Engadin;* Ital. *Engadina;* Latin, *Engiadina*), the name of the upper or Swiss portion of the valley of the Inn, which forms part of the Swiss canton of the Grisons. Its length from the Maloja plateau (5,935 ft.) at its south-western end to Martinsbruck (3,406 ft.) at its north-eastern extremity is about 60 m. Up to and including St. Moritz (6,037 ft., the highest) all the villages (save Sils-Baseglia) at its south-western end are higher than the Maloja plateau itself. The uppermost portion of the valley contains several lakes, such as those of Sils, Silvaplana and St. Moritz. But both the Maloja plateau and the south-western half of the lake of Sils belong to the commune of Stampa in the Val Bregaglia, and are included in the Bregaglia administrative district, so that Sils is the first village included in the Engadine. The rest of the Engadine forms the districts of the Upper Engadine with 11 communes, and of the Inn (*i.e.*, the Lower Engadine), subdivided into the Ob Tasna, Remüs, and Unter Tasna circles, and containing 12 communes. The population (1920) was about 12,000, most of whom are Protestants. The capital of the Upper Engadine is Samaden, and that of the Lower Engadine, Schuls. The valley is reached by many passes. The Maloja (5,935 ft.) is the route from Chiavenna and the Lake of Como to the Upper Engadine, which is also reached from Coire by the Julier (7,504 ft.) and the Albula passes (7,595 ft.) as well as from Tirano in the Valtellina by the Bernina pass (7,645 ft.). On the other hand, the Lower Engadine is accessible from Davos over the Flüela pass (7,838 ft.) and from Mals at the head of the Adige valley (or the Vintschgau) by the Ofen pass (7,071 ft.), while from Martinsbruck, the last Swiss village, a road leads up to Nauders (5 m.), whence it is 27 m. by road down the Inn valley to Landeck, or 17½ m. over the Reschen Scheideck pass (4,902 ft.) to Mals in the Vintschgau.

The Upper Engadine, is not mentioned until 1139, when the bishop of Coire was the great lord, with the Planta family at Zuz as his bailiffs. The valley obtained its freedom from both in 1486 (Planta) and in 1526, when the temporal powers of the bishop were abolished. In 1367 it joined the newly founded League of God's House or *Gotteshausbund* (*see* GRISONS), one of the three Raetian Leagues, which lasted till 1799–1801, when the whole Engadine became part of Canton Raetia of the Helvetic Republic, which, in 1803, altered its name to that of Grisons or Graubünden, and then first entered the Swiss Confederation. In the Upper Engadine the "Referendum" existed as between the different villages composing a bailiwick (*Hochgericht*). The Lower Engadine formed from the 9th century onwards (with the Vintschgau) a separate county, which was gradually absorbed in that which became the county of Tirol. The limit between the Upper Engadine and the Tirolese Lower Engadine was definitively fixed in 1282 at the Punt' Ota just above Brail. In 1363 Tirol came into the possession of the Habsburgers, whose power was stemmed in 1499 at the battle of the Calven gorge (above Mals), though it was only in 1652 that the Lower Engadine bought up the remaining rights of the Habsburgers. But the castle of Tarasp (acquired by them in 1464) was excepted: the lordship was given by them in 1687 to the Dietrichstein family, who held it till 1801, when Austria ceded it to France, which, in 1803, handed it over to the Swiss Confederation; it was incorporated in 1809 with the Canton of the Grisons. This long connection with Tirol accounts for the fact that Tarasp is still mainly Roman Catholic, while the lonely Swiss valley of Samnaun (above Martinsbruck) has given up its Protestantism and its Ladin speech owing to communications with Tirol being easier than with Switzerland. The upper Spöl valley (Livigno) is Italian (*see* VALTELLINA).

The Upper Engadine consists of a long, straight, nearly level trough of 26 m., varying from a mile to half a mile in breadth, through which flows the Inn. On the south-east this trough is limited by the glacier-clad Bernina group (culminating in the Piz Bernina, 13,304 ft.) and the range rising between the Inn valley and that of Livigno to the south-east, while on the north-west the boundary is the extensive Albula group (culminating in Piz Kesch, 11,228 ft.). On its north-west rises the last bit of the Albula group (culminating in Piz Vadret, 10,584 ft.); and on the north the Silvretta group (culminating in Piz Linard, 11,201 ft.), while to the east and south are the ranges on either side of the Ofen pass (culminating in Piz Sesvenna, 10,568 ft.). In the Upper Engadine the villages are on the floor of the valley, but in the Lower Engadine many are perched high above the bed of the river on terraces, and are cut off from each other by deep valleys.

The mineral waters of St. Moritz (*q.v.*) were known in the 16th century, and long formed the great attraction of the region. In the 19th century the Upper Engadine came into fashion as a great "air-cure," and now Maloja, Sils, Silvaplana, Campfer and St. Moritz are all well known. Owing to its great elevation, the scenery of the Upper Engadine has a bleak, northern aspect. Pines and larches alone flourish, garden vegetables are grown only in sunny spots, and there is no tillage. The Alpine flora is very rich and varied. But snow falls even in August. The villages are built entirely of stone (as also in the Lower Engadine), chiefly to guard against destructive fires that were formerly frequent in this narrow, wind-swept valley. The wealth of the inhabitants consists in their hay meadows and pastures. The lower pastures support large herds of cows, while the higher are let out (in both parts of the valley) to Bergamasque shepherds, who come thither every summer with their flocks. In the Lower Engadine the chief attraction is formed by the mineral springs at Schuls below Tarasp, which are much frequented during the summer. The wild gorge of Finstermünz separates the last Swiss village, Martinsbruck, from the first Tirolese village, Pfunds, the gorge being passable only on foot.

The Swiss National park, an area of 54 sq.m., is in the Lower Engadine.



ENGAGED COLUMN

ENGAGED COLUMN, in architecture, a structure taking the form of a column partly embedded in a pier or wall, a half or three-quarter column attached to a pier or wall face. Engaged columns are usually built integrally with the wall of the building of which they form a part, but occasionally, due to the use of the lathe, they are made of separate stones, and in woodwork are almost always separate pieces glued or nailed in place. Engaged columns occur rarely in Greek work, as in the temple of Zeus at Agrigentum (*c.* 500 B.C.); they are, however, common in Roman buildings. As a wall decoration they are occasionally used in temple walls where colonnades are only at the front, as in the temple of Fortuna Virilis, in Rome (*c.* 150 B.C.), and the Maison Carré at Nimes (time of Tiberius). Their most common use is to decorate the piers of arcades, as in the Colosseum at Rome (A.D. 80), and this combination of arch and engaged column is

sometimes termed the Roman order. In mediaeval architecture, engaged columns frequently form the component parts of clustered piers. They are common in all Renaissance styles.

ENGEL, ERNST (1821–1896), German economist and statistician, was born in Dresden on March 16, 1821. After the revolution of 1848 he was attached to the royal commission in Saxony appointed to determine the relations between trade and labour. He was one of the organizers (1850) of the German Industrial Exhibition of Leipzig (the first of its kind). From 1854 to 1858 he was head of the statistical department of Saxony, and from 1860 to 1882 of the Prussian statistical department in Berlin. He died at Radebeul near Dresden on Dec. 8, 1896. Engel's statistical papers are mostly published in the periodicals which he himself established, viz. *Preuss. Statistik* (in 1861); *Zeitschrift des Statistischen Bureaus*, and *Zeitschrift des Statistichen Bureaus des Königreichs Sachsen*. Among his separately published works are some important studies on wages and the cost of living.

ENGEL, JOHANN JAKOB (1741–1802), German author, was born at Parchim, Mecklenburg, on Sept. 11, 1741. He was tutor (1786–94) to the crown prince of Prussia, afterwards Frederick William III., and (1787–94) director of the royal theatre. He died on June 28, 1802.

Engel's most popular work was *Der Philosoph für die Welt* (1775), dialogues on men and morals, written from the utilitarian standpoint. His last work, a romance entitled *Herr Lorenz Stark* (1795), achieved a great success.

His collected works were published in 12 volumes (1801–06); a new edition appeared at Frankfort in 1851. *See* K. Schröder, *Johann Jakob Engel* (1897).

ENGELBERG, Alpine village and valley in central Switzerland, much frequented by visitors in summer and winter. It is 14 m. by electric railway from Stansstad, on the Lake of Lucerne. Pop. (1920) 2,310, practically all German-speaking and Romanists. The village (3,343 ft.) is shut in on all sides by lofty mountains (the highest is the Titlis, 10,627 ft. in the south-east), so that it is often hot in summer. It communicates by the Surenen pass (7,563 ft.) with Wassen, on the St. Gotthard railway, and by the Joch pass (7,267 ft.) past the favourite summer resort of the Engstlen Alp (6,034 ft.), with Meiringen in the Bernese Oberland. The village has clustered round the great Benedictine monastery which gives its name to the valley, from the legend that its site was fixed by angels ("Mons Angelorum"). The monastery, founded about 1120 still survives, though the buildings date only from the 18th century. Its library suffered much at the hands of the French in 1798. From 1462 onwards it was under the protectorate of Lucerne, Schwyz, Unterwalden and Uri. In 1798 the abbot lost his temporal powers, and his domains were annexed to the Obwalden division of Unterwalden, but in 1803 were transferred to the Nidwalden division. In 1816 the valley was again transferred to Obwalden, part of which it still forms. As the pastures forming the upper portion of the Engelberg valley have for ages belonged to Uri, the actual valley itself is politically isolated between Uri and Nidwalden.

ENGELBRECHTSDATTER, DORTHE (1634–1716), Norwegian hymn-writer, was born at Bergen on Jan. 16, 1634 and died on Feb. 19, 1716. The first of her volumes of sacred verse, *Sjaelens aandelige Sangoffer* (Copenhagen, 1678), was the best. Her collected works have passed through many editions.

ENGELHARDT, JOHANN GEORG VEIT (1791–1855), German theologian, was born at Neustadt-on-the-Aisch on Nov. 12, 1791, and was educated at Erlangen, where he afterwards taught in the gymnasium (1817), and became professor of theology in the university (1821). His great works were a *Handbuch der Kirchengeschichte*, 4 vols. (1833–34), and a *Dogmengeschichte* in 2 vols. (1839). He died at Erlangen on Sept. 13, 1855.

ENGELS, FRIEDRICH (1820–1895), German socialist, the friend and collaborator of Karl Marx, was the son of a wealthy cotton-spinner, and was born on Sept. 28, 1820, at Barmen. Although destined by his father for a commercial career, he attended a classical school, and during his apprenticeship and whilst undergoing in Berlin his one year's military service, he had given up part of his free hours to philosophical studies. In Berlin he had frequented the society of the "Freien," and had written letters to the *Rheinische Zeitung*. In 1842 he had gone to England, his father's firm having a factory near Manchester, and had entered into connection with the Owenite and Chartist movements, as well as with German communists. He contributed to Owen's *New Moral World* and to the Chartist *Northern Star*, gave up much of his abstract speculative reasoning for a more positivist conception of things, and took to economic studies. In September 1844, on a short stay in Paris, he visited Marx, and the two found that in regard to all theoretical points there was perfect agreement between them. From that visit dates the close friendship and uninterrupted collaboration and exchange of ideas which lasted during their lives, so that even some of Marx's subsequent works, which he published under his own name, are more or less also the work of Engels. He took part in the Baden revolutionary outbreak in 1848, and after its suppression fled to England. From 1850 to 1869 he worked in his father's business in Manchester, but in 1870 went to London to devote himself entirely to literary work. In 1864 he married Elizabeth Burns, an Irishwoman. He died in London on August 5, 1895. An account of his co-operation with Marx and an examination of his share in Marx's writings, with a list of his own works, is given *s.v.* Marx, Karl Heinrich, on account of the difficulty of dissociating their joint shares.

See D. Riazanor, *Marx and Engels* (London, 1927); Gustav Meyer, *Friedrich Engels*, vol. i. (1920).

ENGHIEN, LOUIS ANTOINE HENRI DE BOURBON CONDÉ, Duc d' (1772–1804), was the only son of Henri Louis Joseph, prince of Condé, and of Louise Marie Thérèse Mathilde, sister of the duke of Orleans (Philippe Égalité), and was born at Chantilly on Aug. 2, 1772. He was educated privately by the abbé Millot, and received a military training from the commodore de Virieux. In 1792, on the outbreak of war, he held a command in the force of *émigrés* (styled the "French royal army") which shared in the duke of Brunswick's unsuccessful invasion of France. On the dissolution of that force after the peace of Lunéville (Feb. 1801) he married privately the princess Charlotte, niece of Cardinal de Rohan, and took up his residence at Ettenheim in Baden, near the Rhine. Early in the year 1804 Napoleon, then first consul of France, heard news which seemed to connect the young duke with the Cadoudal-Pichegru conspiracy then being tracked by the French police. The news ran that the duke was in company with Dumouriez and made secret journeys into France. This was false; the acquaintance was Thuméry, a harmless old man, and the duke had no dealings with Cadoudal or Pichegru. Napoleon gave orders for the seizure of the duke. French mounted gendarmes crossed the Rhine secretly, surrounded his house and brought him to Strasbourg (March 15, 1804), and thence to the castle of Vincennes, near Paris. There a commission of French colonels was hastily gathered to try him. The duke was now charged chiefly with bearing arms against France in the late war, and with intending to take part in the new coalition then proposed against France. The colonels hastily and most informally drew up the act of condemnation, being incited thereto by orders from Savary (*q.v.*), who had come charged with instructions. The duke was shot in the moat of the castle, near a grave which had already been prepared. With him ended the house of Condé. In 1816 the bones were exhumed and placed in the chapel of the castle. It is now known that Josephine and Mme. de Rémusat had begged Napoleon for mercy towards the duke; but nothing would bend his will. The blame which the apologists of the emperor have thrown on Talleyrand and Savary is undeserved.

See H. Welschinger, *Le Duc d'Enghien 1772–1804* (Paris, 1888) and *L'enlèvement d'Ettenheim et l'exécution de Vincennes* (1913); A. Nougaret de Fayet, *Recherches historiques sur le procès et la condemnation du duc d'Enghien*, 2 vols. (Paris, 1844); Comte A. Boulay de la Meurthe, *Les Dernières Années du duc d'Enghien 1801–1804* (Paris, 1886). For documents see *La Catastrophe du duc d'Enghien* in the edition of *Mémoires* edited by M. F. Barrière, also the edition of the duke's letters, etc., by Count Boulay de la Meurthe (tome i., Paris, 1904; tome ii., 1908).

ENGHIEN, a town in the province of Hainaut, Belgium, lying south of Grammont. Pop. estimated 5,000. It is the centre

of considerable lace, linen and cotton industries. The great Condé was given, for a victory gained near this place, the right to use the style of Enghien among his subsidiary titles.

ENGINE, a mechanical tool or contrivance. In the 19th century the term came to have, when employed alone, a specific reference to the steam engine, but it is also used of other prime movers such as the internal combustion engine. For accounts of the various types of engines *see:* STEAM ENGINE; INTERNAL COMBUSTION ENGINE; DIESEL ENGINE; TURBINE, STEAM; TURBINE, WATER; MARINE ENGINEERING; LOCOMOTIVE; REFRIGERATION; AIR ENGINE; FIRE ENGINE.

ENGINEER, PROFESSIONAL. So diversified are the services required of professional engineers throughout the wide range of industries, public utilities and governmental work, and in the discovery, development and conservation of resources, that men of extremely various personality and physique may achieve success. Qualifications include intellectual and moral honesty, courage, independence of thought, fairness, good sense, sound judgment, perseverance, resourcefulness, ingenuity, orderliness, application, accuracy and endurance. An engineer should have ability to observe, deduce, apply, to correlate cause and effect, to co-operate, to organize, to analyze situations and conditions, to state problems, to direct the efforts of others. He should know how to inform, convince and win confidence by skillful and right use of facts. He should be alert, ready to learn, open-minded, but not credulous. He must be able to assemble facts, to investigate thoroughly, to discriminate clearly between assumption and proven knowledge. He should be a man of faith, one who perceives both difficulties and ways to surmount them. He should not only know mathematics and mechanics, but should be trained to methods of thought based on these fundamental branches of learning. Organized habits of memory and large capacity for information are necessary. He should have extensive knowledge of the sciences and other branches of learning and know intensively those things which concern his specialties. He must be a student throughout his career and keep abreast of human progress.

Having been endowed more or less completely with qualifications and capacities requisite for a professional engineer and having developed them with the aid of educational and other institutions and contacts provided by civilized communities, the engineer is under obligation to consider the sociological, economic and spiritual effects of engineering operations and to aid his fellowmen to adjust wisely their modes of living, their industrial, commercial and governmental procedures, and their educational processes so as to enjoy the greatest possible benefit from the progress achieved through our accumulating knowledge of the universe and ourselves as applied by engineering. The engineer's principal work is to discover and conserve natural resources of materials and forces, including the human, and to create means for utilizing these resources with minimal cost and waste and with maximal useful results. (*See* CIVIL, ELECTRICAL, MECHANICAL, MINING and ENGINEER, and CHEMICAL ENGINEERING.)

(A. D. F.)

ENGINEERING in its early uses referred specially to the operations of those who constructed engines of war and executed works intended to serve military purposes. Such military engineers were long the only ones to whom the title was applied. But about the middle of the 18th century there began to arise a new class of engineers who concerned themselves with works which, though they might be in some cases, as in the making of roads, of the same character as those undertaken by military engineers, were neither exclusively military in purpose nor executed by soldiers, and those men by way of distinction came to be known as civil engineers. No better definition of their aims and functions can be given than that which is contained in the charter (dated 1828) of the Institution of Civil Engineers (London), where civil engineering is described as the "art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." Wide as is this enumeration, the practice of a civil engineer in the earlier part of the 19th century might cover many or even most of the subjects it contains. But gradually specialization set in. Perhaps the first branch to be recognized as separate was *mechanical* engineering, which is concerned with steam-engines, machine tools, mill-work and moving machinery in general, and it was soon followed by *mining* engineering, which deals with the location and working of coal, ore and other minerals. Subsequently numerous other more or less strictly defined groups and subdivisions came into existence, such as marine, sanitary, chemical and electrical engineering.

ENGINEERING AND ARCHITECTURAL SOCIETIES. The principal English society dealing with mechanical science is the *Institution of Civil Engineers* (established in 1818, incorporated in 1828), which publishes *Transactions* (4to, 1836–1842) and *Minutes of Proceedings* (8vo, 1837, etc.). George Stephenson was the first president of the *Institution of Mechanical Engineers,* which was founded at Birmingham in 1847, removed to London in 1877, and registered under the Companies Act in 1878. It holds migratory meetings and publishes *Proceedings.* The *Society of Engineers* (1854), with *Transactions* (1861, etc.); The *Civil and Mechanical Engineers' Society* (1859); the *Iron and Steel Institute* (1869, incorp. 1899), with *Journal* and *Mem.;* the *Surveyors' Institution* (1868, incorporated in 1881), which publishes *Transactions* and holds professional examinations; the *Aeronautical Society of Great Britain* (1866), the *Institution of Electrical Engineers* (1871, incorp. 1883), *Journal;* the *Institution of Mining Engineers* has associated with it many branch institutions in the provinces, *Journal;* the *Institute of Gas Engineers* (1863); the *Illuminating Engineers' Soc.* (1909); the *Institute of Metals;* and the *Instn. of Mining and Metallurgy,* meet in London. There are institutions in the provinces at Bradford, Bristol, Cardiff (1857, incorp. in 1881), Chesterfield (1871), Dublin (1835, incorp. in 1857), Glasgow (1857, with *Transactions*), *Liverpool* (1875), Middlesbrough (1864), Newcastle-upon-Tyne (1852, incorp. in 1876, with *Transactions*), Nottingham (1871), Dudley (1866), and Belfast (1892).

The leading architectural society is the *Royal Institute of British Architects,* founded in 1834, incorporated in 1837, and granted new charters in 1887 and 1908. It appoints examining professional boards and publishes *Transactions* (1836; 1879, etc.) and *Proceedings* (1879, etc.). There are also the associations of Birmingham (1873), Edinburgh (1850), Exeter (1843), Glasgow (1868), Leeds (1876), Leicestershire (1855), Liverpool (1848), Manchester (1875), Newcastle-upon-Tyne, and the societies of Manchester (1865) and Oxford (1837). The *Architectural Association* of London publishes a *Sketch Book* (1870, etc.). The *Architectural Publishing Society* (1848) has published *Essays* (1848–1852), and since 1852 has been bringing out a *Dictionary of Architecture.* There is also a *Society of Architects* (1884, incorp. 1893). The *Roy. Inst. of Architects of Ireland* meets in Dublin and publishes a *Journal.*

UNITED STATES: New York, *Inst. of Mining Engineers. Amer. Soc. of Civ. Eng. Trans.; Amer. Soc. of Mech. Eng., Trans.; Amer. Inst. of Min. Eng.; Amer. Inst. of Architects* (1857); Washington, *Society of Naval Eng.* FRANCE: Lyons, *Soc. Acad. d'Arch.* (1830), *Annales* (1867, etc.). Paris, *Soc. des Ingénieurs Civils, Annuaire* (1848, etc.); *Soc. Cent. des Architectes, Bull.* (1851, etc.) and *Annales* (1875, etc.); it has held a congress since 1875. Saint-Étienne, *Soc. de l'Industrie Min.* (1855), *Bull.* GERMANY and AUSTRIA-HUNGARY: Berlin, *Ver. Deutscher Ingenieure, Ztschr.* (1857) and *Wochenschrift* (1877, etc.); *Ver. f. Eisenbahnkunde; Akad. des Bauwesens; Architekten-Ver., Ztschr.* Breslau, *Ver. f. Ges. der Bi'd. Künste* (1862). Constance, *Münsterbau Ver.* (1881). Dresden, *Sächs. Ingen.- u. Architekten-Ver., Protok.* Hanover, *Arch.- u. Ingen. Ver., Ztschr.* Klagenfurt, *Berg- und Hütten-Männischer Ver.* Leoben, *K. k. Berg-Akad.* Munich, *Bayr.*

Arch.- u. Ingen.-Ver., Ztschr. Prague, *Arch.- und Ingen.-Ver.* Vienna, *Österr. Ingen.- u. Arch. Ver., Ztschr.; Ges. f. Bild. Künste.* SWITZERLAND: Lausanne, *Soc. Vaudoise des Ingén. et des Arch.* Zürich, *Ver. Schweiz. Ingen. u. Arch.* ITALY: Turin, *Soc. degli Ingeneri, Atti* (1868–1870). BELGIUM: Brussels, *Assoc. des Ingén.* Liége, *Assoc. des Ingén.* (1847), *Annuaire* (1851, etc.). HOLLAND: Amsterdam, *Maatschappij ter Bevordering der Bouwkunst, Bouwkundige Bijragen* (1843, etc.). The Hague, *Kon, Inst. van Ingen., Verslag* (1848, etc.), *Verhandel* (1848, etc.) and *Tijdschr.* (1870, etc.). SPAIN and PORTUGAL: Lisbon, *Assoc. dos Engenheiros Civ. Port.; Soc. dos Architectos e Archeologos.* Madrid, *Soc. Central de Arquitectos.*

ENGINEERING ARTICLES. For articles on prime movers *see* ENGINE, which gives reference to the various orders of engines. For articles on the different forms in which engineering is concerned with the application of power to traffic on land and sea and in the air, a key will be found under the heading TRANSPORT. The application of power to industry leads to a specialization of engineering in respect of each separate industry, and for an account of this the reader should turn to the articles on various industries; *e.g.*, BRIDGES, BOILER, AERONAUTICS, RAILWAYS, PRINTING, WEAVING, GAS MANUFACTURE and PAPER MANUFACTURE.

Electrical engineering is the subject of a special group of articles, amongst which may be named ELECTRICAL POWER GENERATION, ELECTRICAL POWER TRANSMISSION, ELECTRICITY SUPPLY, ELECTRIFICATION OF INDUSTRY and ELECTRIC FURNACE. For the articles on power transmission, by various means, reference should be made to the key given under that heading. The important subject of mining engineering will be found under the headings MINING, METALLIFEROUS; COAL AND COAL MINING; BORING; BLASTING, etc.; and under various subject headings such as COPPER, LEAD, GOLD, SILVER, etc. For hydraulic engineering, reference should be made to the articles HYDRAULICS; HYDRAULIC MACHINERY; HYDRO-ELECTRIC GENERATION; and TURBINE, WATER. In its application to shipping, the articles MARINE ENGINEERING and SHIPBUILDING should be consulted.

The application of engineering to the chemical trades will be found treated under the wide series of articles dealing with chemical products, including DYES; ALKALI MANUFACTURE; ARTIFICIAL SILK; NITROGEN, FIXATION OF. The engineering connected with natural and artificial waterways, seaports, etc., is of great importance and is treated in a group of articles which cover, *inter alia*, RIVER ENGINEERING, CANALS, DOCKS, DAMS, HARBOURS, BREAKWATER, JETTY and PIER. There are also special articles on LOCK, DOCKS, FLOATING, LIGHTHOUSE and LIGHTSHIP.

ENGINEERING EDUCATION. Engineering education to-day embraces instruction and training not only in the older divisions of civil, mechanical, mining and electrical engineering, and their subdivisions—highway engineering, harbour engineering, automobile engineering, machine tool engineering, structural engineering, illuminating engineering, etc., but also in such allied branches as chemical engineering and metallurgical engineering. In spite however of modern specialisation a sound knowledge of the principles and methods of general science is becoming ever more necessary as engineering becomes more scientific. The general history of the growth of engineering education is to be found in the articles on Technical Education and Polytechnics (*q.v.*), but special reference may be made to George Birkbeck (1776–1841), who founded, in 1823, the "Mechanics Institute" afterwards known as Birkbeck college (University of London), and to the later action of the great Companies of the City of London in founding the City and Guilds of London Institute. The Central Technical college, South Kensington, now part of the Imperial College of Science and Technology, proved a most important foundation, while grants of money to provincial centres and the establishment of "City of Guilds" examinations and certificates in technology paved the way for national schemes. In 1880 Mr. Quintin Hogg founded the Regent Street Polytechnic (London), the success encouraging the opening of numerous provincial "industrial institutes." In university engineering education the way was led by Cambridge, but engineering degrees are now granted by London, Manchester, Sheffield, Birmingham, Newcastle and other universities.

Aims and Standards of Engineering Education.—The principal aims of engineering education should be: (1) To train those who will later be "Captains of Industry" (2) To train the rank and file of the industrial army by enabling them to perform their allotted tasks with greater proficiency and interest, while avoiding the perils of "blind alley" employment.

The introduction of automatic and semi-automatic machinery has made it difficult to acquire craftsmanship in many branches of industry. Fortunately, the peril has been realized. Trade schools for practical instruction are available in most districts, and no young workman should rest content till he has mastered a trade. Even if forced to undertake routine work, he will be all the better for being a skilled craftsman, and his proficiency will stand him in good stead in emergencies.

Preliminary General Education.—For those who will form the great mass of the industrial army of workers, a good primary education is sufficient preliminary preparation, but it should embrace elementary science and such broad subjects as nature study in order that the men and women concerned may have a greater interest in their work and its results, as well as "outside" interests. Those who have a prospect of entering the higher ranks of engineering should seek a good general education on the Modern side, in French, German and science, while a few will benefit by carrying this education a stage higher into the university sphere.

Special Diplomas in Engineering Education.—For those unable to take the university course, certain special diplomas have been created. Thus, in Great Britain, the Sheffield university recognizes as Associates in Metallurgy those who attain a high standard in metallurgical work, with only a preliminary examination in English and chemistry. This diploma is highly valued.

Assistance by Employers.—Much can be done by individual employers to encourage the spread of education among their younger people. Thus Hadfields Limited (Sheffield) has for many years had a scheme based upon refunding the entrance fees of those, under 21 years of age, who secure 75% attendance marks in certain recognized courses, technical and commercial, at the secondary schools or university evening classes. A bonus of 1s. per week is also paid throughout the following year for each subject (up to three in number) in which 75% attendance has been registered and a first-class certificate obtained. During the session 1927–28, about 70% of the students had their fees refunded, and nearly 40% earned an average bonus of £3. 13s. 4d.

Educational Influence of Engineering Institutions.—The great engineering institutions—such as those of civil, of mechanical, and of electrical engineers—have also done much to raise the standard of engineering education. The qualifications demanded for associate membership cover a high degree of proficiency in engineering theory, and a considerable term of practical employment in a responsible position. Membership of such institutions may be considered as equivalent to a university degree.

Suggestions to Students.—(i.) Full attention should be paid by the student to health, physical exercise and social intercourse. Good health and good citizenship are invaluable. (ii.) In every grade of education, most importance should be attached to the underlying principles. Knowledge only becomes valuable when *applied*. Learn, therefore, how to use works of reference, papers before engineering societies, and other stores of accumulated facts; and acquire the habit of applying principles rather than formulae. (iii.) Those who seek the highest positions should have a broad and sound general education. They must be prepared to continue their studies and investigations, even if unaided, during the whole of their active career. (iv.) For the rest a good secondary or primary education according to their intended employment is necessary. Their chances of rising to supervisory grades will increase according to their assiduity in acquiring an intelligent grasp of the reasons underlying their work. (v.) Between the ages of 16 to 21 years, those who hope to qualify as at (iii.) above should, if possible, take advantage of university

courses with a view to a degree or an equivalent diploma. This, again, must be supplemented by practical experience and ability. Mention should also be made here of "sandwich" schemes where the student spends alternate periods of work at some higher institution during his years of apprenticeship, an idea, first started in Sunderland, which certainly gives excellent results. (vi.) Those unable to take the higher courses in education should attend the continuation evening classes available in almost every district.

The Future.—On the whole, the provisions for engineering education in England may be described as excellent and, indeed, second to none. Nevertheless the following improvements seem feasible.

(a) *Monotony of Routine Work.*—A large proportion of those in industrial employment are obviously obliged to remain at the bench, machine or forge throughout their working life. Such need a further education to widen their interests in life. Unfortunately the curricula of many evening classes have not always been suitable. This however is likely to be largely remedied by the Committee on Technical Education for the Engineering Industry recently appointed by Lord Eustace Percy (Great Britain).

(b) *"Blind Alley" Employment.*—Further education including technical education is still more necessary for those who take on those "blind alley" occupations which are an inseparable part of mass production to-day.

(c) *"Individuality" in Research.*—The professional staffs of universities and colleges may usefully engage in research work in pure science, in their spare time; but it is rarely possible for any educational institution to do much in the way of industrial research. The experience and equipment which can be brought to bear on its research problems by any properly organized industrial establishment are naturally greater.

(d) *Science at the Helm.*—Science and engineering are so closely associated with every phase of modern life that a reasonable proportion of the members of central and local authorities responsible for educational policy should themselves have been trained in science and engineering. The policy of the British Board of Education to-day is to delegate increasing responsibility to local authorities in the adaptation of instruction to local requirements, thus averting the consequences which might result from the predominance of classically trained persons in Government Departments.

Conclusion.—The arrangements for engineering education in Great Britain, as already stated, are second to none. Every prospective entrant to the industry should ascertain what provisions for scientific and technical training are made in his district. But he should also remember that the facilities alone can accomplish nothing. The tools of education are ready to hand but those who would use them must work long and hard. (R. Ha.)

THE UNITED STATES

In the American Colonies all industries except agriculture and the production of raw materials were repressed by the British parliament. After the Revolutionary War, a struggle for industrial independence ensued. Societies for the promotion of the useful arts were formed, premiums were offered for useful improvements and trained artisans from abroad were sought. The feeling that the sciences through a new type of education should aid the industries seems to have found first expression in a truly technical school in 1822 under Benjamin Hale at Bowdoin college in Maine. Though it lived but a decade, its purpose, scope and plans have found fruit in the modern engineering school.

In 1824, Stephen Van Rensselaer established at Troy, N.Y., the Rensselaer Polytechnic institute, the oldest of present engineering schools. Initially it was a school for teaching "the sons and daughters of farmers and mechanics" the application of science "to agriculture, domestic economy, the arts and manufactures." Depletion of the soil led to early emphasis on agricultural problems. General engineering soon appeared, and in 1829 civil engineering, the degree being first conferred in 1835. The plan of studies was remodelled in 1849 on the technical lines of the École Centrale of Paris and covered three years. The Rensselaer Polytechnic institute and the U.S. Military academy at West Point were for many years the only schools affording scientific training. Their graduates were a potent factor in making the highways, bridges, canals and railroads essential to the development of the country. Rensselaer graduates have been leaders in scientific and engineering activities and in engineering education.

In 1847 the Lawrence Scientific school at Harvard and the Sheffield Scientific school at Yale were established and in 1853 the University of Michigan offered a course in civil engineering. In 1862, Congress passed the Morrill Act granting land to the States for colleges of agriculture and mechanic arts. The four engineering schools of 1860 increased to 17 by 1870 and to 85 in 1880, about half being land grant colleges (*q.v.*) The others were formed as parts of existing universities, or were independent. This rapid increase was responsive to the industrial trend; in the 50 years prior to 1870 the proportion of the country's working population engaged in manufacture, trade, transportation and professional service increased about threefold.

In its beginning, engineering instruction was included in the term civil engineering. Courses in mining and mechanical engineering formally appeared in the '60s. Civil, mining and mechanical engineering were based on the experience of many generations. In the '80s came electrical and a decade later chemical engineering based upon new sciences. To the technical graduate is largely due the outstanding progress in these fields. Accumulating scientific and technical knowledge has lead to differentiation and subdivision, until there are two score and more engineering courses, offshoots of the initial civil engineering. The usual engineering curriculum, following the four year secondary school course, contains three groups of subjects, scientific (mathematics, physics, chemistry), technical (relating to a specific field of engineering and its allied fields), and non-technical (English, history, social science). The scientific and non-technical subjects are usually substantially similar in the several engineering curricula, differentiation occurring in the technical content of the later years. The degree of bachelor of science, with or without specification of a particular branch, is commonly conferred at the end of four years, while the professional degree, such as civil engineering, is generally reserved for graduate work.

The enrolment in 148 engineering schools in the United States on Nov. 1, 1927, is reported by the U.S. Bureau of Education as 63,023 regular undergraduates (of which 10,073 were seniors) and 1,669 post-graduates. The number of seniors and post- graduates in the larger groups were: electrical, 3,051 and 468; civil, 2,323 and 266; mechanical, 1,855 and 240. Engineering education in America had its beginning under the auspices of educational scientists and professional educators rather than professional engineers or Government bureaux as in Europe. Conventional methods proved inadequate and the engineering colleges in many localities and under many leaders and with changing industrial conditions have been notable organizers in developing a new type of education. They have combined scientific, technological and humanistic subjects in a unified balanced curriculum, introduced the individual method of laboratory instruction and incorporated shop work in the college programme. Shop work has had different aims and has taken different forms: construction shops, as developed at Sibley college and Cornell university; manufacturing shops, with remuneration to students; shop laboratories for teaching principles of industrial production. In lieu of shops the laboratory is supplemented by systematic inspection of industries or by the co-operative plan inaugurated at the University of Cincinnati in which students alternate between school activities and industrial employment. Engineering schools have promoted research, they have organized engineering experiment stations and they have co-operated with industry in various ways.

Fifty years development of engineering education has witnessed a rising status of the engineer. In place of a single feeble national engineering society, there are now several, large and vigorous, with a total enrolment (1928) of some 60,000. But engineering is not as restricted and definite as law or medicine. The engineer sometimes renders service which is technical and specific, but often it involves also contracts and business relations, construction and

management. Much engineering is done by groups rather than by individuals; modern industry employs engineers for co-ordinated work on a large scale; scientific training and technical experience qualify young engineers for dealing with managerial, commercial and financial, as well as purely technical, problems. There is a progressive trend of engineering graduates toward managerial duties. Years ago the demand upon the schools was for trained experts; now it is for men of broad outlook, well grounded in fundamentals, trained in methods of scientific analysis and intellectually capable of progressing through continued studies and a novitiate of practical experience to leadership in various fields, appropriate to their aptitudes and abilities. Prior to about 1900 electrical engineers, for example, were designing and perfecting their apparatus; recently there has come the application of electric service to a thousand uses in transportation and manufacture, in the mine, on the farm and in the home. The versatile and scientifically trained engineering graduate has been an active factor in increasing the use of electricity each decade and making the power industry one of the largest in the investment of new capital and in its economic and social importance.

The Society for the Promotion of Engineering Education was organized in 1893, as a pioneer movement by a professional group for the betterment of education by bringing engineering teachers into helpful contact. It inaugurated a movement by the engineering societies "to examine into all branches of engineering education" which resulted in a report by Dr. C. R. Mann, *A Study of Engineering Education* (1918), under the auspices of the Carnegie Foundation for the Advancement of Teaching. In 1923 the society undertook a new study under its board of investigation and co-ordination with financial support from the Carnegie Corporation, industries and individuals. The engineering schools cooperated actively in a fact-finding survey as to teachers, students, graduates, curricula, costs and the need for improvements. The results of the survey with accompanying comment have appeared in the *Journal of Engineering Education*, and separately issued reports which present the status and trend in engineering education to-day have been made available. (C. F. S.)

ENGINEERING INDEX, a non-commercial card index issued weekly to subscribers by the American Society of Mechanical Engineers. It contains the title and a short abstract of articles appearing in 1,700 technical publications, representing 37 countries. Every phase of engineering activity is covered under 13 main classifications and 118 sub-classifications. All articles that are listed have been read and reviewed by prominent engineering authorities. Any particular division or subdivision may be subscribed for.

ENGINEERING INSURANCE. The use of machinery involves manufacturers in certain special risks which are undertaken by engineering insurance companies. Unlike most other classes of insurance, which are designed to indemnify the insured after he has suffered loss, engineering insurance endeavours primarily to reduce the possibility of a loss occurring. To this end insured machinery is periodically inspected by skilled engineers to ascertain defects before they result in an explosion of, or breakdown in, the plant. A very large proportion of the premiums received is expended upon these services, which enable the insured to receive the advice of experts as to methods of obtaining the utmost economy and efficiency from the plant.

The Factory Acts stipulate that all boilers under pressure must be periodically examined by competent engineers, and in the event of explosion an enquiry will be instituted by the board of trade, or similar authority out of England, under the Boiler Explosions acts to ascertain its cause. The inspections thus rendered essential are undertaken by the insurers in the terms of the boiler policy, which also indemnifies the insured in respect of claims made against him by third parties in respect of personal injuries and covers damage to surrounding property caused by the explosion. Law costs incurred with the consent of the insurers in defending claims are also included.

Policies are not confined solely to boilers, whether under pressure or not, but are issued for all classes of plant working under pressure. Insurances are sought extensively for such items as superheaters, calorifiers, hot water and steam heating boilers with heating pipes and radiators and other vessels working under steam, liquid, air or gas pressure.

In connection with cast-iron sectional low pressure boilers, the risk of cracking of sections and of explosion and cracking pipes may be insured, whilst in approved cases water damage to surrounding property following leakage may be covered.

Breakdown risks of gas, oil and steam engines and power gas plants are commonly insured and subject to the exclusion of certain inexpensive parts, the breakage of any part of a machine proper whilst running, causing a sudden stoppage of the machine and necessitating repair before work can be resumed, is covered. No compensation is payable for loss of use under this type of policy. Whilst gas and oil engine policies include an indemnity in respect of damage due to flying fragments caused by the breakdown, such cover is not provided under the steam engine policy unless specifically insured. Periodical inspections of the plant are followed by the despatch of engineers' reports to the insured containing advice as to its use, although non-compliance with the suggestions made does not invalidate the contract.

Lift insurance covers the risk of liability to third parties for personal injuries due or alleged to be due to defects, or to negligence of attendants, in connection with the lift, its gates, hatchways or shaft. Whilst lift accidents are fortunately infrequent, they are usually attended by serious results followed by substantial claims upon the lift owners for damages. The ordinary lift policy does not include the risk of damage to property, although it may occasionally be covered by special arrangement with the insurers. The proposal form requires full details of the lift to be insured and the proposer is required to indicate the limits of indemnity required in respect of (a) any one person, (b) any one accident, and (c) any one year of insurance. The indemnity selected is generally inclusive of any law costs which may be payable to claimants, but law costs incurred in the defence of the insured are invariably paid by the insurers in addition. The policy stipulates for the quarterly inspection of the lift by skilled engineers and, whilst the insured may select the engineer, subject to the insurers' approval, engineering insurance companies are willing to undertake these services.

Policies similar in principle are issued in respect of hoists and cranes, although the premiums required are frequently greater, having regard to the increased possibility of goods falling upon third parties, particularly when such devices overhang public thoroughfares. Cranes of certain types are liable to collapse and also to toppling risks which may be specifically insured under a special form of policy.

Time loss policies guarantee the payment to the insured of a fixed sum per day to cover the loss of time consequent upon the breakdown of engines, explosion of boilers, or the collapse of flues. Normally the first 48 hours after each breakdown is excluded. Immediate notice must be given to the company of any breakdown, and, as these policies are only issued in conjunction with the appropriate damage or breakdown insurances, the insurers make arrangements for repairs.

Engineering insurance companies are also prepared to undertake inspections of plant for valuation and sale purposes and in many cases superintend the manufacturing processes. Chemical analysis of water for use in boilers in different districts and tests regarding water softeners are also undertaken.

(A. G. M. B.)

UNITED STATES

Fundamentally insurance means the acceptance of a risk of loss for a premium and the payment of that loss if it arises. In this sense there is no such thing as engineering insurance in the United States. Engineering insurance is furnished as a policy service, but not as an insurance or contract undertaking. This service is safety engineering and in its application to insured risks it is commonly called "inspection." In America risks are written which are made up of boilers and machinery, the machinery risks being limited largely to prime movers. This risk group has been sometimes improperly called "engineering in-

surance." A majority of underwriters appear to favour the term "power plant insurance." Insurance is by policy contract, and safety engineering is a voluntary service for the policy holder. Power-plant insurance includes: boiler insurance covering explosion of vessels and piping subject to internal pressure; engine insurance covering the breakdown of prime movers and some accessories; wheel insurance covering the breakdown of fly- or transmission-wheels or other rotating parts which may include shafting; electrical machinery insurance covering the breakdown of electrical transmitters and accessories.

Safety Engineering.—The obvious duties of safety engineers are to prevent losses, and that is true of all lines. Safety engineering (*see* INDUSTRIAL ACCIDENTS, PREVENTION OF) has practically become a profession in the United States and constant efforts are made to apply to safety problems all obtainable skill and knowledge. In the fields mentioned above the duties of the safety engineer are particularly exacting, because resulting losses are by no means limited to the thing particularly insured but involve remote and indirect losses of many kinds, such as damage to the property of others, injuries to persons, use and occupancy losses and spoiling of product because of enforced suspension. This suspension is not always due to machinery within the plant, but may be covered for failure of power furnished from the outside by public utilities and others. The safety engineer cannot hope to prevent remote losses except by preventing loss to the thing insured or against failure of outside power sources. In the early days the companies prepared plans and specifications for boilers and other pressure containers, but this has been largely superseded by the standardized plans of the American Society of Mechanical Engineers. The safety engineering force usually includes one or more chemists who test boiler water and suggest chemical treatment to avoid scale or possible rupture. The general practice is to provide in the policy contract for the *privilege* of inspection by the company's safety engineers.

The most extensive, and probably the most promising, field for safety engineering grows out of the relation between employers and employees. This is particularly true under the workman's compensation laws. There are workman's compensation laws with varying provisions in all States except five. This means that there are 43 different compensation laws to which effective safety engineering practice must be adapted. Practically all companies work upon the theory that an injury prevented is a benefaction, an injury compensated an apology. It would be impossible within reasonable limits to undertake a detailed explanation of this line of safety work. Policy holders are usually advised not only upon mechanical safety but also on sanitation, light, heat and ventilation. Insurance companies assist in the forming of safety organizations in industrial plants, and instruct the members of such organizations in safety principles.

A feature of this form of loss which is not generally recognized is of particular interest to the employer. The loss due to a personal injury is only a small part of the loss which the employer actually sustains. The indirect losses due to the excitement naturally caused by an accident, the general stoppage of work for a time by a considerable part of the force and the temporary loss of *moral* have been demonstrated as losses amounting to several times as much as the direct loss because of the accidental injury, and these collateral losses cannot be insured because of their nature. Insurance companies generally have no right to enforce their safety recommendations, and their only recourse is cancellation.

Extent of Practice.—This engineering practice is not limited to shops or other fixed work places, but extends to a very large number of fields. The construction operations of contractors, for instance, involve special safety engineering work, and this is also true of mining activities. Insurance companies assume no engineering control over construction, but merely keep the operation, as such, under constant observation to prevent accidents. The companies in the United States undertake many kinds of public liability insurance. These are frequently concurrent with workmen's compensation or employers' liability, yet very often they are written alone. General property damage (meaning liability for damage to the property of others) is written usually with as much freedom as the laws permit in connection with public liability lines. The service of the safety engineer is required principally where there are concurrent types of insurance policies, but may be required in any one of them. Elevator insurance requires special safety engineering work, usually applied at stated intervals during the term of the policy. This class of insurance may include personal injury, property damage and collision. In automobile insurance policies the services of the safety engineer are principally directed to fleets where five or more commercial automobiles are in the same ownership or operation. The companies form safety groups among the employees and instruct them on various occasions. Automobile insurance includes personal injury, property damage, collision, fire and theft.

Plate-glass insurance involves no collateral risk, the loss being limited to the particular glass insured. The U.S. companies generally use a surveyor rather than an engineer, although the surveyor has sufficient engineering training to report upon safety conditions. Many companies write policies where the obligation is direct to the policy holder without any question as to liability. In fire policies the companies consider safety engineering important. The obvious purpose is to prevent fires, and recommendations are not usually influenced by probable rate reduction. The safety engineer gives attention to sprinkler systems, location of supply tank, exposure of head to heat sources, defective flues, defective wiring, etc. Burglary insurance with its collateral types is written quite extensively by United States companies and here safety engineering finds an important field. In "mercantile open stock" insurance the safety engineer is called upon to study the best known methods of protection. Apartment house risks receive some attention by the safety engineer particularly as respects door and window locks and fire-escapes. Sprinkler leakage and also various kinds of water damage, including that caused by plumbing, provide a field for the safety engineer in various directions. (W. G. C.)

ENGINEERS, MILITARY. The earliest history of the military engineer is the history of primeval warfare, when every man was a fighter and every fighter to some extent an engineer. Primitive efforts were restricted to the provision of artificial protection for the person and machines for hurling destruction at the enemy. To these activities were added road and bridge building. With the invention of gunpowder came the era of great fortresses and the rise of the technical expert, to whom the great scientific discoveries of the 19th century brought ever-increasing responsibilities; so that, in modern armies, there is scarcely a problem of civil, mechanical or electrical engineering with which the military engineer may not be called upon to grapple. The cost of providing separately for each branch of engineering is prohibitive; and in European armies, with compulsory service and well-marked military frontiers, the tendency has been to confine the engineers to their traditional functions of fortification and siege-craft, depending on the civil departments for such technical services as might be required. To the voluntary service army of Great Britain, such a system is unsuitable, and the need for a corps of all-round engineers has been recognized. Men of all engineering trades are included in its ranks, while the officers after receiving a general scientific education, are liable to serve in any unit of the corps and, by means of periodical changes of employment, are ensured wide practical experience. As history always repeats itself, so the present mechanical era seems likely to reproduce a state in which every soldier will again be, in some wise and of necessity, an engineer.

FROM EARLIEST DATE TO THE WORLD WAR

Great Britain.—In earliest war annals it is difficult to distinguish the military from the civil engineer. Julius Caesar refers to his "praefectus fabrum," an official who controlled the labour gangs employed on road-making and also parties of artisans. The Domesday survey of A.D. 1086 includes one "Waldivus Ingeniator," who held nine manors direct from the Crown, and was probably William the Conqueror's chief engineer. Throughout the middle ages ecclesiastics were frequently employed as military

engineers; not only for purposes of planning and building, but also for fighting. The best known is Gundulph, bishop of Rochester, a famous engineer of his day, who built the White tower of the Tower of London (1078) and Rochester castle. For labour civil artificers were engaged, principally carpenters, wood-cutters and sappers (fossatores) for road-making. In A.D. 1300 the name *Attillator* was given to the official responsible for the maintenance of permanent works of defence, and for manipulating the engines of war. This title, at the time synonymous with "engineer," may perhaps be the origin of "artillery." Headquarters of engineers existed at the Tower of London before A.D. 1350, and a century later developed into the Office (later Board) of Ordnance, whose duty was to administer all matters concerned with fortification, artillery and ordnance stores. The first English record of the employment of engineers and artillery in a siege is in A.D. 1346, when Edward III. was before Calais; the wages roll numbered 31,294, of whom 314 were engineers, gunners and other artificers. Edward III. believed in using trained artificers and he collected experienced miners from the Forest of Dean, also smiths and others from the City of London. The records of later sieges show similarly that bodies of carpenters, miners, labourers and smiths were employed, *cf.* Harfleur A.D. 1415. During the 15th century there are few references to engineers. In A.D. 1513 Henry VIII. appointed a "Master Trenchermaster," who later became "Master of the Ordnance." He also separated combatant engineers from those who merely constructed works; the former were appointed for campaigns only and were entitled "Trenchmaster," or "Captain of the Pioneers"; they had no control over the artillery, which was under a master of the ordnance, also appointed for the campaign, and usually himself an engineer. Those entrusted with the construction of permanent works were called "Surveyors of the King's Works," or sometimes "Master Masons." During this reign "Pioneers" were for the first time organized in regular corps during active operations. Henry VIII. gave much work to his engineers, and the numbers being insufficient, many foreigners, especially Italians and Spaniards, were brought to England; his fear of invasion gave special impetus to work on coast defences. Henry's best known chief engineer was Sir Richard Lee. Elizabeth introduced the title "Lieutenant of the Ordnance," which was borne by Sir William Pelham, the most distinguished engineer of her reign. The title of surveyor fell into disuse about the middle of the 17th century, when that of engineer again became general for both combatant and non-combatant branches. A new division gradually appeared (the King's Engineers) permanently appointed and patented, who were charged with the design, construction and inspection of the fortifications of the country; and engineers appointed to the trains that were formed for war and included all branches of the ordnance; viz., engineers, artillery and store or munitions branch. The commander of the train was usually the chief engineer. The duties of the board of ordnance were first clearly defined by royal warrant in 1683, when the principal engineer was made responsible for the efficiency and attainments of the members of his branch. Previously each individual officer had corresponded direct with the board of ordnance, ministers or other authorities. At the end of the 17th century the train included guns, howitzers, grenades, pontoons, tents, entrenching and artificers' tools, scaling ladders and mining timber; the men were formed into a mortar detachment, gun detachment, company of bridgemen, artificers, store and transport attendants; the whole being commanded by the senior engineer.

The artillery and engineers were separated in 1716, when two companies of artillery and a corps of engineer officers were established, all under the board of ordnance. The system of appointment to the corps of engineers remained that of patronage. There was no academy, no examination, no competition. A code of instructions issued in 1740 shows that the engineers were still supposed to exercise a great measure of control over the artillery; the number of guns, their siting, mounting and protection, all lying within the province of the engineers. The Royal Military Academy, Woolwich, was founded by royal warrant in 1741, on the demand of the board of ordnance, in order "to instruct the raw and inexperienced people of this office in the several parts of Mathematicks necessary to qualify them for the service of the artillery and the business of engineers." The first record of engineers in India is in 1747, when a warrant was issued for a train to accompany the expedition under Admiral Boscawen; in 1773, by a warrant of the king, engineers serving in India ceased to be members of the corps.

The year 1747 saw the commencement of the military survey of Scotland, which was undertaken as a preliminary to the invasion of the Highlands. This was entrusted to the corps of engineers and became the precursor of the Ordnance Survey, which remains to this day under control of Royal Engineer officers. At that period engineer officers had no recognized military rank or status, unless, as occasionally happened, they were granted commissions in other regiments, or on the staff. This was naturally unsatisfactory and had long been a grievance. Direct appeal was at last made by the officers to H.R.H the duke of Cumberland, Captain-General of the Forces, at which the board of ordnance was highly incensed. In 1757, after nearly ten years of friction and argument, military rank was formally approved; no warrant can be traced, but every engineer officer received a signed commission from the king. Thirty years later the title of the corps was changed to its present one of "Royal Engineers," and it was authorized to take precedence with the artillery on the right of the line. No regular units or establishment of men had existed until 1772, when a "corps of military artificers" was formed for service in Gibraltar, in place of the mixed lot of local civilians, soldiers and workmen from England. A similar organization for England was proposed in 1779; but prolonged discussion took place in parliament before a warrant was issued for the formation of six companies of military artificers, each consisting of 100 men, to be officered by the Royal Engineers. The companies were stationed in certain ports in the south of England and might not be employed elsewhere. This was the position during the greater part of the Napoleonic wars, and it is not surprising that Wellington's references to both artillery and engineers are often uncomplimentary. The whole of the train, artillery, engineers and stores departments being directly under the board of ordnance, were entirely independent of control by the military chiefs, while the board could never be persuaded to meet the demands of commanders in the field for either men or material. The numerous sieges in Spain were planned and conducted by engineer officers practically without technical troops or material. Their greatest privilege was to lead the storming party to the assault, where the majority met death or disablement. Wellington's chief engineer in the Peninsular War, Sir Richard Fletcher, was himself killed before San Sebastian in 1813. Four companies of Royal Sappers and Miners took part in this siege, Wellington's insistence having at last prevailed upon the board of ordnance to organize units of technical troops. In this same year the new name had been substituted for the old one of "military artificers." A regular organization was steadily built up, and at Waterloo in 1815 a brigade of engineers was attached to each division, and there was in addition a pontoon train of several companies. The French wars also led to certain improvements in the status and pay of senior engineer officers, and in 1802 the title of chief engineer in England was changed to "inspector-general of fortifications." Another result was the establishment in 1812 of the School of Military Engineering at Chatham under Capt. Charles Pasley, to give instruction to officers and men "in the duties of sapping and mining and other military field works." Pasley had been incapacitated by many wounds from further active service; he remained for nearly 30 years in control of the school, where his scientific knowledge, sane judgment, and broad vision left a permanent mark. The end of the French wars found the engineers at the summit of their fortunes, and the need for scientific soldiers had been proved to the utmost. The subsequent long peace brought drastic reductions and stagnation of promotion, till subalterns of 25 years' service became quite common. A slight improvement resulted from the inception of the ordnance survey of Ireland in 1825; and in 1832 the King granted to the corps its motto "Ubique quo fas et gloria ducunt." Little interest, however, was taken in military engineers until the Great Exhibition of 1851,

the construction of which was entrusted by the Prince Consort to Royal Engineer officers. The universality of application to engineering problems that they displayed, combined with the success of the exhibition, brought the corps prominently to notice; and the subsequent warm interest shown at all times by Queen Victoria opened the door to many and varied channels of scientific and general employment for R.E. officers. The opening of the Crimean War in 1854 found the engineers, like the rest of the army, reduced in numbers and starved for equipment. An immediate increase in numbers was made, seven battalions of sappers being formed, each battalion having 48 officers of Royal Engineers. The old defects in organization still persisted, and were only remedied as the result of the lessons of this war. In 1855 Lord Raglan, master general of the ordnance, died in the Crimea, and the whole board of ordnance was then abolished. Engineer officers and men were at last amalgamated in one "Corps of Royal Engineers" and came directly under the commander-in-chief.

The most distinguished engineer officer of this period, and the first engineer to become field-marshal, was Sir John Burgoyne, who won fame both as military and civil engineer; he died in 1871, aged 89 years, of which 68 had been devoted to the public service. The first mounted troop was hurriedly formed for the transport of bridging equipment in the Crimea, but had no regular status until 1863, when "A" pontoon troop and "B" field equipment troop were formed at Aldershot with a mounted depot to serve both. Field signalling had been first devised and practised at Chatham; also trials with the electric telegraph. Two sappers trained in telegraphy were sent to the Crimea, where they established precarious communication between the trenches and the base; but economy hampered progress, and little more was done until 1870 when, under the influence of the Franco-German War, "C" telegraph troop was added to those at Aldershot. In the same year a detachment of R.E. telegraphists was sent to the post office for employment and training; later they were formed into a regular unit, which for many years exercised complete control over the civil telegraph system in a large part of southern England. The mounted detachment (later named field troop, and then field squadron) was first formed for service in Egypt in 1885.

Ballooning for military purposes was first practised by the French revolutionary armies at the end of the 18th century. Early efforts by R.E. officers met with cold support, and not till 1890 was a proper establishment formed at Aldershot; theoretical instruction in ballooning being added at the same time to the Chatham course. The balloon detachment saw service in the Sudan in 1884, and later in Bechuanaland and South Africa; and gradually died out with the advance of aviation. Submarine mining was introduced by the Royal Engineers. Established as a regular service about 1863, it remained in the hands of the corps for more than 40 years, and was then taken over by the navy. Mechanical transport was another child of the military engineer. Instruction in the maintenance and driving of steam road vehicles (then termed steam "sappers") was given at Chatham, and the first steam road transport unit was organized for service in South Africa in 1899 as an engineer unit.

The charge of military buildings was entrusted to the Royal Engineers in 1826, and at the same time training in practical architecture was added to the course at the School of Military Engineering, Chatham. For over 100 years this has provided the principal means by which British military engineers have been practised in peace in the various branches of constructional engineering and have been kept abreast of scientific advance and development. The greatest monuments to their skill as architects are perhaps to be found in India, exemplified in the irrigation works, railways, surveys, roads, bridges, public buildings and defences of the country. The Indian corps of engineers, at first separately constituted in the three presidencies, and reorganized in 1770 by the East India Company, was finally amalgamated with and became part of the Corps of Royal Engineers in 1862, when Indian administration was transferred to the Crown.

During the latter half of the 19th century R.E. officers were prominent in many lands and many spheres as soldiers, scientists and statesmen. Among famous soldiers may be mentioned Field-Marshals Lord Napier, Sir J. Lintorn Simmons, Lord Nicholson and Maj.-Gen. Charles ("Chinese") Gordon. One of the outstanding figures of the World War of 1914–18, Field-Marshal Earl Kitchener, belonged to the corps of Royal Engineers, among whose officers many rose in the war to high commands and posts, the latter including both adjutant-general and quartermaster-general to the forces. The Institution of Royal Engineers was founded in 1875 with the object of "the general advancement of military science and more particularly for promoting the acquisition of historical and scientific knowledge in relation to engineering as applied to military purposes." In 1923 the institution received the honour of incorporation by royal charter.

United States.—*See* below.

France.—The history of the French engineers shows a somewhat similar development to that of the British. Originally, selected infantry officers were given brevets as engineers; they performed both civil and military duties for the king's service by the aid of companies of workmen, who were enlisted and discharged from time to time. The "Corps de Génie" was founded about 1690 by Vauban, a famous engineer known alike for his skill in designing fortresses and for his system of attack whereby many were later captured in far less time than had been expended in their building. Officers were selected from both soldiers and civilians for the corps, which soon achieved a world-wide reputation as the leading school of fortification and siege-craft. The title of "Génie" was conferred on officers in 1766 and on the companies of sappers and miners in 1801. The commander-in-chief of the French armies in 1914, Marshal Joffre, was an officer of the "Corps de Génie."

Germany.—Prior to 1809 there were separate corps of engineer officers, troops of miners, sappers and pontoniers. The disastrous campaign of 1806 led to reorganization of the army, and in 1809 the engineer troops were combined in a composite corps of engineers and pioneers. The corps was strictly relegated to building and fortress work, and had little if any share in the technical developments of the age. Although the staff took steps to ensure military control of systems of communication in war, military engineers had no part in the technical working of railways or telegraphs; thus they got gradually out of touch with tactics and military science generally. As a result of the Danish and Austrian wars, the higher control of pioneers and fortresses was reorganized, and engineer officers were given rather better opportunities to qualify for the command of all arms. Various improvements in organization had been completed when the Franco-German War of 1870 broke out; but there was a great shortage of officers and material which was continually felt in spite of the devoted service of the corps. There was also serious lack of mutual understanding between the pioneers and other arms. At this period a pioneer battalion consisted of three field companies, a pontoon column, train section, three fortress companies and a depot company. After the war many technical developments had to be pursued, but the corps always had to struggle for adequate establishments. Ballooning was investigated by the engineer committee in 1868. In 1870 two war balloons were obtained from England, and detachments were trained at Cologne to man them, but they met with little success. After the Franco-German war experiments were pushed ahead, and the balloon detachment was on a firm basis a few years later. Submarine mining was studied to some extent by engineer officers from 1871 onwards, but in 1884 was taken over finally by the navy.

THE WORLD WAR

General.—The War of 1914–18 has often been termed an engineers' war, a true description in so far that the increase in the engineer arm was proportionately much greater than in any other; but in the wider sense—the substitution of mechanical for human energy—field engineering made strangely little advance. The variety of work undertaken by military engineers and the numbers of men employed were alike immense. In the British army, on the outbreak of war, the engineer arm amounted to 2% of the total forces; in 1918 it had increased to 12% or 16% if the transportation branch is included; during the same period the total

engineer strength rose from under 14,000 to nearly 330,000. Tactical features varied from trench warfare, recalling the ancient art of siege-craft, to the most rapid movement of mobile columns; climatic conditions from the Arctic cold of Russia to the tropical heat of East Africa; while the enormous concentrations of men and material required, from engineers on lines of communication and at bases, constructional work on a scale previously unknown in war. The undoubted success of the British engineers in meeting these heavy demands is a testimonial to the basic soundness of their all-round training and elastic organization.

The heavy drain on French man-power in the early stages of the struggle made increases in the technical arms a matter of continuous difficulty, while serious drawbacks were inseparable from the system of entrusting rearward services to unfit and over-age personnel.

Engineer development in the German army followed much the same lines as in the British. The German engineers were always struggling to overcome the handicap of short numbers and lack of mutual understanding with which they started the war. They had constant difficulty in finding men for new scientific activities, and were further hampered by having to provide personnel to man the trench-mortar detachments which they initiated and kept throughout the war.

In the allocation of troops to the American army, based on the lessons of experience, provision for technical services was made on a far more liberal scale than had been found possible by any other nation.

Expansion and Work of the Royal Engineers.—Engineer units with the original expeditionary force consisted of a field squadron with the cavalry, one signal and two field companies per infantry division, one bridging train per corps, miscellaneous headquarters' signal units, and three small works or fortress companies for the base. Very early a third field company was added to each division; also an infantry pioneer battalion. Fortress companies were reorganized and re-named "army troops companies"; they undertook all general field engineering outside divisional zones and were raised on a scale of one per division with additions for lines of communication. By degrees various special units were formed both for the field armies and the bases, including electrical and mechanical, workshop, stores, land drainage, water supply, etc. Special tunnelling companies, composed of miners from the colliery districts, were raised early in 1915. By the end of 1916 there were, including men from the Dominions, 25,000 in the field. The greatest mining operation in military history was carried out in connection with the capture of the Messines ridge in June 1917, when charges containing nearly a million pounds of explosive were fired under the German lines. Water supply necessitated work of great importance and variety. Before the battle of the Somme 110 power pumps and 120m. of 4in. pipe-line were installed, and were then added to as the battle progressed. In Flanders special purification processes were largely used; from one pumping station alone 200,000 gallons of very impure Yser water were daily delivered, filtered and purified, to the troops. Special boring sections were formed for the chalk country, and deep well bores varying from 200ft. to 700ft. were sunk on the advice of geologists. For the Palestine campaign a pipe-line was laid across the desert, and filtered Nile water was delivered to a distance of over 150m. during the operations which drove the Turkish army from Beersheba. During the final three months of the war in France 326 steel girder bridges were erected by British and Dominion engineers, in addition to large numbers of timber and of pontoon equipment. Stock girders had been specially designed and details of erection carefully worked out during the long period of immobility; a number of spans were capable of carrying weights up to 30 tons, a striking increase over the pre-war normal load of two tons.

Miscellaneous duties of the engineers included camouflage, anti-aircraft searchlights, survey (including flash-spotting and sound-ranging), chemical warfare, meteorology, geology, post office. Tanks, although organized as a separate arm, were commanded, from their first introduction in 1916 to the end of the war, by a Royal Engineer officer. The part played by officers of the Royal Engineers in their conception and introduction is discussed under TANKS. A separate transportation branch was formed at the end of 1916 which assumed entire control of railways, normal and light, roads, inland water transport, cross-channel ferry, port construction, dock working, ropeways, and all the stores, workshops and administrative services concerned. Signal units remained part of the corps of Royal Engineers throughout the war, but formed practically an independent service. Faced with a multitude of new problems they underwent continual changes and expansion. During the first year of war 20,000m. of field cable were laid; and, during the final year, the amount was 245,000m., these figures being for France. The director of works at the base was responsible for engineering activities on a very great scale. Starting with but two assistants he controlled at the time of the Armistice a staff of nearly 200, in spite of having handed over forestry and engineer stores to independent directorates, and quarries to the transportation branch. Engineer stores were remarkable both for number and variety. A small proportion was procured in theatres of war by local purchase or production, but the main supplies were arranged for by the director of fortifications and works at the War Office. Varying from sandbags to complete irrigation plant for Mesopotamia the monthly shipping tonnage several times exceeded 200,000 tons. Of sandbags 313 million were despatched in one year, and 40 million in one month alone to France.

POST-WAR ORGANIZATION

British Army.—In the regular army the principal changes have been: the separation of signals from the Royal Engineers; the addition of a small headquarters unit, termed field park company, to divisional engineers; and the formation of an anti-aircraft searchlights engineer battalion. Other units that were found necessary in the war have since been provided as "supplementary reserve." They include transportation, army troops, electrical and mechanical, workshops and stores companies, bridging trains and postal section. The personnel of these units do short periods of training and receive a bounty, in return for which they accept liability to be called up for service in case of war. The territorial army embraces divisional, fortress and anti-aircraft searchlight engineers. Royal Engineers serving in India are organized in military engineer services and three corps of sappers and miners under the direct control of the engineer-in-chief; officers are also regularly employed under the civil departments of railways, surveys and public works. In the forces of the Dominions appropriate engineer troops are provided on a similar basis to the regular army. The total engineer strength of the regular army is roughly 1,100 officers and 7,700 other ranks. The latter include men of some two dozen different trades and are obtained partly by direct enlistment and partly from boys who are given a trade training before being posted to the ranks. The majority of the officers pass through the Royal Military Academy, Woolwich, as cadets, and then do a technical course of general and military engineering partly at the School of Military Engineering, Chatham, and partly at Cambridge university, where they study for the Mechanical Sciences Tripos. A few with engineering qualifications are admitted each year direct from the universities and the Dominions. Selected officers later go through practical courses in railway, electrical and mechanical engineering.

Other Armies.—The peace strength of the United States corps of engineers is about 350 officers and 5,000 other ranks. There is a separate signals service which, as in the case of the British army, has a strength roughly equal to half that of the engineers. Most armies now have a separate signals service, though it still has some connection with the engineer organization in the French, Italian, Japanese and Czechoslovak armies. In the last-named the bridging battalion is a special unit in which service is much sought after. Stationed on the Danube for the river defence of the republic it is quasi-naval, manning river gun-boats and performing mining and mine-sweeping duties, in addition to all forms of bridging. The Italian engineers are entrusted with a particularly wide range of duties. They have always been famous for their skill in overcoming the natural difficulties of mountainous

terrain and fast flowing rivers.

A camouflage section is now generally included among engineer troops. Searchlights form, in most cases, a function of the artillery, and this branch has taken over considerable survey activities, including flash-spotting and sound-ranging. The organization of the German engineer and pioneer corps, as defined by the Treaty of Versailles, remains practically as in 1914. The progress of "Mechanization" has peculiar interest for military engineers; and it is impossible to forecast the extent to which it may affect their future organization and employment. (G. H. A.)

UNITED STATES

The need for military engineers was recognized in the War of the Revolution, and General Washington was authorized to raise, officer and equip a corps of engineers. Three companies of sappers and miners were organized, and Brigadier General Louis LeBègue du Portail, of the Royal Corps of Engineers of the French Army, was made commandant of the corps. The appointment of a foreigner to fill this important post is indicative of the deficiency of trained engineering talent available at that time in the American states. The corps was mustered out of the service at the close of the war.

A corps of combined artillerists and engineers had a brief existence, commencing in 1794, but the disadvantage of uniting under one head the art of fortification and the service of artillery was soon apparent and the union was discontinued by the Act of Congress of March 16, 1802, which formally established the Corps of Engineers. The latter corps has constituted the principal engineer component of the regular army of the United States ever since. Officers with the special functions of topographical engineers were appointed on the staff during the War of 1812, and later were formed into a topographical bureau under the Chief of Engineers. A distinct Corps of Topographical Engineers, created in 1838, was merged into the Corps of Engineers in 1863. The Act of 1802 provided that the Corps should be stationed at West Point in the State of New York, where it should constitute a Military Academy, and that the officers should be available for duties elsewhere at the discretion of the President. Major Jonathan Williams was the first Superintendent of the Military Academy, the supervision of which remained in the hands of the Corps of Engineers until 1866, when the superintendency passed to the Army at large.

From the first the officers of the Corps were employed upon the fortification of the coast. For a long time they were the only trained engineers in the country, and their services were utilized on many important public works. Almost all of the routes of internal communication now in existence in the United States were first explored, located and projected by them. The non-military duties imposed upon the officers of the Corps of Engineers by various laws enacted from time to time by Congress embrace, to mention only a few: the improvement of the rivers and harbours of the country for commerce; the planning and construction of lighthouses and other fixed aids to navigation; the planning and construction of many public buildings, monuments and utilities in the National Capital, notably the Capitol, the Washington Monument, the Library of Congress and the Lincoln Memorial; the construction of the Panama Canal; the improvement of the Great Lakes for navigation; the opening of roads and trails in Alaska; and the enforcement of certain laws pertaining to water power and navigation.

Justification for employing army engineers in these civil peacetime pursuits is found in the opportunities such service affords for developing the engineering skill, broad experience in affairs, and general knowledge of the country, which are so valuable in an officer in time of war, whether in the handling of large bodies of troops in military engineering operations, or in the staff work of procurement of supplies, or in the application of the latest developments of engineering science to the solution of the problems arising out of new forms of warfare. The soundness of this policy has been repeatedly demonstrated, notwithstanding the view held by some officers that long periods of service on civil work tend to take officers out of touch with military progress. Whatever merit this contention may have had in the past, the statutory requirement that every officer shall serve with troops at least one year in every five largely corrects the tendency. Furthermore, it is now customary to give officers on civil assignment additional duties of a military nature, such as the conduct of military instruction for the officers of the Organized Reserves, thus ensuring that they keep abreast of changes in the tactics and technique of engineer troops. Officers of the Corps of Engineers have invariably been called upon to direct the creation and early pioneering of new branches of the military service. The submarine mine service, air service, chemical warfare service, the motor transport corps and the tank corps are examples. The Act of 1802, establishing the Corps of Engineers, made no provision for enlisting engineer troops and none were raised until 1812, when one company of bombardiers, sappers and miners was authorized for service in the war with Great Britain. After this company was disbanded in 1821, the army was without engineer troops until 1846 when a single company was again provided for service in the Mexican War.

Upon the outbreak of the Civil War in 1861 the number of engineer companies was increased to four, and, while no battalion organization was legally authorized, it was found expedient to form the companies into a provisional battalion to be commanded by the senior officer present. The battalion was attached to the Army of the Potomac during the winter of 1861–62, and was engaged chiefly upon the defences of Washington and in training. In the succeeding years of the war the battalion was engaged upon the construction of roads, fortifications, and bridges, with the troops in campaign. A noteworthy bridge constructed by this battalion was a pontoon bridge 1,980 feet long, built across the Chickahominy River on August 14, 1862.

The present army regulations charge the Corps of Engineers with the following duties within the theatre of operations: (1) All work of construction and the repair and maintenance of all structures of every character, except telephone and telegraph systems and other signal communications for the use of troops. (2) Military mining, demolitions and protective measures against enemy mines. (3) The operation of railways, portable and fixed electric light and power systems, water supply systems, and all other utilities of general service, except such as are specifically assigned to other services. (4) The execution of surveying and mapping, including the production and distribution of maps. (5) The procurement, storage and issue of all materials for construction work, for the organization of defence systems, and for all other operations assigned to the engineer service, including all plants, tools and appliances for such work.

These duties include: the construction, repair and maintenance of roads and trails; of bridges and other means for crossing rivers and similar obstacles; of shelter for troops and animals, including huts, hospital buildings, barracks, stables and accessory structures; of storehouses, shop structures, hangars and flying fields, including in proper cases the installation of the necessary machinery; of wharves, railroads and light railroads; the provision of water supply, including sterilization in bulk, the provision and installation of baths, disinfectors, dipping vats and incinerators; the installation of plumbing, sewage disposal and heating plants; the installation of machinery for refrigerating plants, laundries and other mechanical plants; assistance to other arms in entrenching, and in organizing defensive lines; the organization and construction of rear lines of defence; the construction of bombproofs, observation stations, machine-gun emplacements and other special works of defence; the execution of special measures for destroying or overcoming enemy obstacles; the supply of camouflage material and the supervision and inspection of its use; the preparation of signs for the direction of troops, including road signs, traffic signs, signs indicating the location of water points and other establishments, and signs safeguarding against the use of impure water; the operation of electric light, gas and power plants and water supply plants; the operation of shops for the erection and repair of railroad rolling stock, of construction machinery of all kinds and for the manufacture of special appliances for engineer operations; photographic and cinematographic work pertaining to terrestrial reconnaissance; terrestrial

surveying; map making and map reproduction; the training of engineer troops for all their duties, and the compilation of technical data and the preparation of training literature on subjects pertaining to any of the operations assigned to the Corps of Engineers.

The experience of the World War indicates that, to carry out these manifold duties, a proper proportion of engineer troops of all classes must be included with each field force if the combatant arms are to be free to devote their efforts to defeating the enemy, unembarrassed by diversions of fighting troops to tasks, no less essential, on the lines of communication. A field force containing an adequate proportion of supporting line-of-communication troops is called a "balanced force," and includes for each field army of 9 infantry divisions (approximately 400,000 troops) the following engineers:

Number of units required for balanced force	Type of unit	Unit strength	
		Officers	Enlisted men
9	Combat Regiments	38	845
10	General Service Regiments	38	1150
21	Engineer Battalions	16	1037
4	Bridge Battalions (heavy)	16	451
1	Camouflage Battalion	22	560
2	Mounted Battalions	15	330
6	Railway Battalions	18	622
1	Topographic Battalion (Army)	18	560
1	Topographic Battalion (GHQ)	18	560
2	Water Supply Battalions	18	590
6	Bridge Companies (light)	4	160
1	Camouflage Company	13	250
5	Depot Companies	4	160
2	Dump Truck Companies	4	152
2	Railway Shop Companies	4	160
2	Shop Companies	4	160
2	Railway Headquarters	10	27
	Engineer sections at		
1	General Headquarters	9	26
1	General Headquarters Reserve	9	23
1	Communications Zone	10	27
1	Army Headquarters	28	105
3	Corps Headquarters	5	17

The combat and general service regiments, mounted battalions, and engineer battalions, are denominated general engineer troops; all others are special engineer troops. General engineer troop units which constitute 70% of the engineers in a balanced force differ among themselves principally in size and in the qualifications of the headquarters personnel.

The special engineer organizations are provided for purposes suggested by their names. Bridge battalions and companies transport the equipage with which general engineer troops construct floating bridges. Camouflage battalions manufacture and supply camouflage materials and give instructions to troops in their proper employment. Railway battalions operate and maintain railways, both narrow and broad gauge. Topographic battalions make terrestrial surveys and reproduce maps by photolithographic processes. Water supply battalions transport water in tank trucks. Depot companies furnish the technical personnel for engineer supply establishments. Dump truck companies furnish transportation on engineer operations involving earthwork. Railway shop companies make major repairs to standard railway equipment. Shop companies assemble, test and repair machinery and do manufacturing.

Most engineer units are armed and trained to engage in combat as riflemen, but, except for a few automatic rifles with the combat and general service regiments, and machine guns with the mounted battalions, the units lack the supporting weapons and communication equipment requisite to effective infantry combat. It is only the gravest emergency that warrants the employment of the highly trained technical personnel of engineer units in combat, as such use involves the virtual abandonment of maintenance work on the routes of communication, and must ultimately result in the breakdown of supply and the curtailment of manoeuvre. The chief engineer officer at each headquarters is known as the unit engineer. He has the dual role of technical staff officer and commander of engineer troops. In the infantry and cavalry divisions the commander of the divisional engineer troops is a member of the staff of the division commander.

During the World War there was a tendency toward over-specialization in engineer troop units, separate organizations being raised for many special purposes besides those outlined above. The consensus of military thought is that the most satisfactory results can be obtained when the bulk of the engineer service consists of general engineer units. These are so organized, equipped and trained, that they may be employed indiscriminately upon engineer work of almost any character, whereas special units, being recruited usually from a limited class of artisans and being organized and equipped for particular purposes, are not readily adaptable to employment upon tasks not closely related to their specialties.

Most of the officers of the Corps of Engineers are obtained from the United States Military Academy at West Point, a few cadets at the head of each class being selected for assignment to the corps. In addition, a few officers are obtained from the graduates of civil technical schools. The education of the engineer officer continues throughout his career in the Army. Those officers who graduate from West Point are sent for one year to civil institutions to supplement their instruction in technical subjects not included in the curriculum of the Military Academy. All the officers, including those from West Point, attend for one year the Engineer School at Fort Humphreys, Virginia, where they pursue the Company Officers' Course, covering military engineering, harbour defence, tactics, logistics and certain engineering subjects pertaining to the civil work of the corps. The next step in the educational scheme is detail as student officers under district engineer officers engaged on civil works, after which the officers are available for general assignment. Engineer officers, like other army officers, are subject to further military education at the Command and General Staff School, at the Army Industrial College, and at the Army War College. It is the policy of the Chief of Engineers to broaden the officers' knowledge of the country by assigning them to duty in different localities. It will be seen from the foregoing that no effort is made to develop specialists, although, through necessity, some officers must be dedicated to such specialties as aerial photographic mapping, map reproduction and certain hydraulic technicalities incident to the civil work of the Corps. The aim is rather to give a broad and general scientific and practical training, looking ultimately to the application of physical science to the preparation for and conduct of military operations. A school for the instruction of enlisted specialists is conducted at Fort Humphreys. Practical experience is given selected men in suitably equipped shops in map reproduction, photography, mechanical drafting, surveying and machinery.

The training of the officers of the Corps of Engineers reserve comprises correspondence courses, inactive duty conference courses and fifteen-day periods of active duty training either with troops of the Regular Army or at headquarters, depending upon their individual assignments. A limited number of reserve officers attend the Engineer school.

When the United States entered the World War, the engineers available for immediate service consisted of 256 officers and 2,228 soldiers. At the time of the Armistice in November, 1918, there were under the Corps of Engineers 10,886 engineer officers and 292,300 soldiers of whom 174,000 (officers and men) were with the American Expeditionary Forces. The Engineers with the American Expeditionary Forces, besides participating in all combat operations, handled over 3,000,000 tons of engineer supplies, constructed an aggregate of 6,360 feet of wharves at ports, constructed 967 miles of standard gauge railroad, provided hospital space for 141,000 beds, constructed 16,000 barracks, operated 1,390 miles of light railway and cut 218,211,000 board feet of lumber.

As now organized (1928), the engineer branch of the army of the United States includes the Corps of Engineers of the Regular Army, 520 officers and about 5,000 enlisted men; the engineer organizations of the National Guard, about 500 officers and 8,000 enlisted men; and the engineer section of the Officers' Reserve Corps, about 7,000 officers. The latter are given assignments to organizations which are to be mobilized in time of war, but which are without enlisted men in peace time. (G. B. T.)

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ENGINES OF WAR. The bow was in all probability the earliest "engine" of war devised by man, the sling and the blowpipe being of later date. In any case we know that the bow was used in the South of France and Cantabria by the prehistoric hunter-artists in the 10th millennium B.C., and that in the East from the earliest historical times it was a common weapon of war. The idea of a more powerful weapon, especially in siege work, when it was necessary to outrange the hand bow in order to cover by fire the approach of scaling and assaulting parties, probably arose in the East during the 9th or 8th century B.C. In the Bible we read that Uzziah, who reigned from 808–9 to 756–7 B.C., "made in Jerusalem engines invented by cunning men, to be on the towers and upon the bulwarks, to shoot arrows and great stones withal."

These engines fall into two main groups, namely, catapults (*q.v.*) and ballistae which to-day are represented by howitzers and guns, the first being used for high and the second for low trajectory fire. In both cases the force of propulsion was generated by tightly twisting a skein of rope, hair or sinew, prepared in a manner now unknown, for though in recent years many replicas of both these engines have been constructed the problem of maintaining the elasticity of the sinews has remained unsolved. Nevertheless, sufficient experience has been gained with the indifferent modern machines to prove that the range claimed by classical writers, varying from 400 to 800 yards, is no exaggeration. The projectiles used were of various kinds, such as large arrows, small metal balls, stone balls and large pebbles coated in baked clay which shattering on impact prevented the enemy using them in his own machines. Their weight varied from a few pounds to sixty or even more. The most complete account of the catapult is given by the historian Ammianus Marcellinus, who says: "In the middle of the ropes (twisted skein) rises a wooden arm like a chariot pole . . . to the top of the arm hangs a sling . . . when battle is commenced a round stone is set in the sling . . . four soldiers on each side of the engine wind the arm down till it is almost level with the ground . . . when the arm is set free it springs up and hurls forth from its sling the stone, which is certain to crush whatever it strikes. This engine was formerly called the 'scorpion,' because it has its sting erect, but later ages have given it the name of onager, or wild ass, for when wild asses are chased they kick the stones behind them." As a protection against the projectiles thrown, Caesar informs us that curtains woven from cable-ropes were sometimes used.

The origins of artillery among the Greeks probably took place in Sicily where they came into contact with the Carthaginians. Diodorus informs us that engines first came into use in 397 B.C. when Dionysius of Syracuse was waging his Punic War. In any case at a later date the Carthaginians relied very largely on artillery. We learn from Livy that when New Carthage was taken by the Romans in 146 B.C., 120 great catapults, 281 small ones, 23 great ballistae and 52 small ones were captured. And it may be noted, that according to Appian of Alexandria, a little previous to this siege the Carthaginians surrendered to the Romans "catapults for shooting swift bolts and for throwing stones to the number of 2,000."

It appears that from Sicily these machines were introduced into Greece, for they were certainly made use of by Philip of Macedon, 360–336 B.C. Under his son Alexander a definite body of artillerists was established, ballistae being mounted on carriages, known later as carro-ballistae, and used by this great soldier as field and mountain artillery are to-day, especially in his campaigns against the Danube tribes and the Scythians. Under his successors, the Diadochi, it may be said that an artillery age was entered, for not only do we find a frequent use of catapults and ballistae but an ever increasing interest taken in their construction by the scientists of Alexandria. There, in the 3rd century B.C., a certain Dionysius invented the first recorded machine-gun called "polybolos" or "repeater-thrower," which fired a succession of arrows from a magazine. At about the same time Ctesibius, an Alexandrian engineer, geared to the catapult arms pistons "working in carefully wrought cylinders." Accounts of these engines and others are given in the works of Heron (284–221 B.C.) and Philo (about 200 B.C.). Among the successors of Alexander, the greatest engineer was undoubtedly the famous Demetrius Poliorcetes, who in 304 B.C. besieged Rhodes, and used all manner of projectile engines, and so important did they become in field and siege operations that at the third battle of Mantineia (207 B.C.) we find a counterpart to the modern artillery battle (*see* Polyb. xi. 12).

In their turn the Romans copied the Greeks, but produced less perfect weapons, such as those depicted on the Trajan Column. The Romans made frequent use of them, having learnt to their cost their value during their siege of Syracuse in 214–212 B.C., in which siege, as Plutarch tells us in his Life of Marcellus, Archimedes "was the informing soul. All other weapons lay idle and unemployed, his were the only offensive and defensive arms of the city." Further Plutarch writes: "Archimedes soon began to play his engines upon the Romans and their ships, and shot stones of such an enormous size (about 100 lb.) and with so incredible a noise and velocity that nothing could stand before them. The stones overturned and crushed whatever came in their way, and spread terrible disorder through the Roman ranks. . . . At length the Romans were so terrified that, if they saw but a rope or a beam projecting over the walls of Syracuse, they cried out that Archimedes was levelling some machine at them and turned their backs and fled."

From this date onwards we find the Romans paying more and more attention to artillery, and especially so in the first century B.C. In the days of Julius Caesar full use was made of catapults and ballistae in the field as is illustrated by his battle with the Bellovaci in 51 B.C., when he drew up his engines in such a way that they could play upon the enemy's columns. At Dyrrachium his IXth Legion seized a hill and began to fortify it when Pompey's soldiers occupied a neighbouring hill and brought such a concentrated artillery fire to bear on Caesar's legionaries that they were forced to withdraw. Josephus, an eyewitness, informs us that at the siege of Jotapata, in A.D. 67, Vespasian used 160 engines. He says: "The noise of the instruments themselves was very terrible, the sound of the darts and stones that were thrown by them was so also; of the same sort was the noise that dead bodies made when they were dashed against the wall." From about this date onwards artillery became an established arm in the legion, and according to Vegetius each cohort was equipped with one catapult, and each century with one carro-ballista, 11 soldiers being required to work the latter machine. The legion, therefore, possessed an artillery train of 60 carro-ballistae and ten catapults, 70 engines in all, which corresponds closely to the number of field-guns and howitzers in a modern infantry division. *See* CATAPULT, BATTERING RAM, FORTIFICATION AND SIEGECRAFT.

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ENGIS, a cave on the banks of the Meuse near Liége, Belgium, where in 1832 Dr. P. C. Schmerling found human remains in deposits belonging to the Quaternary period. Bones of the cave-bear, mammoth, rhinoceros and hyena were discovered in

association with parts of a man's skeleton and a human skull. This, known as "the Engis Skull," gave rise to much discussion among anthropologists, since it has characteristics of both high and low development.

See P. C. Schmerling, ***Recherches sur les ossements découverts dans les cavernes de la province Liège*** (1833); Huxley, ***Man's Place in Nature***, p. 156; Lord Avebury, ***Prehistoric Times***, p. 317 (1900).

ENGLAND. Geographical usage confines the name to the southern part of the island of Great Britain, excluding its western peninsula of Wales. It is the largest, wealthiest and most populous of the units within the United Kingdom of Great Britain and Northern Ireland.

England extends from the mouth of the Tweed in 55° 46′ N. to Lizard Point in 49° 57′ 30″ N., in a roughly triangular form. The base of the triangle runs from the South Foreland to Land's End west by south, a distance of 316 m. in a straight line, but 545 m. following the larger curves of the coast. The east coast runs north-north-west from the South Foreland to Berwick, a distance of 348 m., or, following the coast, 640 m. The west coast runs north-north-east from Land's End to the head of Solway Firth, a distance of 354 m., or following the much-indented coast, 1,225 m. The total length of the coast-line may be put down as approximately 2,350 m., out of which 515 m. belong to the western principality of Wales. The most easterly point is at Lowestoft, 1° 46′ E., the most westerly is Land's End, in 5° 43′ W. The coasts are nowhere washed directly by the ocean, except in the extreme south-west; the south coast faces the English Channel, which is bounded on the southern side by the coast of France, the two shores converging from 100 m. apart at the Lizard to 21 at Dover. The east coast faces the shallow North sea, which widens from the point where it joins the Channel to 375 m. off the mouth of the Tweed, the opposite shores being occupied in succession by France, Belgium, Holland, Germany and Denmark. The west coast faces the Irish sea and St. George's Channel, with a width varying from 45 to 130 m.

The area of England and Wales is 37,327,479 ac. or 58,324 sq.m. (England, 50,851 sq.m.). The principal territorial divisions of England, as of Wales, Scotland and Ireland, are the counties (*see* below), of which England comprises 40. Their boundaries are not always determined by the physical features of the land; but localities are habitually defined by the use of their names.

Physical Geography.—The land is highest in the west and north, where the rocks also are oldest, most disturbed, and hardest, and the land surface gradually sinks towards the east and south, where the rocks become successively less disturbed, more recent and softer. The study of orographical and geological maps of the country allows a broad distinction to be drawn between the west and east. The contrasted districts are separated by an intermediate area, which softens the transition between them, and may be described separately.

The Western Area is composed of Archaean and Palaeozoic rocks, embracing the whole range from pre-Cambrian up to Carboniferous. The outcrops of these rocks succeed each other in order of age in roughly concentric belts, with the Archaean mass of the island of Anglesey as a centre, but the arrangement in detail is much disturbed and often very irregular. Contemporary igneous outbursts are important in some of the ancient formations, and add, by their resistance to atmospheric erosion, to the ruggedness of the scenery (*see* CARNARVONSHIRE). The hills and uplands of ancient rocks do not always form regular ranges, but often rise like islands in distinct groups from a plain of New Red Sandstone (Permian and Triassic), which separates them from each other and from the newer rocks of the Eastern Area. Each of the uplands is a centre for the dispersal of streams that flow rapidly to the sea.

The Eastern Area, lying to the east of the zone of New Red Sandstone, is defined on the west by a slightly curved line drawn from the estuary of the Tees through Leicester and Stratford-on-Avon to the estuary of the Severn, and thence through Glastonbury to Sidmouth. It is built up of nearly uniform sheets of Mesozoic rock, the various beds of the Jurassic lying above the New Red Sandstone (Triassic), and dipping south-eastward under the successive beds of the Cretaceous system. In exactly the same way the whole of the south-east of the island appears to have been covered uniformly with gently dipping beds of early Tertiary sands and clays, beneath which the Cretaceous strata dipped. At some period subsequent to this deposition there was a movement of elevation, which appears to have thrown the whole mass of rocks into a fold along an anticlinal axis running west and east, which was flanked to north and south by synclinal hollows. In these hollows the early Tertiary rocks were protected from erosion, and remain to form the London and the Hampshire Basins respectively, while on the anticlinal axis the whole of the early Tertiary and the upper Cretaceous strata have been dissected away, giving the complex configuration of the Weald. The general character of the landscape in the Eastern Area is a succession of steep escarpments formed by the edges of the outcropping beds of harder rock, and long gentle slopes or plains on the dip-slopes, or on the softer layers; clay and hard rock alternating throughout the series.

The structural contrasts between the Western and the Eastern Areas are masked in many places by deposits of boulder clay, covering most of the low ground north of the Thames basin.

The history of the origin of the land-forms of England is exceedingly complicated. Every geological formation (except the Miocene) is represented, suggesting a long and complicated past. Geologically the separation of Ireland was a comparatively recent episode, while the severance of the land-connection between England and the continent by the formation of the Strait of Dover is still more recent and within the human period.

NATURAL DIVISIONS

The Western Area: The four groups of high land rising out of the plain of red rocks are:—

(*a*) The Lake district, bounded by the Solway Firth, Morecambe bay and the valleys of the Eden and the Lund.

(*b*) The Pennine region, which stretches from the Scottish border to the centre of England running south.

(*c*) Wales (*q.v.*), forming the western landward boundary of England.

(*d*) The South-western peninsula, comprising mainly the counties of Devon and Cornwall.

They are all similar in the great features of their land-forms, which have been impressed upon them by the prolonged action of atmospheric denudation rather than by the original order and arrangement of the rocks; but each group has its own geological character, which has imparted something of a distinctive individuality to the scenery. Taken as a whole, the Western Area depends for its prosperity on mineral products and manufactures rather than on farming; and the staple of the farmers is live-stock rather than agriculture.

Lake District.—The Lake District occupies the counties of Cumberland, Westmorland and north Lancashire. It forms a roughly circular highland area, the drainage lines of which radiate outward from the centre in a series of narrow valleys, the upper parts of which cut deeply into the mountains, and the lower widen into the surrounding plain. Many of the valleys have long narrow lake basins such as Windermere and Coniston, draining south; Wastwater, draining south-west, Ennerdale water, Buttermere and Crummock water (the two latter, originally one lake, are now divided by a lateral delta), draining north-west; Derwent water and Bassenthwaite water (which were probably originally one lake), and Thirlmere, draining north; Ullswater and Haweswater, draining north-east. There are, besides, numerous mountain tarns of small size, most of them in hollows barred by the glacial drift which covers a great part of the district. The central and most picturesque part of the district is formed of great masses of volcanic ashes and tuffs, with intrusions of basalts and granite, all of Ordovician (Lower Silurian) age. Scafell and Scafell Pike (3,162 and 3,210 ft.), at the head of Wastwater, and Helvellyn (3,118), at the head of Ullswater, are of great grandeur in spite of their moderate height. Sedimentary rocks of the same age form a belt to the north, and include Skiddaw (3,054ft.); while to the south a belt of Silurian rocks, thickly covered with boulder

clay, forms the finely wooded valleys of Coniston and Windermere. Round these central masses of early Palaeozoic rocks there is a broken ring of Carboniferous limestone, and several patches of Coal Measures, while the New Red Sandstone appears as a boundary belt outside the greater part of the district, and is especially marked in the vale of Eden and the Carlisle plain, giving good agricultural land. Where the Coal Measures reach the sea at Whitehaven, there are coal-mines, and the hematite of the Carboniferous limestones has given rise to ironworks at Barrow-in-Furness. Except in the towns of the outer border, the Lake district is very thinly peopled, although the remarkable beauty of its scenery attracts numerous residents and tourists. The very heavy rainfall of the district, which is the wettest in England, has led to the utilization of Thirlmere as a reservoir for the water supply of Manchester, over 80m. distant. The district is one of human contrasts, between the simple pastoral life of the high moorlands, and the richer agricultural life that centres around the "Border City," Carlisle. Both forms of life are in greater contrast to the industrial regions of the western coastland south of the district.

Pennine Region.—The Pennine region, the centre of which forms the so-called Pennine Chain, is the outstanding feature of northern England. The region is composed of Carboniferous rocks, the coal and iron deposits making the flanks of the highland busy manufacturing districts, and the centres of dense population. The whole region may be looked upon as formed by an arch or anticline of Carboniferous strata, the axis of which runs north and south; the centre has been worn away by erosion, so that the Coal Measures have been removed, and the underlying Millstone Grit and Carboniferous limestone exposed. On both sides of the arch, east and west, the Coal Measures form outcrops which disappear towards the sea under the more recent strata of Permian or Triassic age. The northern part of the western side of the anticline is broken off by a great fault in the valley of the Eden, and the scarp thus formed is rendered more abrupt by the presence of a sheet of intrusive basalt. In the north the Pennine region is joined to the Southern Uplands of Scotland by the Cheviot hills, a mass of granite and Old Red Sandstone; and the northern part is largely traversed by dykes of contemporary volcanic or intrusive rock. The most striking of these dykes is the Great Whin Sill, which crosses the country from a short distance south of Durham almost to the source of the Tees, near Crossfell. The elevated land is divided into three masses by depressions, which furnish ready means of communication between east and west. The South Tyne and Irthing valleys cut off the Cheviots on the north from the Crossfell section, which is also marked off on the south by the valleys of the Aire and Ribble from the Kinder Scout or Peak section. The numerous streams flow to the east and the south, and, by shorter and steeper valleys, to the west. The dales are separated from each other by high heather covered moorland or hill pasture. The agriculture of the region is confined to the bottoms of the dales, and is of small importance. Crossfell (2,930ft.) and the neighbouring hills are formed from masses of Carboniferous limestone, which received its popular name of Mountain limestone from this fact. Farther south, such summits as High Seat, Whernside, Bow Fell, Penyghent and many others, all over 2,000ft. in height, are capped by portions of the grits and sandstones, which rest upon the limestone. The belt of Millstone Grit south of the Aire, lying between the great coal-fields of the West Riding and Lancashire, has a lower elevation, and forms grassy uplands and dales; but farther south, the finest scenery of the whole region occurs in the limestones of Derbyshire, in which the range terminates. The limestone rocks of Yorkshire and Derbyshire show characteristic subterranean drainage. The coal-fields on the eastern side, from the Tyne nearly to the Trent, are sharply marked off on the east by the outcrop of Permian dolomite or Magnesian limestone, which forms a low terrace dipping towards the east under more recent rocks, and in many places giving rise to an escarpment facing westward towards the gentle slope of the Pennine dales. To the west and south the Coal Measures dip gently under the New Red Sandstone, to reappear at several points through the Triassic plain. The clear water of the upland becks and the plentiful supply of water-power led to the founding of small paper-mills in remote valleys before the days of steam.

The Pennine footlands in the north-east form a very distinct geographical unit, which may be termed North-eastern England. The region is bounded on the north-west by the Cheviots, on the west by the northern Pennines and on the south-east by the North Yorkshire moors. Three important lowland gates leave the region, namely the Northallerton gate to the south, the Tyne Gap to the west and the Berwick gate to the north. The region is one of great contrast between the highly developed, congested, industrial coastal patch and the sparsely populated, bleak, sheep-rearing moorlands of the Pennines to the west. Coal has been exported from this area for centuries and the association of boatbuilding for coal-carrying has laid the foundation of the great shipbuilding industry. The use first of all of local deposits of iron ore and then of the imported raw material has made the region also a great iron-smelting area. The great industries focus around the estuaries respectively of the Tyne, Wear and Tees. Coal, chemical products and shipbuilding focus on Newcastle-on-Tyne—the regional capital. Sunderland, the focus on the Wear, imports timber and exports coal. Difficulties in the early days with the lower Tees channel were overcome by sending the coal to Middlesbrough, where it met with the imported iron ores and thence arose a great iron-smelting region. The discovery of the Cleveland ores and new processes in smelting greatly improved the economic position of this region and now the iron-smelting and its associated industries are world famous. The development of the heavy chemical industry based on the gypsum deposits of the Triassic is a new development. The Tees-mouth ports are grouped under Middlesbrough, Stockton and the Hartlepools. Behind the whole region lies the old-world focus of Durham, beautifully situated—the one-time capital of a vast ecclesiastical border march.

Farther south the footlands of the Pennines have long been interested in woollen industries based upon sheep-rearing. The introduction of cotton caused the woollen manufactures on the western side to be superseded by the working up of the imported raw material; but woollen manufactures now based on imported raw materials have become a feature of the eastern slopes. Some quiet market-towns, such as Skipton and Keighley, remain, but most of them have developed by manufactures into great centres of population, lying, as a rule, at the junction of the thickly peopled valleys, and separated from one another by the empty uplands. Such are Leeds, Bradford, Sheffield, Huddersfield and Halifax on the great and densely-peopled West Riding coal-field, which lies on the eastern slope of the Pennines. The availability of soft water, from the Millstone Grit and peat moorlands, for wool-washing is an important factor of the location of wool-towns, in the main to the north of the Calder. The traditional skill of the inhabitants has also been an important factor in the location and development of the modern woollen industry and many of the towns within the region show a high degree of specialization. Thus Bradford specializes in wool-combing and worsted work; Dewsbury in "shoddy," or the reworked material; Halifax in carpet making and heavy woollens and the Colne valley in fine clothes and tweeds. Leeds is the mercantile and engineering centre of the district with, for example, a leather industry due to its large meat markets.

High on the Pennines are Harrogate, Buxton and Matlock, health resorts, prosperous from their pure air and fine scenery.

The iron ores of the Coal Measures have given rise to great manufactures of steel. This industry has focussed on Sheffield. Familiarity with the smelting of local iron ore and the proximity of hard sandstone for grinding wheels has handed on a traditional skill in this neighbourhood also. Before the extended use of coal, the local smelting was dwindling, but cutlery manufacture revived, thanks to imported iron. With the use of coal power the production of steel and its associated industries concentrated in the Don valley.

Across the moors, on the western side of the anticline, the vast and dense population of the Lancashire coal-field is crowded in the manufacturing towns surrounding the great commercial centre, Manchester, which itself stands on the edge of the Triassic plain.

Ashton, Oldham, Rochdale, Bury, Bolton and Wigan form a nearly confluent semicircle of great towns, dependent on the underlying coal and iron and on imported cotton. The lime-free water of the region is also important for bleaching. The Lancashire coal-field, and the portion of the bounding plain between it and the seaport of Liverpool, contain a population greater than that borne by any equal area in the country, the county of London and its surroundings not excepted. Here again the region shows concentration in certain towns of highly specialized processes. Bolton concentrates on the spinning of fine Egyptian cotton and is important in the bleaching industry; Oldham deals with the medium counts, while the suburbs of Manchester deal with spinning and the city itself is the great market of the finished goods. Liverpool stands out as the great entrepôt for raw cotton and the export centre of the finished goods.

Triassic rocks form the low coastal belt of Lancashire, edged with long stretches of blown sand and dotted with pleasure towns like Blackpool and Southport.

The basin of the River Weaver is the centre of the Cheshire salt-field. Modern developments tend to make this and the mid-Mersey region generally the producer of heavy chemical goods—a factor of no little importance in the bleaching processes.

Chester is the seaward terminus of the way through the great Midland Gap. Like Durham on the north, it was once of greater importance than at present, as the head of a marcher lordship, in this case controlling ways into Wales and the west. The importance of Chester in this region is that it has links with the south, the midlands and the west rather than with the north, but it has become of late a residential centre in relation to the south Lancashire cities, thanks to recent improvements of transport.

In the south-west of the Pennine region the coal-field of North Staffordshire supports the group towns known collectively from the staple of their trades as "the Potteries." The region is somewhat isolated industrially and is mainly dependent on the suitable carboniferous clays and marls. Six of the important pottery towns have been amalgamated into the county borough of Stoke-on-Trent which with extended boundaries was raised in 1925 to the rank of a city (Pop. 1921, 278,000). Further extension of this urbanization will accentuate the already too elongated nature of the settlement. The extreme contrast between Stoke and the non-industrial, old-world town of Newcastle-under-Lyme is one that repeats itself in many parts of modern England.

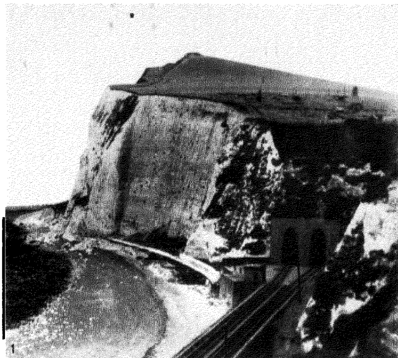
The South-west.—The peninsula of Cornwall and Devon may be looked upon as formed from a synclinal trough of Devonian rocks, which appear as plateaux on the north and south, while the centre is occupied by Lower Carboniferous strata at a lower level. The northern coast, bordering the Bristol channel, is steep, with picturesque cliffs and deep bays or short valleys running into the high land, each occupied by a little seaside town or village. The plateau culminates in the barren heathy upland of Exmoor, which slopes gently southward from a general elevation of 1,600 ft., and is sparsely inhabited. The Carboniferous rocks of the centre form a soil which produces rich pasture under the heavy rainfall and mild climate, forming a great cattle-raising district. There is an interesting seasonal migration of cattle and sheep up to Bodmin Moor and Dartmoor. The Devonian strata on the south do not form such lofty elevations as those on the north, and are in consequence, like the plain of Hereford, very fertile and peculiarly adapted for fruit-growing and cider-making. The remarkable features of the scenery of south Devon and Cornwall are due to a narrow band of metamorphic rock which appears in the south of the peninsulas terminating in Lizard Head and Start Point, and to huge masses of granite and other eruptive rocks which form a series of great bosses and dykes. The largest granite boss gives relief to the wild upland of Dartmoor, culminating in High Willhays and Yes Tor. The clay resulting from the weathering of the Dartmoor granite has formed marshes and peat bogs. The Tamar flows from north to south on the Devonian plain, which lies between Dartmoor on the east and the similar granitic boss of Bodmin Moor (where Brown Willy rises to 1,345 ft.) on the west. There are several smaller granite bosses, of which the mass of Land's End is the most important. Most of the Lizard peninsula, the only part of England stretching south of 50° N., is a mass of serpentine. The great variety of the rocks which meet the sea along the south of Cornwall and Devon has led to the formation of a singularly picturesque coast—the headlands being carved from the hardest igneous and metamorphic rocks, the bays cut back in the softer strata. The fjord-like inlets of Falmouth, Plymouth and Dartmouth are splendid natural harbours, which would have developed great commercial ports but for their remoteness from the centres of commerce and manufactures. China clay from the decomposing granites, tin and copper ore abound at the contacts between the granite and the rocks it pierced. The mineral wealth of the peninsula, especially its tin, attracted prospectors in early times, while mining has been one of the staples of Cornwall for centuries. Redruth and Camborne were the chief centres. Foreign competition and obsolete machinery brought about the collapse of the industry at the end of the 19th century, not before Cornish mining captains had become famous as metal prospectors the world over. The diminution of alluvial supplies of tin from abroad and the consequent rise in the market price, is tending (1928) to cause a revival of mining. Fishing has always been important, the numerous good harbours giving security to the fishing boats. The south-western end of the peninsula is fortunately situated near the southern limit of the cold-water herring and the northern limit of the warm-water pilchard. The sea-faring traditions of the south-west are based on the facilities it gave as a training ground. The Drake and Hawkins type are needed no more now and fishing is a precarious existence and it is with difficulty that the fishermen turn to other activities.

The mild and sunny, but by no means dry, coast has led to the establishment of many health resorts, of which Torquay is the chief. This traffic is increasing with the motor-car.

The peninsula of the south-west, in its isolation, has developed in its people a sense of individuality and aloofness from the life of the English plain. It has many claims to live on a long and glorious past of its own. Saxon colonization never extended west of the Tamar and the Cornish language of Celtic affinity became extinct only in the 18th century. Exeter, once the outpost of this old British kingdom, is now the administrative and ecclesiastical capital.

The Midland Plain.—Between the separate uplands just described, there extends a plain of Permian and Triassic rocks, which may conveniently be considered as an intermediate zone between the two main areas—the west and the east. To the eye it forms an almost continuous plain with the belt of Lias clays, which is the outer border of the Eastern Area; for although a low escarpment marks the line of junction, and seems to influence the direction of the main rivers, there is only one plain so far as regards free movement over its surface and the construction of canals, roads and railways. The plain usually forms a distinct border along the landward margins of the uplands of more ancient rock, though to the east of the Cornwall-Devon peninsula it is not very clear, and its continuity in other places is broken by inliers of the more ancient rocks, which everywhere underlie it.

In the north-west we find a tongue of red rocks forming the Eden valley with Carlisle as its centre, while farther south these rocks help to form the low coastal belt of Lancashire. Triassic rocks also form the Cheshire Plain to the south of the Lancashire coalfield. The plain extends through Staffordshire and Worcester and Hereford forming the lower valley of the Severn. The red soil is good for agriculture which is very well developed in these counties. Orchards and hop-growing are also important, particularly in Herefordshire. The flat surface and low level of much of this country has facilitated the construction of railways, canals and roads. Shrewsbury in its remarkable river loop was long a great fortress guarding ways into Wales and it remains a great market town to-day: it is also the centre of a considerable railway traffic. The great junction of Crewe is a further example of convergence of many routes on this lowland. The new and old red sandstone plains back against the Welsh plateau and there is a characteristic series of old towns beneath the hills where valleys open into the plain. Chester, Wrexham, Ruabon,



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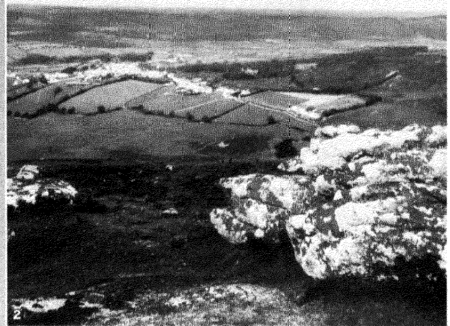

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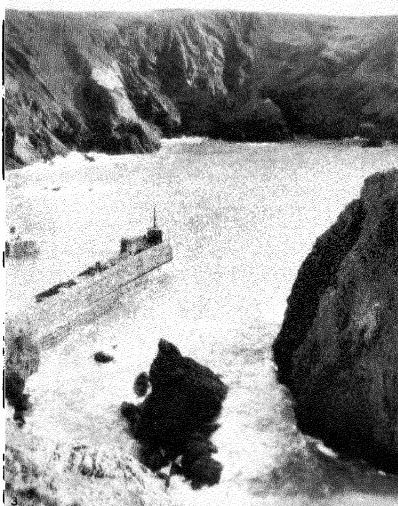

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ENGLISH AND WELSH SCENERY

1. Chalk cliffs at Dover. The chalk country still extant in England is the northern edge of the great sheet of chalk which once covered the whole southeastern part of the island. The Dover cliffs are especially familiar, being the traveler's first view of England when crossing the English channel from Calais
2. View of Chagford, Dartmoor, from Meldon Hill, a characteristic moorland landscape. The elevation of this section of Devonshire is about 1,400 ft., with many higher hills. It is fertile pasture land. The moorland region as a whole is an excellent country for walking excursions, for which Chagford is frequently used as a base
3. Mullion cove on the coast of Cornwall, the southwestern spur of Great Britain. The Cornish coastline is rocky and forbidding, with numerous coves, once used as hiding-places for smugglers
4. The Waveney, one of the shallow streams in the district of the Norfolk Broads, on the east coast of England. A number of shallow lagoons with their connecting streams make this part of the country a favourite resort for angling and smooth-water sailing
5. The Lledr Valley, North Wales, with Moel Siabod in the distance. The valley is green and pastoral in the eastern part, but towards the west is rocky and much quarried

Chirk, Oswestry, Shrewsbury, Ludlow, Leominster and Hereford may be named here.

An outcrop of the Coal Measures from beneath the newer rocks increases the importance of Bristol. This city, at the head of the navigation of the southern Avon, is the "gateway of the west." It has been from early times the wedge between Wales and Cornwall. Its importance grew with trade to and from Ireland and southern France, and later it became the great port for the New World with industries based on its commerce. The passing of the sailing boat, however, changed its fortunes; dock improvements and the refrigerator-boats (for fruit, etc.) are now reorganizing its trade and its industries are still considerable as well as varied. To the south-west is the plain of Somerset with its one-time woollen industry and its now famous cheeses and orchards and successful growing of the sugar beet. The plain is cut off from Bristol by the Mendip hills, an outcrop of Carboniferous limestone rising from beneath the newer rocks.

South of the Pennines, the Red rocks extend eastward in a great sweep through the south of Derbyshire, Warwick, the west of Leicestershire, and the east of Nottingham, their margin being approximately marked by the Avon, flowing south-west, and the Soar and Trent, flowing north-east. South and east of these streams the very similar country is on the Lias clay. Several small coalfields rise through the Red rocks—the largest forms the famous "Black Country," with Birmingham as centre. This midland metropolis draws its population from the three counties of Warwick, Stafford and Worcester at the convergence of which it stands. Its development has been remarkable. It was off the main lines of communication in very early and Roman times and although it was associated with iron-smelting from the late middle ages and its population was increasing, it was still governed as a manor and so had no chartered corporation in the 17th century when, under the Five-Mile Act, dissenters were not allowed to meet in corporate towns; Birmingham in this way became a place of refuge and several families who thus came have provided leaders in scientific, industrial and social life.

With the use of coal its industries enlarged their scope and to-day it is the centre of the motor, rubber and artificial silk industry. Machine tools, wireless apparatus and iron goods of all kinds are made. Around Birmingham are a host of now related towns such as Wolverhampton, Tipton, Walsall, West Bromwich, etc. Some have old industries, *e.g.*, saddlery at Walsall. On the eastern edge of the region is Coventry, also a centre of the motor trade, with recent interests in artificial silk, following old ones in natural silk. To the south-west of the Black Country is the Kidderminster area with its light sandy soils engaged in market gardening for the densely populated industrial areas. In the north-east of Birmingham smaller patches of the Coal Measures appear near Tamworth and Burton, where gypsum beds give the Trent water a special hardness suitable for brewing. Deep shafts have been sunk in many places through the overlying Triassic strata to the coal below, thus extending the mining and manufacturing area beyond the actual outcrop of the Coal Measures. A few small outcrops occur where still more ancient strata have been raised to the surface, as, for instance, in Charnwood forest, where the Archaean rocks, with intrusions of granite, create a patch of highland scenery in the very heart of the English plain; and in the Lickey hills, near Birmingham, where the prominent features are due to volcanic rocks of very ancient date. The midland plain, except in the industrial areas, is fertile and undulating, rich in woods and richer in pasture: the very heart of rural England. Cattle-grazing is the chief farm industry in the west, sheep and horse-rearing in the east; the prevalence of the prefix "Market" in the names of the rural towns is noticeable in this respect.

The manufacture of woollen and leather goods is a natural result of the raising of live stock. Leicester, Derby and Nottingham are manufacturing towns of the region. These towns were important in the middle ages. Nottingham, an old market centre at a river crossing, now manufactures machinery, motor cars, hosiery and cotton goods. Leicester is the great centre of the woollen hosiery trade—its tradition of woollen manufacture going back to the middle ages. Derby is a great entry to the dales, a railway centre and motor manufacturing town.

The midland plain curves northward between the outcrop of Magnesian limestone on the west and the Oolitic heights on the east. It sinks lowest where the estuary of the Humber gathers in its main tributaries, and the greater part of the surface is covered with recent alluvial deposits. The Trent runs north in the southern half of this plain, the Ouse runs south through the northern half, which is known as the Vale of York, lying low between the Pennine heights on the west and the Yorkshire moors on the east. The central position of York in the north made it the capital of Roman Britain in ancient times, and an important railway junction in our own.

The great fault line of the Humber brings the sea nearest to England's manufacturing midlands. Holderness is growing southward into the Humber estuary, but its eastern coast is being rapidly denuded by the sea. The sheltered harbour of Hull, the meeting place of traffic by river and sea, is an important port. On the opposite side of the estuary is Grimsby, importing timber and exporting coal, but best known as the great fishing focus of England. Railways transport the catch in every direction.

The Eastern Area.—Five natural regions may be distinguished in Eastern England, by no means so sharply marked off as those of the west. The first is the Jurassic belt, sweeping along the border of the Triassic plain from the south coast at the mouth of the Exe to the east coast at the mouth of the Tees. This is closely followed on the south-east by the Chalk country, occupying the whole of the rest of England except where the Tertiary Basins of London and Hampshire cover it, where the depression of the Fenland carries it out of sight, and where the lower rocks of the Weald break through it. Thus the chalk appears to run in four diverging fingers from the centre on Salisbury plain, other formations lying wedge-like between them. The Mesozoic rocks of the south rest upon a mass of Palaeozoic rocks, which lies at no very great depth beneath the surface of the anticlinal axis running from the Bristol channel to the Strait of Dover. This is shown by the discovery of Coal Measures, with workable coal seams, at and near Dover.

Eastern England is built up of parallel outcrops, the edges of the harder rocks forming escarpments, the sheets of clay forming plains. The rivers exhibit a remarkably close relation to the geological structure, and thus contrast with the rivers of the West. The Thames is the one great river of the region, rising on the Jurassic belt, crossing the Chalk country, and finishing its course in the Tertiary London basin, drawing its tributaries from north and south. The other rivers are shorter, and flow either to the North sea on the east, or to the English channel on the south.

The Eastern Area is the richest part of England agriculturally and is the part most accessible to the Continent. It is on this plain that the various elements, Celtic, Roman, Saxon, Dane and Norman have been assimilated; it has been a melting-pot of peoples and cultures. The present population is so distributed as to show remarkable dependence on the physical features. The chalk and limestone plateaux are now usually sparsely inhabited and the villages of these districts occur grouped together in long strings, either in drift-floored valleys in the calcareous plateaux, or along the exposure of some favoured water-bearing stratum. In almost every case the plain along the foot of an escarpment bears a line of villages and small towns, and on a good map of density of population the lines of the geological map may be readily discerned.

The Jurassic Belt.—The Jurassic belt is occupied by the counties of Gloucester, Oxford, Buckingham, Bedford, Northampton, Huntingdon, Rutland, Lincoln and the North Riding of Yorkshire. The rocks of the belt may be divided into two main groups: the Lias beds, which come next to the Triassic plain, and the Oolitic beds. Each group is made up of an alternation of soft marls or clays and hard limestones or sandstones. The low escarpments of the harder beds of the Lias run along the right bank of the Trent in its northward course to the Humber, and similarly direct the course of the Avon southward to the Severn. The great feature of the region is the long line of the Oolitic escarpment,

formed in different places by the edges of different beds of rock. The escarpment runs north from Portland island on the English channel, curves north-eastward as the Cotswold hills, rising abruptly from the Severn plain to heights of over 1,000 ft.; it sinks to insignificance in the Midland counties, is again clearly marked in Lincolnshire, and rises in the North Yorkshire moors to its maximum height of over 1,500 ft. Steep towards the west, where it overlooks the low Lias plain as the Oolitic escarpment, the land falls very gently in slopes of Oxford Clay towards the Cretaceous escarpments on the south and east. Throughout its whole extent it yields valuable building-stone. The Lias plain is rich grazing country, the Oxford Clay forms valuable agricultural land, yielding heavy crops of wheat. The towns of the belt are comparatively small, and the favourite site is on the Lias plain below the great escarpment. They are for the most part typical rural market-towns, the manufactures, where such exist, being usually of agricultural machinery or woollen and leather goods. Bath, Gloucester, Oxford, Northampton, Bedford, Rugby, Lincoln and Scarborough are amongst the chief. These towns of old standing retain in many ways something of the life of England before the industrial revolution. Many of them, particularly Oxford and Bath, have been famous for centuries and retain respectively traditions of mediaeval and 18th century England. Lincoln, like Gloucester, is a Roman station and ecclesiastical centre, retaining an importance at the present time as an administrative centre and market town with good railway connections. North of the gap in the low escarpment in which the town of Lincoln centres, a close fringe of villages borders the escarpment on the west; and throughout the entire Jurassic belt the alternations of clay and hard rock are reflected in the grouping of population.

The Chalk Country.—The dominating surface-feature formed by the Cretaceous rocks is the Chalk escarpment, the northern edge of the great sheet of chalk that once spread continuously over the whole south-east. It appears as a series of rounded hills of no great elevation, running in a curve from the mouth of the Axe to Flamborough Head, roughly parallel with the Oolitic escarpment. Successive portions of this line of heights are known as the Western Downs, the White Horse hills, the Chiltern hills, the East Anglian ridge, the Lincolnshire Wolds and the Yorkshire Wolds. The rivers from the gentle southern slopes of the Oolitic heights pass by deep valleys through the Chalk escarpments, and flow on to the Tertiary plains within. The hills of the Chalk country rise into rounded downs, often capped with clumps of beech, and usually covered with thin turf, affording pasture for sheep. The chalk, when exposed on the surface, is an excellent foundation for roads, and the lines of many of the Roman "streets" were probably determined by this fact. The Chalk country extends over part of Dorset, most of Wiltshire, a considerable portion of Hampshire and Oxfordshire, most of Hertfordshire and Cambridgeshire, the west of Norfolk and Suffolk, the east of Lincolnshire, and the East Riding of Yorkshire. From the upland of Salisbury plain, which corresponds to the axis of the anticline marking the centre of the double fold into which the strata of the south of England have been thrown, the great Chalk escarpment runs north-eastward; fingers of Chalk run eastward one each side of the Weald, forming the North and South Downs, while the southern edge of the Chalk sheet appears from beneath the Tertiary strata at several places on the south coast, and especially in the Isle of Wight. Flamborough Head, the South Foreland, Beachy Head and the Needles are examples of the fine scenery into which chalk weathers where it fronts the sea, and these white cliffs gave to the island its early name of Albion. The chalk supports only a small population, except where it is thickly covered with boulder clay, and so becomes fertile, or where it is scored by drift-filled valleys, in which the small towns and villages are dotted along the high roads. The thickest covering of drift is found in the Holderness district of Yorkshire. Of the few towns in the Chalk country, the same may be said as of those on the Jurassic belt, that their interest is historical or scholastic; Salisbury, Winchester, Marlborough and Cambridge are the most distinguished. Reading manufacturing biscuits flourishes from its position on the edge of the London basin. The narrow strip of Greensands appearing from beneath the Chalk escarpment on its northern side is crowded with small towns and villages on account of the plentiful water-supply.

The Fenlands.—The continuity of the belts of Chalk and of the Middle and Upper Oolites in the Eastern plain is broken by the shallow depression of the Wash and the Fenlands. The Fenland comprises a strip of Norfolk, a considerable part of Cambridgeshire, and the Holland district of Lincoln. Formerly part of the channel of a large river draining to join an extended Thames in the region now the North sea, the region is now low, flat and marshy, and for the most part within 15 ft. of sea-level; the seaward edge in many places is below the level of high tide, and is protected by dykes as in Holland, while straight canals and ditches carry the sluggish drainage from the land. The soil is composed for the most part of silt and peat. In early times it offered seclusion to the hermit and saint, but a line of approach to raiders from the sea. The difficult nature of the country made its Isle of Ely the last stronghold of Hereward the Wake against the Normans. With the drainage schemes of the 17th century, much land was reclaimed and the intensive agriculture of recent times is making for prosperity. Wheat, market gardening and sugar beet are important. A few elevations of gravel, or of underlying formations, rise above the 25 ft. level: these were in former times islands, and now they form the sites of a few villages. Boston and King's Lynn are memorials of the maritime importance of the Wash in the days of small ships. The numerous ancient churches and the cathedrals of Ely and Peterborough bear witness to the lead given by religious communities in the reclamation and cultivation of the land.

The Weald.—The dissection of the east and west anticline in the south-east of England has given a remarkable piece of country, occupying the east of Hampshire and practically the whole of Sussex, Surrey and Kent. The sheet of Chalk shows its cut edges in the escarpments facing the centre of the Weald, and surrounding it in oval fashion. The eastern end of the Weald is broken by the Strait of Dover, so that its completion must be sought in France. From the crest of the escarpment, all round on south, west and north, the dip-slope of the Chalk forms a gentle descent outwards, the escarpment a very steep slope inwards. The cut edges of the escarpment forming the Hog's Back and North Downs on the north, and the South Downs on the south, meet the sea in the fine promontories of the South Foreland and Beachy Head. The Downs are sparsely populated, waterless and grass-covered, with patches of beech wood. Their only important towns are on the coast, *e.g.*, Brighton, Eastbourne, Dover, Chatham, or in the gaps where rivers from the centre pierce the Chalk ring, as at Guildford, Rochester, Canterbury, Lewes and Arundel. Within the Chalk ring, and at the base of the steep escarpment, there is a low terrace of the Upper Greensand, seldom a mile in width, but in most places crowded with villages, ranged like beads on a necklace. Within the Upper Greensand an equally narrow ring of Gault is exposed, its stiff clay forming level plains of grazing pasture, without villages, and with few farmhouses; and from beneath it the successive beds of the Lower Greensand rise towards the centre, forming a wider belt, and reaching a considerable height before breaking off in a fine escarpment, the crest of which is in several points higher than the outer ring of Chalk. Leith hill and Hindhead are parts of this edge in the west, where the exposure is widest. Several towns have originated in the gaps of the Lower Greensand escarpment which are continuous with those through the Chalk: such are Dorking, Reigate, Maidstone and Ashford. Folkestone and Pevensey stand where the two ends of the broken ring meet the sea. It is largely a region of oak and pine trees, in contrast to the beech of the Chalk Downs The Lower Greensand escarpment looks inwards in its turn over the wide plain of Weald Clay, along which the Medway flows in the north, and which forms a fertile soil, well cultivated, and particularly rich in hops and wheat. The primitive forests have been largely cleared, the early marshes have all been drained, and now the Weald Clay district is well peopled and sprinkled with villages. From the middle of this plain the core of Lower Cretaceous sandstones emerges steeply, and reaches in the centre an elevation

of 796 ft. at Crowborough Beacon. It is on the whole a region with few streams, and a portion of the ancient woodland still remains in Ashdown forest. The forest ridges are poorly inhabited and towns are found only round the edge bordering the Weald Clay, such as Tonbridge, Tunbridge Wells and Horsham; and along the line where it is cut off by the sea, *e.g.*, Hastings and St. Leonards. The broad low tongue of Romney marsh running out to Dungeness is a product of shore-building by the Channel tides, attached to the Wealden area, but not essentially part of it.

The historical associations of the area are important as showing it to be the great gateway into England from the Continent. The south-east is the pivot on which Britain balances its Continental influences. Its fertile soil made it a region of early settlement and the large number of small ports along its shore line, giving choice of land to the little boats of early times driven by force of wind and tide, necessitated inland foci of the many landing places from the Continent, and in such positions there grew up Canterbury, characteristically the centre whence Roman Christians spread over England. The coast land remained dotted with active ports during the middle ages, the activity of the Cinque Ports (*q.v.*) and their satellites being famous. The mediaeval iron smelting dependent on the Weald forest lands ceased with the protection of the woodland and the use of coal on a large scale in other areas. It is possible that the recent development of the Kent coalfield may recreate this industry on a different basis. The rapid development of the coalfield with its deep pits and problems of transport is the outstanding feature of the south-east, linked up as it is with a remarkable regional-planning scheme calculated to avoid the overcrowded, dirty, ugly settlements with their many social difficulties that have hitherto characterized British industrial areas. Alongside this development is the extensive use of the region both as a holiday resort and as a residential area for the ever-growing metropolis.

The London Basin and East Anglia.—The London basin occupies a triangular depression in the Chalk which is filled up with clays and gravels of Tertiary and later age. It extends from the eastern extremity of Wiltshire in a widening triangle to the sea, which it meets along an irregular line from Deal to Cromer. It thus occupies parts of Wiltshire, Hampshire, Surrey, Kent, Berkshire, Hertfordshire, the whole of Middlesex, the county of London and Essex, and the eastern edge of Suffolk and Norfolk. The gravel hills are often prominent features, as at Harrow and in the northern suburbs of London; the country is now mainly under grass or occupied with market and nursery gardens, and many parts, particularly Epping forest, still retain much oak wood. The coast is everywhere low and deeply indented by ragged and shallow estuaries, that of the Thames being the largest. Shallow lagoons formed along the lower courses of the rivers of Norfolk have given to that part of the country the name of the Broads, a district of low and nearly level land. Apart from the immense area of urban and suburban London (for its development *see* separate article) the London basin has few large towns. Norwich and Ipswich, Yarmouth, Lowestoft, Harwich and Colchester may be mentioned in the north-eastern part, all depending for their prosperity on agriculture or on the sea; and a fringe of summer resorts on the low coast has arisen which depend on London's population. Reading and Windsor lie in the western portion beyond the suburban sphere of London. The Bagshot beds in the west form infertile tracts of sandy soil on which is situated Aldershot. The London clay in the east is more fertile and crowded with villages, while the East Anglian portion of the basin consists of the more recent Pliocene sands and gravels, which mix with the boulder clay to form the best wheat-growing soil in the country. This country appears to have had agricultural associations from the Bronze Age times and even at that time there was a long tradition of human settlement. Mediaeval contacts with the Flemish weavers over the North sea gave an impetus to the East Anglian woollen trade. Foodstuffs were also exported thither and before the days of coal East Anglia was one of the most important industrial and most populous regions of England. Rural beauty called forth some of England's greatest landscape painters, while centuries of contact with the Continent and especially with Flemish weavers, both traders and artisans, gave her people a broad vision in agricultural, economic, political and religious life, a factor that has to be considered when we remember the part she has played at important crises in the history of England.

London itself, as primarily the focus of its basin and the lowest Thames crossing, is too large a subject for treatment here, but its complementary relation to the estuarine ports of the Continental shores and its consequent facilities as an entrepôt, once England had become a great agent in the carrying trade, may be mentioned. The western suburban industrial growth, following application of electrical power in recent years, is portentous.

Hampshire Basin.—The remaining Tertiary basin for consideration forms a triangle between Dorchester, Salisbury and Worthing. The Tertiary rocks are enclosed by a vein of chalk which to the south appears in broken fragments in the Isle of Purbeck, the Isle of Wight and to the east of Bognor. On the infertile Bagshot beds is the large area known as the New Forest. Considerable sections are still under oak. The London Clay of the east is more fertile, but the feature of the district lies in its coastline, which is deeply indented like that of the London Basin. On a fine natural harbour, with deep water and a double inroad from the sea, stands Southampton—the focus of the Hampshire basin. It is well placed for direct services to northern France and for transatlantic traffic. The development of a network of railways in its hinterland has facilitated its contact with London and the remainder of the British Isles. It has recently become the leading passenger port of England and has developed secondary interests and trades dependent on a large collecting and distributing centre. Portsmouth, with another fine harbour, has specialized on naval work. Bournemouth and Bognor, from their favourable position in the sunniest belt of the country, have developed as health resorts. Winchester was of old an inland focus behind a number of harbours and was thus in some ways analogous with Canterbury (*see* above).

CLIMATE

The main features of the climate of England are dependent upon the passage from the North Atlantic of cyclones which are centres of low barometric pressure usually having phases of strong winds and much rainfall. Equally important for English weather is the extension of high-pressure systems (anti-cyclones) from the Continent or the neighbourhood of the Azores. These conditions bring calm, dry, sunny weather in summer and dry cold weather in winter. The alternation of these conditions, and particularly the relation of England to the Continental high pressure region in winter and low pressure region in summer, cause the variety of atmospheric conditions experienced. These conditions are always modified locally by the configuration of the land and lead to contrasts of climate on the western highlands and eastern lowlands of England. The fact that England is surrounded by the sea obviates extremes of heat and cold at all times. The chief paths of depressions from the Atlantic are from south-west to north-east across England; one track runs across the south-east and western counties, and is that followed by a large proportion of the summer and autumn storms. A second track crosses central England, entering by the Severn estuary and leaving by the Humber or the Wash; while a third crosses the north of England from the neighbourhood of Morecambe bay to the Tyne. Individual cyclones may and do cross the country in all directions, though very rarely indeed from east to west or from north to south.

The average barometric pressure normally diminishes from south-west to north-east at all seasons. The direction of the mean annual isobars shows that the normal wind in all parts of England and Wales must be from the south-west on the west coast, curving gradually until in the centre of the country and on the east coast it is westerly. The normal seasonal march of pressure-change produces a maximum gradient in December and January, and a minimum gradient in April. In spring the gradient is often slight enough for a temporary fall of pressure to the south of

England or rise to the north to reverse the gradient and produce an east wind over the whole country. The liability to east wind in spring is a marked feature of the climate especially on the east coast. The southerly component is most marked in the winter months, and westerly, predominating in summer.

Rainfall.—The Western or highland Area is the wettest at all seasons, each orographic group forming a centre of heavy precipitation. There are few places in the Western Area where the rainfall is less than 35in., while in the south-west, the Lake district and the southern part of the Pennine region the precipitation exceeds 40in., and in the Lake district considerable areas have a rainfall of over 60in. In the Eastern Area, on the other hand, an annual rainfall exceeding 30in. is rare, and in the low ground about the mouth of the Thames estuary and around the Wash the mean annual rainfall is less than 25in. In the Western Area and along the south coast the driest month is usually April or May, while in the Eastern Area it is February or March. The wettest month for most parts of England is October, the most noticeable exception being in East Anglia, where, on account of the frequency of summer thunderstorms, July is the month in which most rain falls, although October is not far behind. In the Western Area there is a tendency for the annual maximum of rainfall to occur later than October. It may be stated generally that the Western Area is mild and wet in winter, and cool and less wet in summer; while the Eastern Area is cold and dry in winter and spring, and hot and less dry in summer and autumn; that is the Eastern Area approximates more closely to continental conditions. The south coast occupies an intermediate position as regards climate.

Temperature.—The mean annual temperature of the whole of England and Wales (reduced to sea-level) is about 50° F, varying from something over 52° in the Scilly isles to something under 48° at the mouth of the Tweed. The mean annual temperature diminishes very regularly from south-west to north-east, the west coast being warmer than the east, so that the mean temperature at the mouth of the Mersey is as high as that at the mouth of the Thames. During the coldest month of the year (January) the mean temperature of all England is about 40°. The influence of the western ocean is very strongly marked, the temperature falling steadily from west to east. Thus while the temperature in the west of Cornwall is 44°, the temperature on the east coast from north of the Humber to the Thames is under 38°, the coldest winters being experienced in the Fenland. In the hottest month (July) the mean temperature is about 61·5°, and the westerly wind then exercises a cooling effect, the greatest heat being found in the Thames basin immediately around London, where the mean temperature of the month exceeds 64°: the mean temperature along the south coast is 62°, and that at the mouth of the Tweed a little under 59°. In the centre of the country along a line drawn from London to Carlisle the mean temperature in July is found to diminish gradually at an average rate of 1° per 60m. The coasts are cooler than the centre of the country, but the west coast is much cooler than the east, modified continental conditions prevailing over the North sea. Oceanic influence penetrates the midlands especially by way of the Severn estuary. The Mersey estuary, being partly sheltered by Ireland and north Wales, does not serve as an inlet for modifying influences to the same extent; and as the wind entering by it blows against the slope of the Pennines, it does not much affect the climate of the midland plain.

The amount of sunshine experienced in various places varies naturally with the seasons, but there is more sunshine recorded for some coastal regions than for the inland areas. The regions of England that get most sunshine are the south-west and a belt covering the south coast around East Anglia to the Fen country. The north-east including the Pennine region and the whole of Yorkshire is very cloudy. It is estimated that in Britain mists, fogs and clouds obscure the sun for about two-thirds of the time that it is above the horizon.

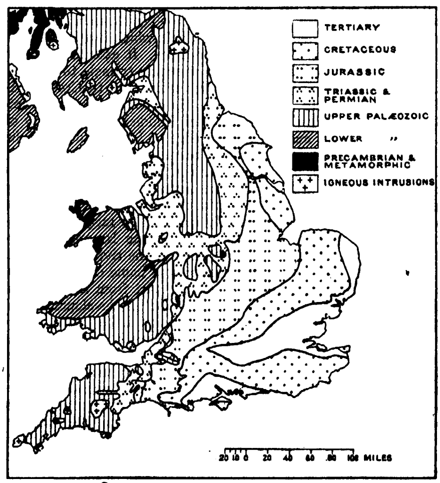
GEOLOGY

In a general account of the geological history of England it is natural to include Wales since the two have been intimately connected during geological time. Many of the major divisions of geological time are named after places or tribes in England or Wales, and it is fortunate that much of the early work on stratigraphy was done in a country where representatives of rocks of nearly every age are exposed at the surface.

The Pre-Cambrian formation, on which the later fossiliferous strata were deposited, appears at the surface only in small and scattered exposures; but these give indications of the earliest geological time in the island. Small areas of gneiss are found in Anglesey, N. Wales, the Malvern Hills and Cornwall which suggest that gneiss forms the basal rocks here as in Scotland and elsewhere. Following these, and probably considerably later in date, are certain volcanic and pyroclastic rocks found in Charnwood Forest, Nuneaton, Church Stretton, Malvern and elsewhere, whilst later still there are the red sandstones of the Longmynd which are in all probability of the same age as the Torridonian.

Thus, in the Pre-Cambrian there is evidence of a period of great earth-movement probably followed by violent volcanic action and finally the arid conditions of deposition of the Longmyndian. All these rocks were intensely folded, generally with a N.W.-S.E. strike, and formed the land masses and sea floor against and on which the first fossiliferous deposits were laid down.

Throughout Lower Palaeozoic times there was continuous deposition in a trough, one shore of which lay along the southern border of the Scottish Highlands while the other appears to have run more or less along the present line of the Pennines to Shropshire and S. Wales, with a second trough occupying much of the area of the present English Channel. Naturally the actual position of the shore-line varied from time to time. The Cambrian, Ordovician and Silurian together form one protracted marine period in this trough, during which the type of sediment was usually sand or finer mud with occasional thin limestones, whilst during the Ordovician period there were frequent and often important eruptions of volcanic material. These formed massive



GEOLOGICAL MAP OF ENGLAND AND WALES

beds of lava and ash which now weather into mountainous ground with bold crags and are responsible for much of the finest scenery of the island, such as Snowdonia or the Lake District. Towards the end of Silurian times this marine trough became silted up and warped, and as compressional forces increased in intensity the whole area with the exception of Devon and Cornwall became land, while farther north the great Caledonian range of mountains was formed. These compressional forces are responsible for the strong slaty cleavage which is found in Wales and the Lake District in the older Palaeozoic rocks and gives

rise to some of the most perfectly cleaved slates in the world.

It was during the elevation of this great mountain chain and while much of England was land that vast amounts of material were worn from the newly formed hills to accumulate in the low-lying elongated basins between the ranges. Thus the Old Red Sandstone with the earliest vertebrates, the fish, was laid down; while to the south, in S. Devon and Cornwall, the sea still remained with its deposits of limestones and shales. In the neighbourhood of the main mountain chain much igneous activity took place, but in England this is restricted to the intrusion of a few granite masses in the Lake District and elsewhere.

Coal Seams Formed.—After the gradual destruction of the land masses by denudation, the sea again invaded the area from the west and deposited extensive beds of Carboniferous Limestone which now form the characteristic scenery of the Pennines, Peak district and Mendip hills. Later these seas were filled up with deltaic and estuarine deposits; and it was on the resulting swampy flats that a luxuriant vegetation grew and accumulated which eventually turned into the coal seams alternating with the sands and muds of the estuaries. The conditions of the crust once more became unstable and another period of mountain-building was initiated, but at this time the main range lay to the south in Brittany with secondary ranges on the line of the Mendip hills and in S. Wales.

The chief result of this uplift together with the residual mountains of the former range in Scotland was the formation of a land with an arid climate, a large intermontane tract deprived of almost all moisture-laden winds; while the western shores of an inland sea reached to the line of the Pennines. In this sea the Magnesian Limestone was laid down; on much of the land surface wind-blown sands and breccias were accumulated, while in other places sheets of highly saline water deposited beds of salt and gypsum. These arid conditions continued to the end of Trias times.

There now followed a long period of comparative quiescence during which the sea invaded the area, probably from the south-east and spread up in a Y-shaped gulf between the high land of Wales and the old rocks of East Anglia bifurcating on the Pennines, one branch running up to the west coast of Scotland and the other to the Yorkshire coast. This Y was broken by cross-bars of greater rigidity than the rest of the trough, so that the deposits thin out both to the margins of the trough and also when traced along its length. The deposits are mostly clays and shallow water limestones full of fossils, showing that the waters supported abundant life. This state of affairs lasted throughout the Jurassic and Lower Cretaceous, and it was not until the beginning of the deposition of the Chalk that any general submergence took place. In this deepening and clear sea the highly characteristic deposit of the Chalk which gives rise to the familiar scenery of the Downs and Chiltern Hills was laid down.

At the end of the Cretaceous period important changes took place in the geography of the British islands and what had been an open sea was uplifted into land, all excepting an area in the south-east of England where Tertiary clays and sands were deposited. At this period the fringe of the great Alpine earth movement reached England, causing the marked folding of the beds in the Isle of Wight and the less marked but equally important folds which located the London basin and Wealden anticline. The whole of England and Wales appears also to have received a slight tilt down to the east about that time, and this occasioned the removal by erosion of most of the western part of the Mesozoic sediments and also much from the Palaeozoic rocks of Wales and the Pennines.

While this was happening, widespread volcanic acivity was taking place in northern Ireland and western Scotland, but the only evidence of a similar occurrence in England is the Cleveland dyke in Yorkshire and possibly some intrusions of doubtful age in the Midlands. The quantity of material which was removed must have been enormous and the land appears to have been worn down to a gradually sloping surface out of which the higher hills rose as residual mountains. In East Anglia the shell-banks of the Pliocene were laid down, during a time when the climate was gradually changing from temperate to arctic, a change that continued, with fluctuations, until the end of the Pliocene when conditions were such that great ice sheets formed and covered most of England and Wales north of a line from the Severn estuary to the Thames.

There is considerable evidence that there were marked advances and retreats of the ice coinciding with marked oscillations of temperature and probably with considerable changes in the relative level of land and sea, but as the oscillations became less the climate gradually approached its present state and geological time merged into the historic period. (W. B. R. K.)

FAUNA AND FLORA

Flora.—The spread of ice to the line of the Thames and Severn during the maximum Pleistocene glaciation, evidently impoverished the flora of the whole country most drastically. If, as seems probable, the land stood higher, it may be that some plants needing a more temperate climate survived on the then coasts, that is, on land now submerged. The sinking of the land after the Ice age, by converting a one-time peninsula into the British archipelago, made the repeopling of the islands incomplete and the species spreading in from the continent become fewer and fewer westwards. Remains of a post-glacial colony of Arctic plants, such as the dwarf-birch, have been found near Teignmouth, and patches of Arctic-Alpine flora still survive in Scotland and North Wales, on high ground. It is now generally agreed that while the glaciers of north-west Europe were retreating, steppe conditions prevailed widely, and there are plants on sandy soils in Norfolk that may be relics of these conditions; they do not occur in the wetter west. The steppe period of the Upper Palaeolithic age was followed by land-sinking and the spread of Atlantic climate, with growth of forest as a result.

It has been proved that pines, especially *Pinus sylvestris*, were widely distributed, and many remains of this tree occur in the submerged forests off the west coasts, as well as in the peats of the high lands, while what seem to be survivals of very ancient pine forests, with junipers, etc., still grow in north-east Scotland. The west of Ireland has some special plants, such as *Saxifraga umbrosa* (London pride), *S. hirsuta*, *S. geum*, *Erica mediterranea*, *E. Mackaii*, *Daboecia polifolia* (St. Dabeoc's heath), and *Arbutus Unedo* (strawberry tree). The south-west of England has *Erica ciliaris*, *E. vagans*, *Lobelia urens* and a few other plants which seem to belong to the same association. Several species are common to south-west England and southern Ireland, and hardly occur elsewhere. Forbes interpreted this flora as a survival of a pre-glacial flora, but Clement Reid urged that it must be a post-glacial immigration, in view of the arctic condition which must have prevailed over the whole of the present area of the British Isles. The apparent conflict of view would be greatly diminished if it could be established that during glaciation the land lay higher, as this would make it probable that there were plants of the then south-west coasts of Europe which might well have maintained their coastal position as the coastline receded, and thus have established themselves in west and south Ireland and south-west England. Praeger has well named this flora the south-west European. The pennywort (*Cotyledon umbilicus*), not strictly included in the above group, is characteristic of walls and some stony hedges of the south and west of England.

The Forest period was probably beginning in the west when East Anglia was still under steppe conditions. There are two forest beds along various parts of the coast related to movements of land levels as well as to changes of climate, but this is a matter for geological and archaeological argument. The great development of forest spread trees to far higher levels than they occupy at the present time; their remains have been found by Lewis at a height of 2,600 ft. on Cross Fell. The lowland and the drier uplands grew oak forest (including the large oak *Quercus robur*), while the non-calcareous soils of the western hills were clothed with the smaller *Quercus sessiliflora*. It has been estimated that they grew up to levels exceeding their present limits by over 300 feet. The birch still grows above the upper limit of the oak. The beech has existed in Britain since early prehistoric times, though its invasion of Denmark was probably not long before the

beginning of the last millenium B.C. It is highly characteristic of soil-covered slopes on the chalk hills, and it is often accompanied by the yew. Ash forests are specially important in limestone areas. Beech forests degenerate into scrub, and may even become grassland, as on parts of the chalk.

The wide extension of woodland in the period following post-glacial land sinking, had considerable effect in limiting the sites of human occupation, but though Fox has shown in special detail that man reduced the forest, especially after Roman times in England, it is doubtful whether the reduction of the forest should be ascribed entirely to the efforts of man. The reduction of its upper limit on the hills might be sheer denudation or wastage due to sheep and goats, but its universality suggests rather a reduction of temperature, which is also a possible cause of the invasion of forests by peat bogs. It has been shown that, whereas in the heyday of the Swiss lake villages the water-level lay very low, the lake-dwellers civilization was brought to an end by the cooling of the climate and the increase in the volume of the lakes. The invasion of forest by peat bog in Scandinavia, the invasion of the previous oak forests of Denmark by the beech, which can stand less heat, all point to a climatic change 1000 B.C., and evidence is being gathered for this from the Mediterranean region as well. At the same time it should be remembered that a beech wood, for example, accumulates acid humus in its soil, and so makes that soil unfavourable, in the long run, to renewal of the trees as they die. In some parts of the British Isles peat bogs are decaying; in others they are stable; in others again they are growing at the present time. The gorse or yellow whin (*Ulex europaeus*) is one of the most characteristic plants of Britain.

The cultivation of wheat in England finds highly suitable soil in the east, but the climate in many parts makes the harvest risky; there may be an occasional drought; there is far more often an excess of rain when the ears are ripening. Wheat is most largely grown in the south-east of the country, but the amount is diminishing. Oats, more tolerant of rain, ripen more assuredly, and it is noteworthy that the English oats-harvest is before the wheat-harvest, whereas in Poland the order is reversed. Barley is grown in many different areas. Hops are grown in large quantities in Kent, and also on the Hereford plain. Beet-sugar is being established in East Anglia, Salop, Somerset, etc. Fruit orchards of apples, plums and cherries are important in Herefordshire, Gloucestershire, Worcestershire, Somerset, Devon, etc. Kent is well named the garden of England.

Fauna.—The wild fauna of Britain is characterized by its poverty, which arises from its devastation in the Ice age, its conversion into an island as the climate was becoming temperate once more, and its density of human population. The wolf probably disappeared from England before Tudor times, the wild boar and beaver have also gone within historic times. The pure wild cattle have vanished, but their blood has influenced the races of domestic cattle in Britain. Red deer and roe deer and fox owe their preservation to the huntsmen of the country. The pine marten still occurs now and then, and the polecat is found in some localities still; the badger and hare are of some importance, as are the stoat and weasel. The so-called brown rat has largely displaced an older-established smaller black race. The rabbit, a mediaeval introduction, has spread far and wide.

Many of the birds that used to visit England in the breeding season come no longer. The draining of the Fens in eastern England has curtailed the breeding ground of many of the warblers, the crane and the bittern. The only peculiar British species, the red grouse (*Lagopus scoticus*), occurs in the northern counties, while the introduced pheasant is widely distributed. The most numerous bird is probably the meadow pipit, the most familiar the house sparrow.

Particular interest attaches to certain species of fresh water fishes, especially the salmon and trout, as they react both in pigment and form to different environments, and there are thus many local peculiarities. Some fish (char, etc.) of the lakes of Westmorland and Cumberland are of interest in that they probably represent an old group, related to the trout, that formerly migrated to the sea, but with the tectonic changes that formed these lakes, their outlets were cut off. All that need be said of the invertebrates is that there exists in England no species not found on the Continent, while some of the invertebrates offer the best examples of the Continental origin of our fauna.

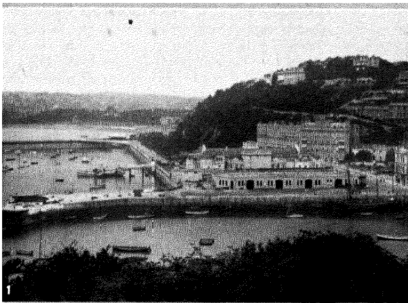
PEOPLE AND SETTLEMENTS

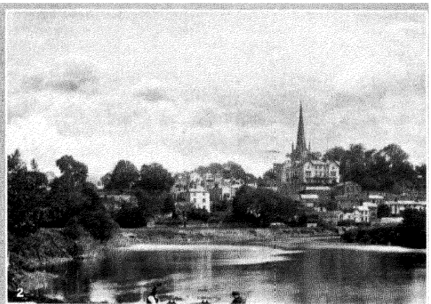
The subject of early immigrations into Britain can be followed, in outline, in the section of ethnology in the article EUROPE, and some of the archaeological correlations can be studied in article ARCHAEOLOGY. Here it must suffice to say that the old notion of a purely savage Britain civilized by Roman conquerors seems to be fading away. The persistence of features of older organization in Roman times is a noteworthy fact in several parts of south Britain. The much debated problem of the relations of Anglo-Saxon invaders to pre-existing populations is still very difficult to follow to any reasonable conclusion, but it is often argued that the very large amount of medium and dark brown hair in British populations is a sign of survival of pre-Saxon elements, and we note the fact that there are numerous nests of dark types, apart from the Celtic fringe, notably in the Chilterns.

Early Settlement.—The view is often held, but sometimes disputed, that settlements in lowland villages in England began in Anglo-Saxon times, and introduced the system of common arable land held in strips, and cultivated on a two-field (one field each year), or a three-field (one field winter corn, one spring corn and one fallow) scheme. Leeds has recently brought forward evidence to suggest that there were valley villages on the gravelly patches near certain rivers in the Bronze age, the cultivation scheme of which is quite unknown, while Crawford's air surveys have revealed a scheme of hamlets high on the downs, with small enclosed fields, a system of cultivation presumably dating from the Early Iron age. The lynchets of the Downs are another old scheme of cultivation probably linked with definitive settlement. Whatever may be the facts about pre-Roman settlement, there can be no doubt that it utilized mainly the land that was not densely wooded, and that the post-Roman centuries in Britain, as in central Europe, saw a great extension of lowland rural settlement above water meadows and in woodland clearings. Nor is there any doubt that the villages thus arising utilized the two-field, and probably the three-field, system of cultivation, whatever may be the truth as to the origin of such systems.

The fair, tall, long-headed element in the British population was probably strengthened by Viking and Danish invasions, and the study of place names organized recently by Allen Mawer, will throw further light, it is hoped, on the distribution of these populations; it appears that the abundance of Scandinavian names around the Solway firth, and in Cumberland and Lancashire, indicates an influence that had much to do with the definitive isolation of Celtic-speaking elements in Strathclyde from Celtic-speaking peoples in Wales. It seems clear that at this period the Celtic-speaking inhabitants were still under tribal organization, with the homesteads of the herdsmen on the hill sides, and probably with the custom of moving up to the hill pastures in summer.

Norman Period.—The Norman period witnessed a considerable extension of rural settlement along with the growth of manors, and the regions which were once, or are still in some cases, rich in parish churches of Romanesque (Norman) architecture, might be mapped to give clues to the spread of population. At the same time there was urban and commercial growth followed by the establishment of bishops' sees in regional capitals, especially such as had communication by water with the Continent. The placing of bishops at Lincoln, Norwich and Exeter is typical here. At the same time comes the rise of Bristol in connection with trade to Ireland, where Dublin became for a while a dependency of Bristol. An estimate of the population of England at the time of the Domesday survey makes the total 1,500,000, and, especially after a measure of order had been established under Henry II., and a further measure under Edward I., it seems to have grown, for estimates of the total just before the Black Death (1348–49) give totals varying from 2,500,000 upwards. The tendency to specialize in wool seems to have been





BY COURTESY OF (1) THE GREAT WESTERN RAILWAY; PHOTOGRAPHS (2) F. FRITH AND CO., (3, 4, 5, 6) EWING GALLOWAY

SEASIDE AND RURAL TOWNS OF ENGLAND

1. View of Torquay, Devon, a popular watering-place and health resort. It is situated on seven hills rising above Tor Bay at the convergence of two valleys. The town is protected from all winds except those from the south and the temperature range is about 30°–75°
2. The old market town of Ross, Herefordshire, from the River Wye. The river was at one time the boundary between the Saxons and the Welsh. The most prominent building in the town is the Decorated and Perpendicular church, the spire of which is shown at the right
3. Clovelly, a herring-fishing village, situated in a rift in the cliffs on the shore of the Bristol channel. The main street descends in steps and stages from a height of 400 ft. to the little cove and pier. No two of the whitewashed houses are on the same level
4. Lynmouth, a summer resort on the shore of the Bristol channel at the point where the valleys of the East and West Lyn converge. Its twin village, Lynton, is situated on a cliff 430 ft. above Lynmouth. These two villages have literary associations of interest; Shelley and his wife Harriet Westbrook lived here at one time, and Southey, who visited the villages, wrote a famous description of them
5. Airplane view of Blackpool, on the Irish Sea, a popular seaside resort of England. It is crowded in summer by excursionists from all parts of the industrial North and the Midlands. In the left foreground of the picture is a view of the big enclosed pool
6. Robin Hood's Bay, and Bay Town, on the Yorkshire coast, a fishing-village built on a steep slope at the north end of the bay

promoted by shortage of labour due to the Black Death, and the claim has been made that the Cistercians had, prior to this, done a good deal to foster the wool trade. Some manors fell into decay, owing both to loss of population and to the spread of sheep-farming and, with the decay of manorial restrictions and the rise of wool trade, movement began to be a little freer, and money payments began to take the place of dues in service. With the rise of the wool trade came the enclosure of common lands, sometimes old arable, more often old woodland and hill pasture, with the result that population and the wool trade grew in several areas such as the Cotswolds. It is interesting to note that, at the Reformation, bishoprics of Chester, Gloucester, Oxford and Peterborough were created; this seems to mark a considerable inland development in England.

Tudor, Stuart and Hanoverian Periods.—The Age of Discovery changed England from a land at the edge of the known world, to a collection of harbours in the centre of the land hemisphere and at a prime focus of maritime routes. Devon sea-dogs spread Britain's power at the expense of that of Spain. London began to function on a new scale in relation to the Continent; trade with the Indies and with the new populations of Anglo-Saxon America was added. The spread of root crops increased stock-raising possibilities and, by interfering with the right of stubble-pasture, weakened the agricultural village communities. The little regional centres, county-towns and the like, had a period of development following agricultural improvement and consequent growth of markets, and many towns show this in their fine 18th century houses, so well seen at Shrewsbury and Ludlow. These towns became social centres of some importance so long as roads were not good enough to draw people to London from more distant districts. Up to this time the population was dense on the south-eastern plains of England and sparse in the west and north, denser where there was more cultivation or more woollen manufacturing, sparser where there was more woodland and hunting and where stock-raising was the characteristic rural activity. The region of denser, more commercial population was, in the main, Roundhead in the 17th century struggles, the region where it was sparser was, on the whole, Royalist. From the 16th to the 18th century England received a new influx of people, not in large numbers but of great energy and initiative, mainly religious refugees from France and Flanders, who caused the woollen manufactures to grow enormously, brought commercial experience, and a power of criticism in both religion and politics. Their influence and that of their descendants on the subsequent growth of British towns and industries has been a very great one.

The population at the various decades was:—

Date	Population	Decennial rate of increase per cent
1801	8,892,536	..
1811	10,164,256	14·00
1821	12,000,236	18·06
1831	13,896,797	15·80
1841	15,914,148	14·27
1851	17,927,609	12·65
1861	20,066,224	11·90
1871	22,712,266	13·21
1881	25,974,439	14·36
1891	29,002,525	11·65
1901	32,527,843	12·17
1911	36,070,492	10·89
1921*	37,886,699	..

*The World War of 1914–18 makes the figure for 1911–21 of no value for comparisons.

The Industrial Revolution.—Coal had been used domestically in the middle ages, and it had been exported from Newcastle-on-Tyne, Swansea, etc. In the 19th century it was applied on a large scale, at first in Staffordshire for iron work, then for iron smelting, and then for steam machinery of all kinds, with the result that there was an enormous and rapid growth of new centres of population where the coal was dug, usually in regions that had previously been old-fashioned and sparsely peopled. The rapid growth of clusters of very large towns in previously out-of-the-way areas is a feature that makes English industrial development very different from that of Germany, where Cologne, Düsseldorf, Leipzig, Nürnberg and many another industrial city has been great and famous for centuries. Invention followed invention, population on the coal fields grew, and the British markets were opened freely to foreign corn to feed the masses that industrialism had called into existence; cultivation and rural population entered upon a period of decline in the second half of the 19th century, with a resultant drift to the poor quarters of the ill-planned towns of mushroom growth. The smoke and grime of coal pits, and transport of crude coal has added to the squalor of many of the industrial agglomerates of Britain, and a characteristic reaction of the last generation has been the Town and Regional Planning movement, which has owed much of its inspiration to the Society of Friends and to Ebenezer Howard and Patrick Geddes. There is still serious overcrowding and bad housing in many centres, notably in Northumberland and Durham.

In 1921 the distribution on a county basis in England was:—

English counties	Area, 1921 (acres, land and water) counties including county boroughs	Population including county boroughs
Bedfordshire	302,942	206,588
Berkshire	463,834	294,794
Buckinghamshire	479,360	236,171
Cambridgeshire	315,168	129,602
Isle of Ely	238,073	73,817
Cheshire	657,950	1,025,724
Cornwall	868,167	320,705
Cumberland	973,086	273,173
Derbyshire	650,369	714,662
Devonshire	1,671,364	709,614
Dorsetshire	623,612	228,160
Durham	649,244	1,479,033
Essex	979,532	1,470,257
Gloucestershire	805,794	757,651
Hampshire	958,896	910,252
Isle of Wight	94,146	94,666
Herefordshire	538,924	113,189
Hertfordshire	404,523	333,195
Huntingdonshire	233,985	54,741
Kent	975,965	1,141,666
Lancashire	1,194,555	4,927,484
Leicestershire	532,779	494,469
Lincolnshire:		
The parts of Holland	263,355	85,254
The parts of Kesteven	469,142	108,250
The parts of Lindsey	972,796	408,698
London	74,850	4,484,523
Middlesex	148,692	1,253,002
Monmouth	349,552	450,794
Norfolk	1,315,064	504,293
Northamptonshire	585,148	302,404
Soke of Peterborough	53,464	46,959
Northumberland	1,291,515	746,096
Nottinghamshire	540,123	641,149
Oxfordshire	479,220	189,615
Rutlandshire	97,273	18,376
Shropshire	861,800	243,062
Somersetshire	1,037,594	465,710
Staffordshire	741,318	1,348,877
Suffolk, East	557,353	291,073
Suffolk, West	390,916	108,985
Surrey	461,833	930,086
Sussex, East	530,555	532,187
Sussex, West	401,916	195,810
Warwickshire	605,275	1,389,977
Westmorland	504,917	65,746
Wiltshire	864,101	292,208
Worcestershire	458,352	405,842
Yorkshire, E. Riding	750,115	460,880
Yorkshire, N. Riding	1,362,058	456,436
Yorkshire, W. Riding	1,773,529	3,181,174
York, City of	3,730	84,039

(Those in italics are not complete counties.)

Population and Vital Statistics.—Thus, during the 19th century, the face of England was changed. Regions of relatively dense population in 1800 (excluding London) were regions of

relatively sparse population by 1900, less because of local decline than because of immense growth in the coal fields. The present (1921) distribution shows five great centres of dense population —south Lancashire, of which Manchester and Liverpool are the centres; Northumberland, with Newcastle as focus; the West Riding of Yorkshire around Leeds and Sheffield; the Midlands, with Birmingham as centre; and the region of Greater London. During the century the population of England and Wales had increased from 8,750,000 to 32,500,000. The total population had reached 37,750,000 in 1921.

The towns with a population (1921) over 100,000 were:—

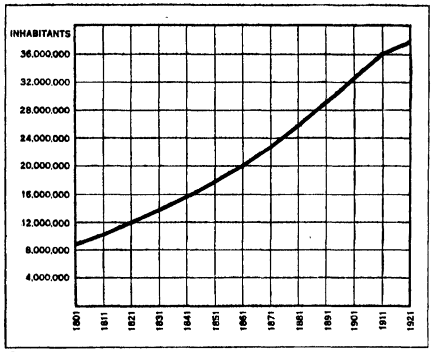
	Area in acres (1921)	Census population
Birkenhead (C.B.)	3,909	145,577
Birmingham, City of (C.B.)	43,601	919,444
Blackburn (C.B.)	7,420	126,643
Bolton (C.B.)	15,280	178,683
Bradford, City of (C.B.)	22,881	285,961
Brighton (C.B.)	2,545	142,430
Bristol, City of (C.B.)	18,436	376,975
Burnley (C.B.)	4,620	103,157
Coventry, City of (C.B.)	4,147	128,157
Croydon (C.B.)	9,012	190,684
Derby (C.B.)	5,272	129,796
East Ham (C.B.)	3,324	143,246
Gateshead (C.B.)	3,132	125,142
Huddersfield (C.B.)	11,875	110,102
Kingston-upon-Hull, City of (C.B.)	9,042	287,150
Leeds, City of (C.B.)	28,090	458,232
Leicester, City of (C.B.)	8,582	234,143
Liverpool, City of (C.B.)	21,242	802,940
Manchester, City of (C.B.)	21,690	730,307
Middlesbrough (C.B.)	4,159	131,070
Newcastle-upon-Tyne, City of (C.B.)	8,452	275,009
Norwich, City of (C.B.)	7,898	120,661
Nottingham, City of (C.B.)	10,935	262,624
Oldham (C.B.)	4,735	144,983
Plymouth (C.B.)	5,711	210,036
Portsmouth (C.B.)	7,964	247,284
Preston (C.B.)	3,964	117,406
St. Helens (C.B.)	7,284	102,640
Salford (C.B.)	5,202	234,045
Sheffield, City of (C.B.)	24,930	490,639
Southampton (C.B.)	9,192	160,994
Southend-on-Sea (C.B.)	7,082	106,010
South Shields (C.B.)	2,399	116,635
Stockport (C.B.)	7,063	123,309
Stoke-on-Trent (C.B.)	11,142	240,428
Sunderland (C.B.)	3,357	159,055
West Ham (C.B.)	4,683	300,860
Wolverhampton (C.B.)	3,525	102,342

(C.B.) = County Borough.

A town with a population of over 50,000 may become a county borough. All towns over 50,000 are not, however, county boroughs, while four towns with small populations, according to present standards, were created county boroughs for other reasons long ago, and still retain the name, though not all the distinctive organization. They are Carmarthen and Haverfordwest in South Wales, Poole and Lichfield in England.

Of the 38 towns listed above, 26 belong to the industrial north and the Black Country area of the Midlands, while three more, Bristol, Leicester and Nottingham, also owe their great growth in considerable measure to coal in their neighbourhoods, and another five are units dependent on London. This leaves the non-coal area with only four cities of this size, apart from the places which are extensions of the metropolis, and three of the four are modern ports; Portsmouth, the naval centre, and Southampton and Plymouth. Norwich is thus, in a sense, alone in this class as an old centre which has maintained itself without coal or steamship traffic. The change of distribution of population following the rise of industry is thus dramatically demonstrated.

An outstanding feature of the English population, as contrasted, for example, with that of France, is the discontinuity in social and economic development of the former. The enclosure of common lands, as a long-continued change, culminated in the general Enclosures Act of 1845. This movement broke up the traditional village organization and, incidentally, converted a former peasantry into landless labourers, who often drifted to industrial and mining centres, and sometimes became squatters on the heaths and waste lands. By 1875 means of overseas transport had improved sufficiently, and the populations of far-off lands had grown sufficiently, to flood the British market with foreign-grown wheat at rates below those at which it could be produced



GRAPH SHOWING GROWTH OF POPULATION IN ENGLAND AND WALES FROM 1801–1921. IN 1921 THERE WERE 109.6 FEMALES TO 100 MALES

in England, in which country the wheat harvest is particularly dependent on the weather. From 1875 onward more rural workers, and especially the abler youths among their children, migrated to the large towns or emigrated abroad, and the enormous growth of industry drew immigrants from Ireland and the Clyde and Wales, the immigrants usually taking up activities arising out of their previous experience in some way. There seems little doubt that this vast redistribution of population has altered, not only the location, but the proportions of the types of the population. The old-established British stock, marked by dark hair, long head and moderate stature, appears better able than others to withstand crowding and factory conditions, provided that it gets a sufficient quantity of food, and the immigrants into industrial areas included large numbers of this type, while the fair, stalwart type has apparently been streaming off to the new lands pioneering, just as it came pioneering to Britain centuries ago. The growth of towns is illustrated by the fact that, in England and Wales, only 23% of the population was rural in 1901, and the proportion had gone down to 20·7% in 1921. In France, on the other hand, the proportion of rural population in 1911 was nearly 59%; it is doubtless lower now, but satisfactory estimates would be difficult to make in a period of transition and reconstruction such as that which is just closing. In Germany, the proportion of the population living in agglomerations of over 2,000 inhabitants each was estimated for 1919 at 62·5%, giving a rural population of 37·5%; it was claimed that the cities were becoming stabilized and that immigration of rural workers into the towns was not likely to continue on a large scale.

Vital Statistics.—The birth rate and the death rate in England, as well as in the British Isles, in general, are diminishing. The birth rate rose during the 19th century until, between 1870–75, it was 35·5 per 1,000 of the population. Since that date it has fallen steadily; in 1927 it was calculated at 16·6. The fall in the death rate has not been quite so marked. It was about 23 per 1,000 of the population about 1845, and had fallen to about 12 per 1,000 in 1921. When we remember that, late in the 18th century, mortality of infants under the age of five was as high as 75% of the births, and has been reduced at the present time to about 5%, we realize the triumph of medical science and social and hygienic improvements. The birth rate minus death rate figures have come down very considerably during the present century,

which suggests that the population is moving towards stability. In 1928 the population was still actually increasing, but the rate of increase is growing less and less. Recent calculations (*see* Sir C. F. Close, "Population and Migration," *Geography*, vol. xiv.) seem to indicate that the effect of the war of 1914–18 was very marked and that the population is at least 2,000,000 less than it would have been if there had been no war.

In 1927 there were 1,041 male to 1,000 female births. This ratio has now become approximately what it was before 1914. During 1914–18, and for some time afterwards, the proportion of male births was abnormally high. Infantile mortality is, however, greater among males, and the general population has an excess of females at almost all ages, an excess which increases for adult life. The proportion of females is usually highest in residential districts with considerable domestic staffs; it is lowest in mining areas, though this would probably be more true of newly-developing regions than of those that have become more stabilized.

The marriage rate of the population (adults, aged 20 and upwards) was 14·2 per 1,000 in 1886, and 16·5 per 1,000 in 1899. In 1927 it was 15·7 per 1,000. The number of births per 1,000 married women in 1921 was 100. It was 166 per 1,000 in the '70s of last century. (*See* A. M. Carr-Saunders and Caradog Jones, *The Social Structure of England and Wales*, p. 222.)

The number of British emigrants to places outside Europe was 153,505 in 1927. Their destinations were mainly the United States (25,662), British North America (52,916), Australia (40,991), New Zealand (7,841), British South Africa (7,572), India and Ceylon (6,476). These figures are low compared with those previous to the World War. There was a large emigration in 1923, reaching 199,000. The high figure was due to the approaching restrictions on immigration into the United States.

RELIGION

The distribution of adherence to religious organizations in England is difficult to survey in the absence of suitable records. In the religious revolution of the 16th century the English aristocracy in general, and the rural population with them, adhered to the State Church, which was also strongly supported by the wealthier residents in towns, and retained a large following among the poor. Contacts with religious refugees from the Continent, however, and the progress of discussion, developed a large dissenting element, mainly in industrial centres and among the tradesfolk of market towns. This element received a considerable intellectual stimulus from the clergy dispossessed at the time of the Act of Uniformity (1661). From these early dissenting groups there have arisen chiefly the Congregationalists and Baptists, who have their traditional centres in the part of England that was Parliamentarian in the Civil War, and especially in parts of the east Midlands. Some dissenting groups, especially in industrial centres, became Unitarian or related themselves to the Society of Friends, and the Unitarian and Quaker groups of many of the great cities of England have played a part, altogether out of proportion to their numbers, in the economic development and, especially, in the social amelioration of British life. The fact that at the time Birmingham was still governed as a manor and was not a municipality, made it a specially important centre of dissent (*see* BIRMINGHAM). On the other side of the State Church position stood some old families, chiefly of the Welsh border and Lancashire, continuing to adhere to the Roman Catholic Church.

In the 18th century the Methodist movement gained considerable numbers of adherents in the old dissenting centres of the south and east, but had its greatest influence among the miners and heath peoples of the west and north, and the coincidence in time between its spread and the rise of textile industries made it play a great part in shaping opinion in 19th century England.

The 19th century has witnessed the gradual removal of disabilities under which non-members of the State Church formerly lived, and this, among other factors, has helped to bring into the State Church considerable numbers of descendants of dissenting and Methodist families. It has also witnessed a considerable sub-division of the Methodist groups, followed by efforts now apparently approaching a successful issue, to reunite the various bodies in one large Methodist Church. The removal of disabilities has almost ended religious persecution, save for conscientious objectors in war time, and outlying groups such as spiritualist practitioners, whose beliefs or practices bring them into conflict with laws which did not visualize such cases.

In the Church of England the ecclesiastical system is episcopal, and the whole of England is divided into two provinces, Canterbury and York, each with its archbishop. Until the Welsh Church Acts of 1914 and 1919, the whole of Wales was included under Canterbury, but since 1920 Wales has been formed into a separate archbishopric. The archbishoprics are divided into bishoprics, and these are subdivided again into parishes (the smallest ecclesiastical units). The parishes are grouped for certain administrative purposes into rural deaneries. The cathedral churches are governed by chapters, consisting of a dean, canons and prebendaries. The present civil parishes do not coincide with ecclesiastical parishes, which have lost their old significance. Each parish has its church, with its priest who is known as a vicar, rector or perpetual curate, according to his relation to the temporalities of his parish.

Twenty-six bishops have the right to seats in the House of Lords, of whom five, namely, the two archbishops and the bishops of London, Durham and Winchester, always sit, the others taking their seats in order of seniority of consecration.

Under the Church of England Assembly (Powers) Act, 1919, there is a National Assembly called "The Church Assembly" in England, consisting of a house of bishops, a house of clergy, and a house of laymen, which has power to legislate regarding Church matters. Every measure passed by the Church Assembly must be submitted to an ecclesiastical committee nominated by parliament, and this committee reports on each measure which becomes law, if passed by both houses of parliament.

The various Nonconformist Churches generally have a resident minister (pastor) where the churches have large congregations. The smaller congregations are visited periodically by ministers, but otherwise have lay preachers. The Wesleyan Methodist and some other Methodist ministers change circuit periodically, the period in the Wesleyan Methodist Church having formerly been three years. The organization of the Wesleyan Methodist and other Churches is highly developed, government being vested in a conference. The Congregationalist and Baptist Churches have a less elaborate general organization, and have relied more on the principle of self-government of each group. The Presbyterian Church has developed in England on Scottish lines. The Society of Friends occupies a very special position, as fixed dogmas and an ordained ministry are against the principles of the society; though a small group numerically, the influence of the Society upon thought and policy is a great one. The Salvation Army, with a more or less military organization, is a group famed for its work among the less fortunate strata of the community. The Jewish religion numbers about 300,000 adherents, with about 200 synagogues. The removal of restrictions has permitted the Roman Catholic Church to build up afresh its organization in this country, and it has in England (1924) three archbishops, of whom one is a cardinal, 13 bishops and four bishops-auxiliary.

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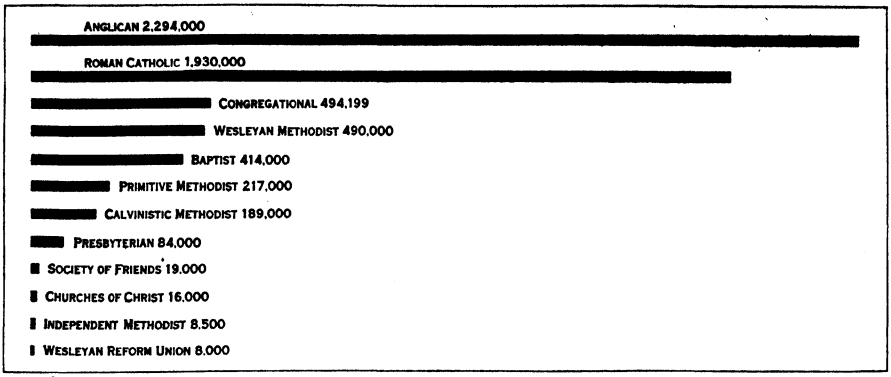

GRAPH SHOWING THE NUMBER OF FULL MEMBERS OF CERTAIN CHURCHES IN ENGLAND AND WALES, CHANNEL ISLAND, AND ISLE OF MAN. THERE ARE ABOUT THREE HUNDRED THOUSAND JEWS IN THE UNITED KINGDOM WITH ABOUT TWO HUNDRED SYNAGOGUES

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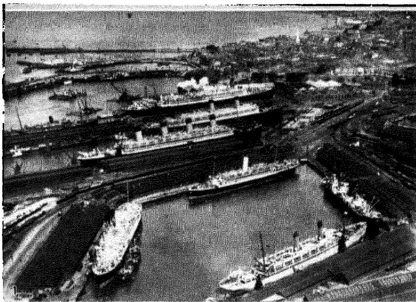
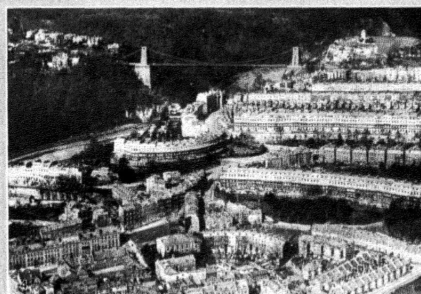
ENGLAND, THE CHURCH OF. The Christian Church in England existed as the Church of the English people long before that people became a united nation; and notwithstanding changes of doctrine, ritual and organization, there has been no real breach of continuity from the 6th century onwards. In the present article only the most outstanding and significant facts in the history of the Church of England are described, until we come to the last decade of the 19th century, from which date the course of events is treated more fully.

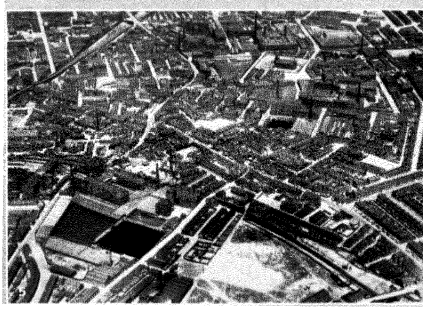
The British Church.—Christianity reached Britain during the 3rd century, and perhaps earlier, probably from Gaul. An early tradition records the death of a martyr Alban at Verulamium, the present St. Albans. A fully grown British Church existed in the 4th century: bishops of London, York and Lincoln attended the council of Arles in 314; the church assented to the council of Nicaea in 325, and some of its bishops were present at the council of Rimini in 359. Britons made pilgrimages, to Rome and to Palestine, and some joined the monks who gathered round St. Martin, bishop of Tours. Among these was Ninian, who preached to the southern Picts, and about 400 built a church of stone on Wigton Bay; its whiteness struck the people and their name for it is commemorated in the modern name Whithorn. From northern Britain, St. Patrick (*see* PATRICK, ST.) went to accomplish his work as the apostle of Ireland. When the Britons were hard pressed by Saxon invaders large bodies of them found shelter in western Armorica, in a lesser Britain, which gave its name to Brittany. A British Church was founded there, and bishops, scholars and recluses of either Britain seem constantly to have visited the other. Afterward Gildas (about 550) and other British monks preached in Ireland, and from them the Scots, the dominant people of Northern Ireland, received a ritual. The organization of the Scotic Church in Ireland was similar to that of the British Church. Its monastic settlements or schools were many and large, and were the abodes of learning. Bishops dwelt in them and were reverenced for their office, but each was subject to the direction of the abbot and convent. In 565 (?) St. Columba, the founder and head of several Scotic monasteries, left Ireland and founded a monastery in Iona, which afforded gospel teaching to the Scots of Dalriada and the northern Picts, and later did a great work in evangelizing many of the Teutonic conquerors of Britain. But the Anglo-Saxon invasion had cut off Britain from communication with Rome. The British Church had no share in the progressive life of the Roman Church. The Britons themselves gradually retreated before the invaders to Wales, and to western and northern districts, or dwelt among them as slaves or as outlaws, and they made no attempts to evangelize the conquering race.

Foundation of the English Church.—The romantic story of the Roman Abbot Gregory (afterwards Pope Gregory the Great) seeing some fair-haired English boys exposed for sale in Rome, and so being led to take a practical interest in the Christianization of their country, is well known. After he became pope he sent a mission to England headed by Augustine. The way was prepared, for Aethelberht, king of Kent, had married a Christian, a Frankish princess Berhta. Augustine and his band landed probably at Ebbsfleet in 597. They were well received by Aethelberht, who was converted and baptized. On the 16th of November Augustine was consecrated by the archbishop of Arles to be the archbishop of the English, and by Christmas had baptized many hundreds of Kentish men. Augustine restored a Roman church at Canterbury to be the church of his see. Gregory sent directions for the rule of the infant church. There were to be two archbishops, at London and York; London, however, was not fully Christianized for some years, and the primatial see remained at Canterbury. The mission prospered, but its influence depended on the varying fortunes of the Anglo-Saxon kings; and in 30 years only Kent, East Anglia and parts of Northumbria remained Christian.

The work of the Romans was taken up by Scotic missionaries. Oswald, under whom the Northumbrian power revived, had lived as an exile among the Scots, and asked them for a bishop to teach his people. Aidan was sent to him by the monks of Iona in 635, and fixed his see in Lindisfarne, or Holy Island, where he founded a monastery. Saintly, zealous and supported by Oswald's influence, he brought Northumbria generally to accept the gospel. The conversion of the Middle Angles and Mercians, and the reconversion of the East Saxons, were also achieved by Scots or by







PHOTOGRAPHS, (1, 4) EWING GALLOWAY, (2, 6) AEROFILMS, LTD., (3, 5) AEROFILMS, FROM EWING GALLOWAY

COMMERCIAL AND INDUSTRIAL CENTRES

1. View of the docks at Southampton. Among the best equipped in the world, they can accommodate the largest ships afloat. Transatlantic passenger traffic passes largely through this port

2. Docks at Sunderland, Durham, on the North Sea, a base for the export of coal. Shipbuilding is also an important industry here. The iron bridge shown in the centre of the picture, crossing the River Wear, was the most advanced structure of its kind when built, in 1796

3. Preston, Lancashire. Cotton mills and the tenement homes of the workers surrounding them. The photograph shows the congested conditions in which the mill-hands and their families live

4. Clifton, Bristol, showing old tenement houses. It is situated on the gorge of the Avon, which is here crossed by the Clifton suspension bridge. Chains on the bridge once formed part of the London Hungerford bridge

5. General view of Oldham, a Lancashire cotton town with over 300 cotton-spinning mills, and which manufactures a large amount of velvet, silks, sateens and cotton goods

6. Hanley, one of the six towns of "The Potteries," showing mills where pottery is made. An entire district about 10 miles long and ⅔ mile wide is devoted to this industry. Pottery of every description from the artistic to the utilitarian is manufactured

disciples of the Scotic mission. The Scots were admirable missionaries, holy and self-devoted, and building partly on Roman foundations and elsewhere breaking new ground, they and their English disciples, as Ceadda (St. Chad), bishop of the Mercians, and Cuthbert, bishop of Lindisfarne, who were by no means inferior to their teachers, almost completed the conversion of the country. But they practised an excessive asceticism and were apt to abandon their work in order to live as hermits. Great as were the benefits which the English derived from their teaching, its cessation was not altogether a loss, for the church was passing beyond the stage of mission teaching and needed organization.

Its organization like its foundation came from Rome. An archbishop-designate who was sent to Rome for consecration having died there, Pope Vitalian in 668 consecrated Theodore of Tarsus as archbishop of Canterbury. The church had no system of government nor means of legislation. Theodore united it in obedience to himself, instituted national synods and subdivided the overlarge bishoprics. He also gave the church learning by establishing a school at Canterbury, where many gained knowledge of the Scriptures, of Latin and Greek, and other religious and secular subjects. In the north learning was promoted by Benedict Biscop in the sister monasteries which he founded at Wearmouth and Jarrow. There Bede (*q.v.*) received the learning which he imparted to others. In the year of Bede's death, 735, one of his disciples, Ecgbert, bishop of York, became the first archbishop of York, Gregory III. giving him the *pallium*, a vestment which conferred archiepiscopal authority. He established a school or university at York, to which scholars came from the continent. His work as a teacher was carried on by Alcuin (*q.v.*), who later brought learning to the dominions of Charlemagne. The infant church, following the example of the Irish Scots, showed much missionary zeal, and English missionaries founded an organized church in Frisia and laboured on the lower Rhine. Most famous of all, Winfrid, or St. Boniface, the apostle of Germany, with many English helpers preached to the Frisians, Hessians and Thuringians, founded bishoprics and monasteries, became the first archbishop of Mainz, and in 754 was martyred in Frisia. Meanwhile, religion, learning, arts, such as transcription and illumination, flourished in English monasteries; but heathen customs and beliefs lingered on among the people, and in Bede's time there were many pseudo-monasteries where men and women made monasticism a cloak for idleness and vice.

The Danish Invasions.—The invasions of the Danes fell heavily on the church; priests were slaughtered and churches sacked and burnt. Learning disappeared in Northumbria, and things were little better in the south. Bishops fought and fell in battle, the clergy lived as laymen, the monasteries were held by married canons, heathen superstitions and immorality prevailed among the laity. The successful efforts of King Alfred to improve the religious and intellectual condition of his own people (*see* ALFRED), and the gradual reconquest of middle and northern England by his successors, was accompanied by the conversion of the Danish population. A revival of religion was effected by churchmen inspired by the reformed monasticism of France and Flanders, by Odo, archbishop of Canterbury, Oswald, archbishop of York and Dunstan (*see* DUNSTAN). Dunstan sought to reform the church by ecclesiastical and secular legislation, forbidding immorality among laymen, insisting on the duties of the clergy and compelling the payment of tithes and other church dues; but the ecclesiastical revival was short-lived. Renewed Danish invasions, in the course of which Archbishop Alphege was martyred in 1012, and a decline in national character, injuriously affected the church and, though in the reign of Canute it was outwardly prosperous, spirituality and learning decreased. Bishoprics and abbacies were rewards of service to the king, the bishops were worldly-minded, plurality was frequent, and simony not unknown. A political conflict led to the banishment of the Norman archbishop and the appointment of an Englishman, Stigand, in his place. When William of Normandy planned his invasion of England, Alexander II., by the advice of Hildebrand, afterwards Gregory VII., moved doubtless by this schism and by the desire to bring the English Church under the influence of the Cluniac revival and into closer relation with Rome, gave the duke a consecrated banner, and the Norman invasion had something of the character of a holy war.

Norman Times.—The Conqueror's relations with Rome ensured a reform; for the papacy was instinct with the Cluniac spirit. Lanfranc, abbot of Bec, was appointed archbishop of Canterbury and worked harmoniously with the king in bringing the English Church up to the level of the church in Normandy. William and Lanfranc also worked on Hildebrandine lines in separating ecclesiastical from civil administration. Ecclesiastical affairs were regulated in church councils held at the same time as the king's councils. Bishops and archdeacons were no longer to exercise their spiritual jurisdiction in secular courts, as had been the custom, but in ecclesiastical courts and according to canon law. The king, however, ruled church as well as state; Gregory granted him control over episcopal elections, he invested bishops with the crozier and they held their temporalities of him, and he allowed no councils to meet and no business to be done without his licence. Gregory claimed homage from him; but while the king promised the payment of Peter's pence and such obedience as his English predecessors had rendered, he refused homage; he allowed no papal letters to enter the kingdom without his leave, and when an anti-pope was set up, he and Lanfranc treated the question as to which pope should be acknowledged in England as one to be decided by the crown. The relations established by the Conqueror between the crown, the church and the pope, its head and supreme judge, worked well as long as the king and the primate were agreed, but were so complex that trouble necessarily arose when they disagreed. William Rufus quarrelled with Anselm (*q.v.*), who succeeded Lanfranc; and Anselm maintained against Henry I. the papal right of investiture (*q.v.*). This question was settled in England by a compromise: Henry surrendered investiture and kept the right to homage. The substantial gain lay with the crown, for, while elections were theoretically free, the king retained his power over them.

The Angevin Kings.—During Stephen's reign the church grew more powerful than was for the good either of the state or itself. Its courts encroached on the sphere of the lay courts, and further claimed exclusive criminal jurisdiction over all clerks whether in holy or minor orders, with the result that criminous clerks, though degraded by a spiritual court, escaped temporal punishment. Henry II., finding ecclesiastical privileges an obstacle to administrative reform, demanded that the bishops should agree to observe the ancient customs of the realm. These customs were, he asserted, expressed in certain constitutions to which he required their assent at a council at Clarendon in 1164. In spirit they generally maintained the rights of the crown as they existed under the Conqueror. Archbishop Becket (*see* BECKET) agreed, repented and refused his assent; and a long quarrel ensued. The archbishop's murder consequent on the king's hasty words shocked Christendom, and Henry did penance publicly. By agreement with the pope he renounced the Constitutions, but the encroachments of the church courts were slightly checked, and the king's decisive influence on episcopal elections and some other advantages were secured. Under the guidance of ecclesiastics employed as royal ministers, the church supported the crown until, in 1206, Innocent III. refused to confirm the election of a bishop nominated by King John to Canterbury, and consecrated Stephen Langton as archbishop. The resulting quarrel with the pope ended with the king's surrender in 1213, when he acknowledged that he held his kingdom of the Roman see, promised a yearly tribute for England and Ireland, surrendered his crown to the legate, and received it again from him. Langton guided the barons in their demands on the king which were expressed in Magna Carta. The first clause provided, as charters of Henry I. and Stephen had already provided, that the English Church should be "free," adding that it should have freedom of election, which John had promised in 1214. As John's suzerain, Innocent annulled the charter, suspended Langton, and excommunicated the barons in arms against the king. These prerogatives were maintained by the papal legates after the accession of Henry III., until 1221, when Pandulf's departure restored Langton to his rightful position as head in England of the church. Reforms in discipline and clerical work were

then carried out. Religious life was quickened by the coming of the friars (*see* FRIARS). Parochial organization was strengthened by the institution of vicars in benefices held by religious bodies. It was a time of intellectual activity, in character rather cosmopolitan than national. English clerks studied philosophy and theology at Paris or law at Bologna; some remained abroad and were famous as scholars, others like Archbishop Langton and Bishop Grosseteste returned to be rulers of the church, and others like Roger Bacon to continue their studies in England. The schools of Oxford had already attained repute, and Cambridge began to be known as a place of study. The spirit of the age found expression in art, and English Gothic architecture, though originally, like the learning of the time, imported from France, took a line of its own and reached its climax at this period. Henry's gratitude for the benefits which in his early years he received from Rome was shown later in subservience to papal demands; but the state of the national church was noted by the Provisions of Oxford in 1258 as part of the general misgovernment which the baronial opposition sought to remedy. The alliance between the crown and the papacy in this reign diminished the liberties of the church.

The 13th, 14th and 15th Centuries.—Edward I., who was a strong king, checked an attempt to magnify the spiritual authority by the writ *Circumspecte agatis,* which defined the sphere of the ecclesiastical courts, put a restraint on religious endowments by the Statute of Mortmain, and desiring that every estate in the realm should have a share in public burdens and counsels, caused the beneficed clergy to be summoned to send proctors to parliament. The clergy preferred to make their grants in their own convocations, and so lost the position offered to them. The king's dealings with the church were on the whole statesmanlike. He employed clerical ministers and paid them by church preferments, but his nominations to bishoprics did not always receive papal confirmation which had become recognized as essential. His weak son Edward II. yielded readily to papal demands. The majority of the bishops in his reign, and specially those engaged in politics, were unworthy men; religion was at a low ebb; plurality and nonresidence were common. Moreover the residence of the popes at Avignon from 1308 to 1377 brought them under French influence; and Englishmen during the war with France were specially displeased that large sums should be drawn from the kingdom for them and that they should exercise ecclesiastical patronage in England. Papal interference in suits concerning temporalities was checked by a law of 1353 (the first statute of *Praemunire*), which made punishable by outlawry and forfeiture the carrying before a foreign tribunal of causes cognizable by English courts. This measure was extended in 1365, and in 1393 by the great statute of *Praemunire*. Indignant at this, Urban V. demanded payment of the tribute promised by John, which was then thirty-three years in arrear, but parliament repudiated the claim.

The Black Death disorganized the church by thinning the ranks of the clergy, who did their duty manfully during the plague. Large though insufficient numbers were instituted to benefices and unfit persons received holy orders. The value of livings decreased and many lay vacant. Some incumbents deserted their parishes to take stipendiary work in towns or secular employments, and unbeneficed clergy demanded higher stipends. Greediness infected the church in common with society at large. The state needed money and attacks were made in parliament on the wealth of the church. A definitely anti-clerical party formed itself, with John of Gaunt, duke of Lancaster, at its head. For political reasons he supported John Wycliffe; but he was unpopular, and when the bishops cited Wycliffe before them in St. Paul's, the duke's conduct provoked a riot and the proceedings ended abruptly (*see* WYCLIFFE). Wycliffe held that temporal power belonged only to laymen; and not to popes nor priests; and he even attacked the papacy itself, which in 1378 was distracted by the great schism; and afterwards condemned pilgrimages, secret confession and masses for the dead. He taught that Holy Scripture was the only source of religious truth, to the exclusion of church authority and tradition, and he and his followers made the first complete English version of the Bible. His opinions were spread by the poor priests whom he sent out to preach and by his English tracts.

With the accession of the Lancastrian house the crown allied itself with the church, and the bishops adopted a repressive policy towards the Lollards. In 1401 a statute, *De heretico comburendo,* ordered that heretics convicted in a spiritual court should be committed to the secular arm and publicly burned, and, while this statute was pending, one Sawtre was burned as a relapsed heretic. Henry V. was zealous for orthodoxy and the persecution of Lollards increased, although the movement had ceased to have any political importance and the church itself was in an unsatisfactory state. As regards the papacy, the crown generally maintained the position taken up in the previous century, but its policy was fitful, and the custom of allowing bishops who were made cardinals to retain their sees strengthened papal influence. The bishops were largely engaged in secular business; there was much plurality, and cathedral and collegiate churches were frequently left to inferior officers whose lives were unclerical. The clergy were numerous and drawn from all classes, and humble birth did not debar a man from attaining the highest positions in the church. Preaching was rare, partly from neglectfulness and partly because, in 1401, in order to prevent the spread of heresy, priests were forbidden to preach without a licence. Monasticism had declined. Papal indulgences and relics were hawked about chiefly by friars. On the other hand, all education was carried on by the clergy, and religion entered largely into the daily life of the people, into their gild-meetings, mystery-plays, and holidays, as well as into the great events of family life—baptisms, marriages and deaths. Many stately churches were built in the prevailing Perpendicular style, often by efforts in which all classes shared.

The Reformation Era.—During the earlier years of the 16th century Lollardism still existed among the lower classes in towns, and was rife here and there in country districts. Persecution went on and martyrdoms are recorded. The old grievances concerning ecclesiastical exactions remained unabated. Lutheranism affected England chiefly through the surreptitious importation of Tyndale's New Testament and "heretical" books. In 1521 Henry VIII. wrote a book against Luther in which he maintained the papal authority, and was rewarded by Leo X. with the title of Defender of the Faith. Henry, however, whose will was to himself as the oracles of God, finding that the pope opposed his intended divorce from Catherine of Aragon, determined to allow no supremacy in his realm save his own. He carried out his ecclesiastical policy by parliamentary help. Parliament was packed, and was skilfully managed; and he had on his side the popular impatience of ecclesiastical abuses, a new feeling of national pride which would brook no foreign interference, the old desire of the laity to lighten their own burdens by the wealth of the church, and a growing inclination to question or reject sacerdotal authority. He used these advantages to forward his policy, and when he met with opposition, enforced his will as a despot. The parliament of 1529 lasted until 1536; it broke the bonds of Rome, established royal supremacy over the English Church, and effected a redistribution of national wealth at the expense of the clergy. Appeals to Rome were forbidden by statute, and the council ordained that the pope should thenceforth only be spoken of as bishop of Rome, as not having authority in England. In 1534 all payments to Rome were forbidden, and it was enacted that, on receiving royal licence to elect, cathedral chapters must elect bishops nominated by the king. The papal power was extirpated by statute, parliament at the same time declaring that neither the king nor kingdom would vary from the "Catholic faith of Christendom." The submission of the clergy was made law; appeals from the archbishops' courts were to be made to the king in chancery, and to be heard by royal commissioners appointed for the purpose; and the king's title as "Supreme Head in earth of the Church of England" was declared by parliament without qualification. Fisher, bishop of Rochester, and Sir Thomas More, lately chancellor, the two most eminent Englishmen, were beheaded in 1535 on an accusation of attempting to deprive the king of this title.

By breaking the bonds of Rome Henry did not give the church freedom; he substituted a single despotism for the dual authority which pope and king had previously exercised over it. In 1535

Cromwell, the king's vicar-general, began a visitation of the monasteries. The reports (*comperta*) of his commissioners having been delivered to the king and communicated to parliament in 1536, parliament declared the smaller monasteries corrupt, and granted the king all of less value than £200 a year. A rebellion in Lincolnshire and another in the north, the formidable Pilgrimage of Grace, followed. The suppression of the greater houses was effected gradually, surrenders were obtained by pressure, and three abbots who were reluctant to give up the possessions of their convents for confiscation were hanged. Monastic shrines and treasuries were sacked and the spoil sent to the king, to whom parliament granted all the houses, their lands and possessions. Some of the wealth was used for the bishoprics of Westminster, Bristol, Chester, Gloucester, Oxford and Peterborough.

The publication of the "Ten Articles" (1536), the "Bishop Book" (1537), the "Six Articles" (1539) and the "King's Book" (1543), showed that Henry, while changing many things in the church, would not allow any deviation in essentials from the religion of Catholic Europe, which was not then so dogmatically defined as it was later by the council of Trent. Edward VI. was a child, and the Protector Somerset and the council favoured further changes, which were carried out with Cranmer's help. Many German reformers came to England, were favoured by the council, and gained influence over Cranmer. The first Book of Common Prayer was authorized by an Act of Uniformity in 1549; it retained much from old service books, but the communion office is Lutheran in character. It excited discontent, and a serious insurrection broke out in the West. After Somerset's fall the government rapidly pushed forward reformation. Altars were destroyed and tables substituted. Five bishops, Bonner of London, Gardiner of Winchester, and Heath of Worcester, then already in prison, and two others, were deprived. Under the influence of the Swiss reformers, who took a lower view of the Eucharist than the Lutheran divines, Cranmer soon advanced beyond the prayer-book of 1549. A second prayer-book, departing further from the old order, appeared in 1552, and without being accepted by convocation was enforced by another Act of Uniformity, and in 1553 a catechism and forty-two articles of religion were authorized by Edward for subscription by the clergy, though not laid before convocation. Edward died in 1553. Apart from matters of faith, the church had fared ill under a royal supremacy exercised by self-seeking nobles in the name of the boy-king. Convocation lost all authority and bishops were treated as state officials liable to deprivation for disobedience to the council. Means of worship were diminished, and the poor were shamefully wronged by the suppression of chantries, gilds and holy day; even the few sheep of the poor brethren of a gild were seized to swell a sum which from 1550 was largely diverted from public purposes to private gain. Churches were despoiled of their plate; the old bishops were forced, the new more easily persuaded, to give up lands belonging to their sees.

When Mary succeeded her brother, the deprived bishops were restored, some reforming bishops were imprisoned, and Cranmer, who was implicated in the plot on behalf of Lady Jane Grey, was attainted of treason. As regards doctrine, religious practices and papal supremacy, Mary was set on bringing back her realm to the position existing before her father's quarrel with Rome. Her first parliament repealed the ecclesiastical legislation of Edward's reign, and convocation formally accepted transubstantiation. Cardinal Pole was received as legate, and the title of Supreme Head of the Church having been dropped, a parliament carefully packed, and the fears of the rich appeased by the assurance that they would not have to surrender the monastic lands, he absolved the nation in parliament and reunited it to the Church of Rome on November 30, 1554, the clergy being absolved in convocation. Parliament repealed all acts against the Roman see since the twentieth year of Henry VIII. The heresy laws were revived, and a horrible persecution of those who refused to disown the doctrines of the prayer-book began in 1555, and lasted during the remainder of the reign. Nearly 300 persons were burned to death as heretics in these four years, among them being five bishops: Hooper of Gloucester, Ferrar of St. David's, Ridley of London, and Latimer (until 1539) of Worcester in 1555, and Archbishop Cranmer in 1556. The chief responsibility for these horrors rests with the queen. Mary died in 1558. Her reign arrested the rapid spoliation of the church, but the persecution by which it was disgraced made another acceptance of Roman supremacy impossible.

Elizabethan Settlement.—Elizabeth's accession was hailed with pleasure; she was known to dislike her sister's ecclesiastical policy, and a change was expected. An Act of Supremacy restored to the crown the authority over the church held by Henry VIII., and provided for its exercise by commissioners, whence came the Court of High Commission nominated by the crown, as a high ecclesiastical court. An Act of Uniformity prescribed the use of the prayer-book of 1552 in a revised form which raised the level of its doctrine, and injunctions enforced by a royal visitation re-established the reformed order. Adherents to Rome vainly tried to obtain papal sanction for attending the church services, and were forced either to disobey the pope or become "recusants"; many were fined, and those who attended mass were imprisoned. Meanwhile a party, soon known as Puritans, rebelled against the prescribed church order; exiles who had come under Genevan influence objecting on their return to vestments and ceremonies enjoined by the prayer-book. There was much non-conformity in the church which the queen ordered the bishops to correct. Meanwhile the pope endeavoured to involve the English Catholics in political rebellion. Active opposition to the government was stirred up by Pius V., and in 1569 a rebellion in the north, where the old religion was strong, was aided by papal money and encouraged by hopes of Spanish intervention. In 1570 Pius published a bull excommunicating and deposing the queen. Thenceforward recusants had to choose between loyalty to the queen and loyalty to the pope. They lay under suspicion, and severe penal laws were enacted against Romish practices. About 1579 many seminary priests and Jesuits came over to England as missionaries; some actively engaged in treason, all were legally traitors. The council hunted down these priests and their abettors, and many were executed. The papal policy defeated itself; a large number of the old religion while retaining their faith chose to be loyal to the queen.

In the meantime the doctrine of the church was officially set forth in the revised articles of religion which appeared as the XXXIX. Articles in 1576; and from this time began the non-conformist effort to introduce Presbyterianism. Cause for grievance existed in the state of the church which had suffered from the late violent changes. Separation, or Independency, began about 1578 with the followers of Robert Browne, who repudiated the queen's ecclesiastical authority (*see* CONGREGATIONALISM); but many nonconformists remained in the church and continued their efforts to subvert its episcopal system. Elizabeth understood the political value of the church, and would allow no slackness in enforcing conformity. Archbishop Whitgift, though kind-hearted, was strict in his administration of the law; and his firmness met with success. The church regained a measure of orderliness and vigour; its claims on allegiance were advocated by eminent divines and expounded by Hooker. The queen died in 1603.

The Puritan Rebellion.—On the accession of James I. the Puritans expressed their desire for ecclesiastical change in the Millenary Petition which purported to come from 1,000 clergy. At a conference between divines of the two parties at Hampton Court in 1604, James roughly decided against the Puritans. Some small alterations were made in the prayer-book, and a new version of the Bible was undertaken, which appeared in 1611 as the "authorized version." Although conformity could be enforced, the Puritan party grew in strength partly from religious and partly from political causes. They would not admit any authority in religion that was not based on the scriptures; their opponents maintained that the church had authority to ordain ceremonies not contrary to the scriptures. The bishops derived their support from the king, and the church in return supported the king's claim to absolutism and divine right. It suffered heavily from this alliance. As men saw the church on the side of absolutism, Puritanism grew strong both among the country gentry, who were largely represented in the Commons, and among the nation at large, and the church lost ground through the king's political errors. Many of the changes introduced by Laud after he became archbishop in

1633 were needful. Their purpose was partly to restore order and decency in worship; but the introduction of more ceremonial offended the Puritans and was enforced in a harsh and tyrannical manner. Laud lacked wisdom and sympathy. Under his rule nonconforming clergy were deprived and sometimes imprisoned. The cruel punishments inflicted by the Court of Star Chamber of which he was a member, his own harsh dealing, and the part which he took in politics as a confidential adviser of the king, combined to bring odium upon him and upon the ecclesiastical system which he represented. A storm of discontent with the course of affairs both in church and state gathered. In 1640 Charles, after dissolving parliament, prolonged the session of convocation, which issued canons magnifying the royal authority. The Long Parliament voted the canons illegal; Laud was imprisoned, and in 1642 the bishops were excluded from parliament. The civil war began in 1642; in 1643 a bill was passed for the taking away of episcopacy, in 1645 Laud was beheaded, and parliament abolished the prayer-book and accepted the Presbyterian directory, and from 1646 Presbyterianism was the legal form of church government. The king, who was beheaded in 1649, might have extricated himself from his difficulties if he had consented to the overthrow of episcopacy. The victory of the army over parliament secured England against the tyranny of Presbyterianism, but did not better the condition of the episcopal clergy; the toleration insisted on by the Independents did not extend to "prelacy." Community of suffering and the execution of Charles I. brought the royalist country gentry into sympathy with the clergy, and at the Restoration the church had the hold which it lacked under the Laudian rule.

The Restoration Period.—On the king's restoration the survivors of the ejected clergy quietly regained their benefices. The Presbyterians helped to bring back the king and looked for a reward; but the parliament of 1661 was violently anti-Puritan, and in 1662 passed an Act of Uniformity providing that all ministers not episcopally ordained or refusing to conform should be deprived on St. Bartholomew's Day, the 14th of August following. About 2,000 ministers are said to have been ejected, and in 1665 ejected ministers were forbidden to come within five miles of their former cures. Nonconformist worship was made punishable by fine and imprisonment, and on the third offence by transportation. In 1673, parliament passed a Test Act making reception of the holy communion and a denial of transubstantiation necessary qualifications for public office, thus excluding both nonconformists and Roman Catholics. Later, when the dissenters found friends among the party in parliament opposed to the crown, the church supported the king, and the doctrine of passive obedience was generally accepted by the clergy. Nevertheless the church was popular, and among the great preachers and theologians were Jeremy Taylor, Pearson, Bull, Barrow, South and Stillingfleet.

The church and the nation, however, were strongly Protestant, and were alarmed by the efforts of James II. to Romanize the country. James dispensed with the law by prerogative and appointed Romanists to offices in defiance of the Test Act. In 1688 he ordered that his declaration for liberty of conscience, issued in the interest of Romanism, should be read in all churches. His order was almost universally disobeyed. Archbishop Sancroft and six bishops who remonstrated against it were brought to trial, and were acquitted to the extreme delight of the nation.

Revolution Period.—James's attack on the Church cost him his crown. Protestantism was secured from further royal attack by the Bill of Rights; and in 1701 the Act of Succession provided that all future sovereigns should be members of the Church of England. That the king's title rested on a parliamentary decision was destructive of the clerical theory of divine right, and encouraged Erastianism, then specially dangerous to the church. William, a Dutch Presbyterian, secured the passing of an Act for toleration of Protestant dissenters who did not deny the doctrine of the Trinity. Anxious for further concessions to dissenters, he appointed a committee of convocation for altering the liturgy, canons and ecclesiastical courts, but the Tory party in the lower house of convocation was strong and the scheme was abortive. A long controversy began between the two houses: the bishops were mostly Whigs with latitudinarian tendencies, the lower clergy Tories and high churchmen. During most of the reign convocation was suspended and the church was governed by royal injunctions, a system injurious to its welfare. Nevertheless its religious life was active; associations for worship and the reformation of manners led to more frequent services, to the establishment of schools for poor children, and to the foundation of the Societies for Promoting Christian Knowledge (S.P.C.K.) and for the Propagation of the Gospel in Foreign Parts (S.P.G.). Unfortunately for the church, its supposed interests were used by the Tories for political ends.

The 18th Century.—With the accession of the Hanoverian line the church entered on a period of feeble life and inaction: many church fabrics were neglected; daily services were discontinued; holy days were disregarded; Holy Communion was infrequent; the poor were little cared for; and though the church remained popular, the clergy were lazy and held in contempt. The church was regarded as subservient to the state; and it was treated by politicians as though its principal function was to support the government. This change was accelerated by the silencing of convocation. A sermon by Hoadly, bishop of Bangor, impugned the existence of a visible church, and the "Bangorian controversy" (*q.v.*) which ensued threatened to end in the condemnation of his opinions by convocation, or at least by the lower house. As this would have weakened the government, convocation was prorogued, letters of business were withheld, and from 1717 until 1852 convocation existed only in name.

While the church was inactive in practical work, it showed vigour in the intellectual defence of Christianity. Controversies of earlier origin with assailants of the faith were ably maintained by, among others, Daniel Waterland, William Law (a nonjuror) Bishop Butler, whose *Analogy* appeared in 1736, and Bishop Berkeley. At length a deep and far-reaching revival of spirituality and energy set in, known in history as the *Evangelical Revival.* Its origin has been traced to Law's *Serious Call*, published in 1728. Law's teaching was actively carried out by John Wesley (*q.v.*), a clergyman who from 1739 devoted himself to evangelization. While he urged his followers to adhere to the church, he could not himself work in subordination to discipline; the Methodist organization which he founded was independent of the church's system and soon drifted into separation. Nevertheless, he did much to bring about a revival of life in the church. A number of the clergy were his allies, and these became the fathers of the Evangelical party. They differed from the Methodists in not forming a separate organization, but remaining in the church and working on the parochial system. The Evangelicals soon grew in number, and their influence for good was extensive. They laid stress on the importance of conscious conversion, giving prominence to the necessity of personal salvation rather than of incorporation with and abiding in the church of the redeemed. Bishop Porteus of London sympathized with them, Lord Dartmouth was a liberal patron, and Cowper's poetry spread their doctrines.

During the reign of George III. the progress of toleration, though slow and fitful, greatly advanced both as regards Roman Catholics and Protestant dissenters. The spirit of rationalism, which had been manifested earlier in attacks on revelation, appeared in a movement against subscription to the Articles demanded of the clergy and others which was defeated in parliament in 1772. The alarm consequent on the French Revolution checked the progress of toleration and was temporarily fatal to free-thinking; it strengthened the position of the church, which was regarded as a bulwark of society against the spread of revolutionary doctrines; and this caused the Anglican Evangelicals to draw off more completely from the Methodists. The church was active: the Sunday-school movement, begun in 1780, flourished; the crusade against the slave-trade was vigorously supported by Evangelicals; and the Church Missionary Society (C.M.S.), a distinctly Evangelical organization, was founded. Excellent as were the results of the revival generally, the Evangelicals had defects which tended to weaken the church. Some characteristics of their teaching were repellent to the young; they were deficient in theological learning, and often in learning of any kind; they regarded the church as the offspring of the Protestant reformation;

they expounded the Bible without reference to the church's teaching, and paid little heed to the church's directions.

The Oxford Movement.—Reforms within the church were urgently needed. In 1813, out of about 10,800 benefices, 6,311 are said to have been without resident incumbents; the value of some great offices was enormous, while many of the parochial clergy were wretchedly poor. The repeal of the Test Act, long practically inoperative, in 1828, and Catholic emancipation in 1829, mark a change in the relations of church and state; and the Reform Bill of 1832 transferred political power from a class which generally supported the church to classes in which dissent was strong. Yet wholesome changes were effected by legislation: dioceses were rearranged, plurality and non-residence were abolished, tithes were commuted, and the Ecclesiastical Commission, which has effected reforms in respect of endowments, was permanently established in 1836. But convocation remained silenced and the church was regarded merely as an institution subject to the state. Among the clergy generally ritual observance was neglected and rubrical directions disobeyed. A few churchmen, including Keble and Newman, set themselves to revive church feeling, and Oxford became the centre of a new movement. The cardinal doctrine of its promoters was that the Church of England was a part of the visible Holy Catholic Church and had unbroken connection with the primitive church; they inculcated high views of the sacraments, and emphasized points of agreement with those branches of the Catholic Church which claim apostolic succession. Their party grew in spite of the opposition of low and broad churchmen, who, specially on the publication of Tract XC. by Newman in 1841, declared that its teaching was Romanizing. In 1845 Newman and many others seceded to Rome. The Oxford movement was wrecked, but its effect survived both in the new high church party and in the church at large. As a body the clergy rated more highly the responsibilities and dignity of their profession, and became more zealous in the performance of its duties and more ecclesiastically minded. High churchmen carried out rubrical directions, and after a while began to introduce changes into the performance of divine service which had not been adopted by the early leaders, were deprecated by many bishops, and excited opposition.

The Church and the Law Courts.—In 1833 the supreme jurisdiction in ecclesiastical matters was transferred to the judicial committee of the privy council. Before this court came an appeal by a clerk named Gorham, whom the bishop of Exeter refused to institute to a benefice because he denied unconditional regeneration in baptism, and in 1850 the court decided in the appellant's favour. The decision was followed by some secessions to Rome, and high churchmen were dissatisfied that spiritual questions should be decided by a secular court. Convocation was revived in 1852. Meanwhile broad church opinions were gaining ground to some extent owing to a reaction from the Oxford movement. Among the clergy the broad church party was comparatively small, but it included some men of mark. In 1860 appeared *Essays and Reviews,* a volume of essays by seven authors, of whom six were in orders. The book as a whole had a rationalistic tendency and was condemned by convocation: two of the essayists were suspended by the Court of Arches, but its judgment was reversed by the judicial committee. An attack on the historicity of the Old Testament was published by Colenso, bishop of Natal, for which he was deposed by Bishop Gray of Cape Town, in 1863, but the judicial committee decided that the bishop of Cape Town had no coercive jurisdiction over Natal. Some practices introduced by clergy desirous of bringing the services of the church to a higher level came before the judicial committee in the case of *Westerton* v. *Liddell* in 1857, with a result encouraging to the ritualists, as they then began to be called. An increase in ritual usages, such as eucharistic vestments, altar lights and incense, followed. In 1860 the English Church Union was formed mainly to uphold high church doctrine and ritual, and assist clergy prosecuted for either cause, and in 1865 the Church Association, mainly to put down such doctrine and ritual by prosecution. A royal commission appointed in 1867 recommended that facilities should be granted for enabling parishioners aggrieved by ritual to gain redress, and in 1870 that a revised lectionary and a shortened form of service should be provided. A new lectionary was approved by the two convocations and enacted, and convocation having received letters of business in 1872 and 1874 drew up a shortened form of prayer which was also enacted, but the commission had no further direct results. Between 1867 and 1871 two decisions of the judicial committee were adverse to the ritualists, and by exciting dislike to the court among high churchmen indirectly led to an increase in ritual usages. Among those who adopted them were many self-devoted men; their practices, which they believed to be incumbent on them, were condemned as illegal, yet they saw the rubrics daily disregarded with impunity by others who trod the easy path of neglect. In 1873 a declaration against sacramental confession received the assent of the bishops, and in 1874 Archbishop Tait of Canterbury introduced a bill for enforcing the law on the ritualist clergy; it was transformed in committee, and was enacted as the Public Worship Regulation Act. It provided for the appointment of a new judge in place of the old ecclesiastical judges, the officials principal, of the two provinces. Litigation increased, the only check on prosecutions being the right of the bishop to veto proceedings, and in 1878–1881 four clergymen were imprisoned for disobedience to the orders of courts against whose jurisdiction they protested. In consequence of the scandal raised by this mode of dealing with spiritual causes, a royal commission on ecclesiastical courts was appointed in 1881, but its report in 1883 led to no results, and the bishops strove to mend matters by exercising their veto. Advanced and illegal usages became more frequent. Proceedings in respect of illegal ritual having been instituted against Bishop King of Lincoln, the archbishop of Canterbury (Benson) personally heard and decided the case in 1890, and his judgment was upheld by the judicial committee (*see* LINCOLN JUDGMENT). The spiritual character of the tribunal and the authority of the judgment had a quieting effect. (X.)

THE CHURCH SINCE 1890

The beginning of the last decade of the 19th century was marked by two factors which indicate the lines of subsequent development within the Church of England. These were the Lincoln Judgment and the publication of *Lux Mundi.* The one aided the progress of that ritualistic and doctrinal movement known as Anglo-Catholicism. The other was even more fundamentally important. It revealed the progress of Biblical criticism among men who secured the acceptance of the principles of that science in circles in which they had hitherto been identified with disloyalty to Christ, and so gave great impetus to the growth of Modernism, even within the Anglo-Catholic movement itself. Anglo-Catholicism has encountered the strongest opposition of a kind which has often been fanatical rather than thoughtful, and which has therefore assisted the movement it sought to destroy. In 1890 a certain Mr. Kensit founded the Protestant Truth Society, pledged to such opposition. It engaged in such measures as the raiding of ritualistic churches and the disgraceful interruption of divine worship in them, and attempted to secure the election to Parliament of men pledged to oppose ritualism. Archbishop Benson laboured for peace, but the feud was intensified by the Papal condemnation of Anglican Orders in September 1896. Certain French clergy had suggested that these Orders might be recognized as valid; and Leo XIII., most liberal of Popes, appointed a Commission to examine the matter. This Commission was understood to be favourable, but a committee of Cardinals reported adversely and the subsequent Bull *Apostolicae Curae* declared that "ordinations performed by the Anglican rite have been and are utterly invalid and altogether null." This set-back to Anglo-Catholic aspiration, so far from satisfying the Protestant opposition, provoked a renewed outburst of anti-Roman controversy, in which Sir William Harcourt, the champion of the earlier Public Worship Regulation Acts took a leading part. There can be no doubt that there was the most lamentable and flagrant disorder within the Church, though it was then as nothing to what it has since become. Various questions concerning it were argued at the Lambeth Hearings in 1899. The Archbishops condemned the ceremonial use of incense and of lights in procession, and, in general, diocesan Bishops have accepted this

decision as the law in the matter. In the following year the Reservation of the Sacrament was condemned. Individual Bishops have attempted to secure obedience to this prohibition, but no concerted action has been taken, and it has never been successfully enforced. Bishop Creighton held conferences at Fulham in an attempt to bring the opposing leaders together; Temple, anxious for the weightier matters of the law, allowed wide divergencies in externals. None the less the agitation became so acute that in 1904 a Royal Commission on Ecclesiastical Discipline was appointed, which in 1906 produced a Report filling five bulky Blue Books. It revealed departures from the use of the Church of England such as the interpolation into the Communion Office of prayers from the Roman Mass, the practice of Reservation, of the Mass of the Pre-sanctified, of Corpus Christi processions, of the invocation of the Virgin Mary and of Saints, and the observance of such Roman festivals as those of the Assumption and of the Sacred Heart. These practices were bluntly declared to be "clearly inconsistent with and subversive of the teaching of the Church of England." They suggested doctrines repudiated by the Church of England and "should promptly be made to cease." There was also some illegality at the other end of the ceremonial scale, *e.g.*, Evangelicals neglected to say the prescribed daily services, but the Commissioners, while noting such breaches, ruled that few of them had any doctrinal significance. At the same time it was stated with equal frankness that "the law of Public Worship in the Church of England is too narrow," the ecclesiastical courts were recognized as effete and their reconstruction was recommended, together with an increase of the Bishops' power in dealing with obstinate law-breakers, against whom it was suggested that the final measure should be not imprisonment but deprivation. It was further urged that Letters of Business should be issued to the Convocations to prepare a new Ornaments Rubric and "to make such modifications in the law relating to Divine Worship as may tend to secure greater elasticity." The Letters were duly issued. Convocation attempted compromises acceptable to neither party, and began a 20 years consideration of Prayer Book revision.

ROYAL COMMISSION REPORT

The Report of the Royal Commission, violent Protestant opposition, fatherly episcopal counsel coupled with inaction, have all been in vain. Anglo-Catholicism has grown and has done much to transform the outward appearance of the Church of England and the teaching given inside it. It gained no little impetus from the fact that it stressed that idea of historical continuity which characterized the time of its origin, it has been fortunate in the zeal of its devotees, and the undoubted attraction it possesses for a certain type of mentality. Its three Anglo-Catholic Congresses held in the Albert Hall have been thronged with devout men and women, and the same is true of many provincial congresses. These meetings elicit a religious emotional fervour which has not been witnessed in England since the days of Wesley. The work done by Anglo-Catholics among the poor is beyond praise and covers a multitude of intellectual sins. Like everything else in the Church of England it is a loose collection of elements by no means altogether agreed or consistent. It is eclectic, choosing from among the doctrines of Western Catholicism instead of from among those of Protestantism. From the days of *Lux Mundi* it has contained a Liberal and a traditionalist wing, and the divergence between them is growing. The former accepts Biblical criticism, sometimes in an extreme form, and also, though perhaps to a less degree, historical criticism. The more traditional section can scarcely be said to do so, except verbally. The great influence of *The Church Times,* to which the whole movement owes an immense debt (not all of one kind), steadily prevents any effective control of Anglo-Catholicism by its liberal scholars; these continue the best tradition of the Oxford Movement which has tried to stand on the side of learning and for the full use of art and knowledge in the service of faith. They largely adopt Newman's theory of Development. *Lux Mundi* revealed this feature in contrast to the attitude of earlier Tractarians. The Editor, in his essay on *The Holy Spirit and Inspiration,* recognized the fact of limitation in the human knowledge of Jesus; his "Kenotic" theory, rendered necessary by his historical and critical investigations, was a rather desperate attempt to retain the Chalcedonian Christology. The same principles which animated *Lux Mundi,* appeared again in a volume by some Oxford tutors called *Contentio Veritatis* (1902). The work has gone on and is exemplified to-day in all the best of the younger scholars of the liberal wing of Anglo-Catholicism. The more traditional Anglo-Catholicism is not without learned men, but they are few and old. The ideals of the more liberal school were clearly stated by Dr. Rawlinson in a paper entitled *Catholicism with Freedom* which he read at an Anglo-Catholic Congress in Birmingham. A protest followed from the unprogressive orthodox, similar to that caused by *Lux Mundi* a generation earlier. The traditions of that book have recently found admirable expression in the work *Essays Catholic and Critical,* in which the essential corner-stone of Roman and traditional Catholicism—oracular external authority—is repudiated in the clearest terms. The book gives an account, and offers some defence of, a form of Christianity which values historical continuity, Catholic custom and, above all, sacramental religion, combined with a full acceptance of modern criticism and learning.

It is very unfortunate, however, that this is not the type of Anglo-Catholicism taught in most churches of the movement. There is a large and influential propaganda which is definitely Roman in spirit and outlook, in its teaching about revelation, about ecclesiastical authority as a ground of belief, about the binding character of tradition; definitely Roman in its forms and modes of worship. It is denied that the Church of England, apart from Rome, has any authority for her members in matters of faith. The hope is cherished, through many disappointments, that some day infallibility will compromise with its own claim; there is a pathetic longing for recognition by Rome. This is a fundamental departure from the attitude characteristic of the Oxford Movement. Among this traditionalist school, Biblical criticism is somewhat regretfully accepted in regard to the Old Testament; it is not denied that it must be applied to the New, but it is allowed to have no doctrinal consequences. It is openly confessed that Anglo-Catholicism wishes to do for England what the Counter-Reformation has done for Belgium, for Northern France, and for Southern Germany, and that to try this system means to try it as a whole. Further it is claimed that there is no important difference between the Anglican Eucharist and the Roman Mass. Thus, in June, 1924, some 3,000 Anglican clergymen, including Bishop Gore, presented a "Declaration of Faith" to the Orthodox Patriarch of Alexandria. It stated that "the signatories affirm that they hold it to be the genuine doctrine of the Anglican Church that they have received Apostolic Orders through their Bishops with the purpose that we should offer the unbloody Sacrifice of the Eucharist for both the living and the departed. We hold that by consecration the bread and wine are changed and become the true Body and Blood of Christ, and we hold that Christ, thus present, is to be adored." This, as a leading Jesuit affirms, states the pre-Reformation belief, and the belief of Rome to-day, but to call it the historic witness of the Anglican Communion during the past 375 years, or to say that it is the official Anglican faith to-day is to state what simply is not a fact. Indeed, there are many Churches in England to-day in which the whole Roman system is inculcated, except the doctrine of Papal Infallibility, and an attitude of deferential respect even to this claim is much more common than any opposition to it. It is said that Catholic doctrine is static; the most there can be is variation and development of interpretation; that the order of the Christian Church was decided once for all in the years immediately following the Ascension; that the Creeds, the Sacraments and the Episcopal Ministry derive their authority directly from the Apostles, and that any modification of them would involve the abandonment of what is essential to Christianity.

MODERNISM

The other development of thought which, with more or less consistency, has steadily grown in the English Church since the last decade of the 19th Century, is the phenomenon known as Modernism (*q.v.*). While it is absurd to suggest that an insistence on the practical nature of the gospel, and the preaching thereof, is

characteristic of any one school of thought; it is nevertheless true that, at least in earlier days, the emphasis of Modernism has been concerned with the intellectual element in religion. It is, among other things, a protest against a stereotyped intellectualism. The content of Modernism is not easy to distinguish inasmuch as it represents a fundamental attitude of mind rather than a system of thought. In brief, it demands that a fair hearing be given to every new suggestion, and is anxious to make use of whatever in the knowledge, practice or aspiration of the modern world can be used by the Church in its task of reconciling man to God. It recognises that Biblical criticism which has made its way in the Church of England through the efforts of such men as the late Drs. Driver and Sanday, and Bishop Gore, involves a totally different attitude towards the Bible from that formerly common to all schools of Anglican theology. It is a movement inside the Church, and aims at a reconstruction of theology. It demands that the claims of scientific history have to be applied, and the results accepted, in the study of traditional theology, and it involves a fundamentally different attitude to Dogma, the relations of Faith to History, and Authority, from that which is characteristic of the Roman or narrower Anglican type of Catholicism. It has little organisation. At the close of the 19th century "The Churchmen's Union for the Advancement of Liberal Religious Thought" was founded, and has steadily increased in membership though it does not include a tenth of those who sympathise with its ideals. As early as 1905 there appeared an important "Declaration on Biblical Criticism," asking that the clergy should receive "authoritative encouragement" to face the critical problems of the New Testament with entire candour. It further declared that grave responsibility and peril was involved in building "the faith of souls primarily upon details of New Testament narrative, the historical validity of which must ultimately be determined in the court of trained research." This Declaration was signed by some 1,362 of the home clergy and about 360 of those working in Colonial and foreign lands. Today, though there is much difference and controversy about the implications of Biblical criticism, the fact of it is so widely accepted that there is no University or College of any note in this country where the old view of the Bible is defended. Only among a very few of the older Anglo-Catholics and Evangelicals does it still survive. A book of essays called *Liberal Evangelicalism* (1920) shows to what extent the basis of this latter and honourable school of English Churchmanship has been modernized.

But Modernism, like Anglo-Catholicism, has not made its way without the hindrance, and occasional assistance, of hostile opposition. In 1911 the Rev. J. M. Thompson published a book called *Miracles in the New Testament.* His explicit denial that the "wonder" type of miracle ever happened produced a storm. He was compelled to abandon the exercise of his office in Magdalen College, Oxford: to-day the same position can be freely adopted without the least danger of any action being taken. The next year saw the publication of essays by some Oxford theologians under the title *Foundations.* The contribution of the Editor, Canon B. H. Streeter, who is among the foremost of English New Testament scholars, aroused hostile comment; in particular, his suggestion that the Resurrection appearances were of the nature of visions gave much offence. Today a similar view is maintained in *Essays Catholic and Critical,* by a very advanced Anglo-Catholic, and no outcry has been raised. It is probably the case that the change is more due to decline of interest in such controversies than to the spread of more modern views. A further noisy protest against Modernism was made in 1914, by Bishop Weston of Zanzibar, an extreme Anglo-Catholic. His protest was occasioned partly by the Hulsean Lectures on *The Eschatology of Jesus,* and led to a debate in the Upper House of Convocation. Their Lordships passed the inevitable resolution, the form of which tended in opposite directions. It was affirmed that "the denial of any of the historical facts stated in the Creeds, goes beyond the limits of legitimate interpretation, and gravely imperils that sincerity of profession which is plainly incumbent on the ministers of the Word and Sacraments," yet, in view of what they called "new problems" raised by "historical criticism," the Bishops demanded "considerateness in dealing with that which is tentative and provisional in the thought and work of earnest and reverent students": to-day, few Bishops would refuse to ordain an otherwise suitable candidate who stated his inability to affirm belief in such a miracle as the Virgin Birth. A further transient controversy was aroused by the appointment of Dr. Henson to the see of Hereford: an attempt was made to induce the Archbishop to refuse consecration on the ground of heresy of the Bishop-elect. He was duly consecrated in Feb. 1918, and to-day, as Bishop of Durham, is on the side of a moderate Anglo-Catholicism and is a foremost champion of the spiritual independence of the Church. Two years later the Lambeth Conference assembled, but no guidance was forthcoming on the situation created by Modernist advance. In 1921, at a Conference at Girton College, Cambridge, organised by The Churchmen's Union, the inadequacy of the traditional forms of Christological doctrine was affirmed in the most definite terms. Full account was taken of the bearings of Biblical criticism and modern knowledge, and an attempt was made to restate belief in Christ in modern terminology. A bitter controversy followed, the readers of the Conference papers being freely accused of denying the divinity of Christ. The English Church Union, the largest Anglo-Catholic organization, took up the matter and petitioned Convocation to declare the opinions expressed at Girton contrary to the teaching of the Bible and the Church. The Churchmen's Union presented a counter-petition which was signed by many distinguished theologians outside the Society. The Canterbury Convocation acknowledged "the gain which arises from free enquiry at once fearless and reverent into the meaning and expression of the faith" and deprecated "the more blunt denunciation of contributions made by earnest men in their endeavour to bring new light to bear upon these difficult and anxious problems." The need for caution received emphasis. The Convocation of York pronounced even more favourably in a Modernist direction. Today scholars within the Church of England enjoy a full freedom in study and in the publication of its results; only a party of Anglo-Catholics, and these not the scholars to whom Anglo-Catholicism must look for its future defence, would wish to expel Modernists from the Church.

SCHOOLS AND THE CHURCH

Since 1870, when the State began to provide primary schools in districts where there were no Church schools, education has been steadily but surely passing out of the control of, and largely out of all association with, the Church. In State schools religious teaching is neither ordered nor forbidden, except that the famous "Cowper-Temple clause" provides that no teaching distinctive of any particular denomination may be given in them. In 1896, a Conservative Government, pledged to support Church schools, introduced a far-reaching measure providing for grants to poor voluntary schools in aid of staff and apparatus and that local managers should make arrangements for denominational instruction in religion where a number of parents desired it. Unfortunately for these schools, the Bill was withdrawn. In 1901 another attempt at settlement was made by Convocation. The basis of it was the public financing of secular teaching in all schools coupled with provision for effective local control in the case of voluntary schools. While demanding Church teaching for Church children in Board schools, Convocation proposed facilities for the denominational teaching of other children in Church schools. In the following year Mr. A. J. Balfour's Bill proposed to make the County Council (in the Counties) and the Borough Council (in the Boroughs) the only educational authority; managers of voluntary schools were to provide for the maintenance and improvement of their buildings, but they were to be given a majority in the controlling authority so that they could appoint teachers paid with public money. That the control of religious teaching should be taken from the parson and vested in the managers was opposed by many Anglicans unable to recognize good in any convictions not those of the parish priest; Roman Catholics were committed in advance to opposition; Nonconformists objected to having to pay for religious teaching which they disliked and could not control. The Bishops approved the Bill and it became law. Subsequent attempts to change matters have so far proved abortive: The

difficulties of the Church schools have enormously increased and necessity will decide their fate. The raising of the general educational standard has increased expense; the cost of post-war building is alone sufficient to make the difficulties acute. Primary education is slowly but surely passing altogether from direct association with the Church. In secondary education the same transition proceeds. The Public schools alone maintain their independence by reason of their fees, but few of them are directly connected with the Church of England. At the older Universities all "religious tests" have gone; if the official services are those of the Church of England they are, where voluntary, poorly attended. Thoughtful and learned University sermons are delivered to congregations, small and grey headed, almost bereft of undergraduates. The modern Universities for the most part have no ecclesiastical allegiance and provide no, or next to no, training in the teaching of religion. Since 1921 the Board of Education is no longer prevented from making grants from public money to secondary schools where the teachers are required to belong, or not to belong, to a particular denomination, but in these schools, Church influence is practically non-existent. In elementary schools "the religious question" has been little more than a squabble about ecclesiastical and political rights, in which the interests of the children have escaped attention. Happily, however, the old definite lines of cleavage in this matter between Churchmen and Nonconformists are less clear. The Churchmen who hold that only "definite Church teaching" is worth giving to Church children are a diminishing number: an increasing number weigh the fact that thousands of Church children are educated in Council schools, and realize that the Church has responsibility to the nation at large. Free Churchmen naturally still feel at a disadvantage in districts where the Church school is the only one, but they are increasingly willing to co-operate in efforts to establish a system of religious teaching at once definite and free from emphasis on particular denominational tenets. The regular teachers resent the intrusion of outside teachers of religion who know nothing of the art of teaching, and, less reasonably, are apt to object to any qualifications being demanded of themselves. They have a real grievance in the fact that too many headships are only open to members of the Church of England. But with the spread of the demand that education shall be directed to the training of good citizens rather than denominational bigots these difficulties will prove less and less intractable.

The last forty years have witnessed great changes in the organisation of the Church, and a wealth of legislative acts. As early as 1872 there was much talk about the Disestablishment of the Welsh Church. In 1894 an attempt to make it a fact by the Liberal Government then in power proved abortive. But in 1906 a Commission was appointed to examine the condition of the Church in Wales. It was revealed that, while the Church was the largest of the religious bodies in the Principality, less than a quarter of the inhabitants nominally belonged to it. In 1912, though the project was never really popular in England, a Measure of Disestablishment was introduced into the Commons and passed, but it was rejected in the Lords. It was reintroduced and passed under the Parliament Act, and the separation was finally effected in 1920. The Bishop of St. Asaph became the first Archbishop of Wales and now presides over six dioceses, two new ones having been added since 1920. A splendid co-operation between clergy and laity has triumphed over the crippling effects which were predicted as the inevitable consequence of the Act of Disestablishment.

Ever since the revival of Convocation there has been an increase in the number and importance of deliberative bodies within the Church. Since 1878 a Conference of the Bishops of the Anglican Communion has been called to meet at Lambeth once in every ten years (*see* LAMBETH CONFERENCES). The desire for lay co-operation and support led to the formation of a House of Laymen in each Province, the members of which were elected by the Diocesan Conferences. But these Houses had no legal or ecclesiastical status. In 1896 the Convocations of Canterbury and York held a joint Session with the two Houses of Laymen, and in 1905 a body called the Representative Church Council was formed of members of the Convocations and of the Houses of Laymen. In 1913 this Council petitioned the Archbishops to appoint a Committee on Church and State "to enquire what changes are advisable in order to secure in the relations of the Church and the State a fuller expression of the spiritual independence of the Church as well as of the national recognition of religion." An unofficial organization known as *The Life and Liberty Movement* did much to awaken popular interest in the need for change. The Archbishops' Committee published its Report in 1916, on the basis of which Convocation in 1919 presented an Address to the Crown, recommending legislation to provide for a National Assembly of the Church of England. In December of the same year the Church of England Assembly (Powers) Act (otherwise known as the Enabling Act) became law. The Assembly constituted under this Act has power to prepare and pass Measures for submission to Parliament for approval, "relating to any matter concerning the Church of England." All baptized members of the Church of England of responsible age who will signify themselves as such and declare that they are not members of any religious body not in communion with the Established Church may have their names entered on an Electoral Roll, kept in every Parish. Of these electors there are some $3\frac{3}{4}$ millions. In every parish they elect a Parochial Church Council whose function, as defined by a further Powers Measure of 1921 is "to co-operate with the incumbent in the initiation, conduct and development of Church work both within the parish and without it." The Councils elect Ruridecanal and Diocesan Conference members, and the lay members of the latter elect the House of Laity in the Church Assembly; the number of representatives for each diocese depends on the total number of parochial electors in the diocese. The Church Assembly meets in February, July and November for five-days Sessions. It works through many Committees. A Measure, corresponding to a Parliamentary Bill, is prepared by a Committee, circulated to Members of the Assembly and formally introduced. General Approval is sought for it. There follows a stage of Revision in which amendments may be interested. Then comes a Committee Stage, and sometimes a Drafting Stage, in which verbal adjustments are made. The Measure is then presented for Final Approval and, if this is secured, it is handed over to the Legislative Committee of the Assembly for presentation to the Ecclesiastical Committee of Parliament. This last is a body specially constituted under the Enabling Act. Fifteen members of each House are nominated respectively by the Lord Chancellor and the Speaker and hold office during the life of a particular Parliament. It is the duty of this Committee to examine Assembly Measures, and to report on their nature, legal effect and expediency, whereon (the Report being favourable) any member of Parliament can propose that it be presented to His Majesty for Royal Assent. Parliament must either approve or reject the Measure, but cannot amend it. If both Houses pass it, the Measure becomes law on receiving the Royal Assent.

ADVANTAGES OF REFORM

The great advantage of this reform is that it provides a representative body with a legal status through which the Church can initiate reform. It can carry out work for which Parliament has neither the time nor the qualifications. Facts reveal its utility. During the 25 years from 1888 to 1913, some 217 Bills dealing with ecclesiastical matters were introduced into the House of Commons; 33 of them became law, though only one was rejected: the remainder were dropped for lack of time. Since 1920 more than 20 Measures have received the Royal Assent, that is two-thirds of the former number in slightly more than a quarter of the time. The Convocations which formerly were largely *ex officio* bodies have been reformed and made more representative. Their relation to the Church Assembly is by no means clear, but it is likely that they will continue, in spite of their superfluous character, for reasons of historical sentiment, and because Anglo-Catholics think that so many of the matters with which the Assembly deals affect the clergy alone, and that priestly approval is always doctrinally necessary. Thus, since the Convocations give their approval to Assembly Measures, and are, in fact, themselves the Episcopal and clerical Houses of the Assembly, this feeling of

Church opinion is respected by a redundant formality, which adds substantially to that avalanche of words which seems to be regarded as a sign of religious vitality. A brief summary may be added of the more important of the Measures which have become law since the Enabling Act. (a) In 1921 a scheme was introduced for securing a better distribution of the diminishing man-power of the Church by providing for the amalgamation into a single parish of cures too small to provide adequate work for one parson. The arguments in favour of this policy are theoretically unanswerable, but, in practice, it always elicits strong opposition. (b) A Measure of 1923 prohibits the sale of the right to appoint to a benefice: after the two vacancies next following the passage of the Measure, no such sale can take place. (c) The Clergy Pension Measure of 1926 provides that every parson under the age of 55 must contribute 3% of his ecclesiastical income to the Pension's Fund. This secures a maximum pension of £237 *per annum* at the age of 70 after 40 years service. The contributions of those who die earlier are returned with compound interest. A capital foundation of £350,000 was provided by the Ecclesiastical Commissioners who also made an annual contribution rising to £100,000. The Church Assembly Fund also provides £50,000. This measure removes the long standing scandal of the fact that no provision was made for the old age of an ill-paid clergy beyond allowing a man, on resignation, to appropriate part of the income of the benefice as a pension and thus frequently to handicap his successor. A similar Measure provides for episcopal pensions. (d) The Delapidations Measure of 1923 arranged for the systematic repair of parsonage houses, which are regularly surveyed. Definite annual contributions are made from the parish or by the parson; the Ecclesiastical Commissioners provide £500,000. In the case of benefices under the annual value of £250 Queen Anne's Bounty is empowered to pay half the initial cost of repair and, thereafter, half of the annual charges. (e) The Sees Committee has been very active. The ancient diocese of Winchester has been divided into three, the two new dioceses being those of Portsmouth and Guildford; a new diocese of Leicester has been carved out of Peterborough, Blackburn out of Manchester, Derby out of Southwell. A proposal to divide Lichfield was rejected by one vote in the Lords. There exists considerable doubt both as to the wisdom and the necessity of this policy of multiplying Bishoprics. There is no corresponding growth in Church membership to demand such an increase of episcopal oversight; and, where money is scarce, the founding of new sees is a luxury; improved methods of locomotion should make episcopal work easier; it may be doubted whether there are enough men of eminence to fill so many sees, and still more so whether there will be in the future. (f) The Assembly asked the Archbishop to appoint a Commission to inquire into the Property and Revenues of the Church. After 3 years work a Report was produced which is a mine of information on all aspects of ecclesiastical finance. The Commission suggested a wider use of the money controlled by the Ecclesiastical Commissioners, a more equitable distribution of the total amount available for the parochial clergy, and certain reforms in the administration of Cathedral estates, the payment of episcopal stipends, etc. Some of these recommendations have already been carried into effect: others are still being considered. (g) The Benefices (Ecclesiastical Duties) Measure of 1927 provides that when a charge of negligence is brought against any incumbent, the Bishop can appoint 7 persons, one of whom may be nominated by the accused incumbent, and if their enquiry results in proved neglect of duty, more drastic steps can be taken than were formerly possible. Considerable objection was raised against this Measure on the grounds that "inadequate performance of duty" is an exceedingly vague charge, and that it is not necessary to state the grounds of complaint in detail before the Commission is appointed.

Certain other Measures have been before the Assembly for a long time, but have not yet resulted in definite legislation. Two of them are very contentious. One proposes extensive and far reaching changes in the exercise of patronage: the other is concerned to reform the Courts Ecclesiastical. Reconstitution of the latter was recommended by the Royal Commission of 1904. The trouble is that a large number of clergy will not recognize the competence of the Judicial Committee of the Privy Council as the Court of Final Appeal in spiritual matters, and demands its replacement by a spiritual court. There is, however, little likelihood that the proposals which have so far been made on either of these subjects will ever pass into law without considerable modifications. Whatever criticisms can be made upon the working of the Church Assembly and its actual achievements, there is no doubt that since the Enabling Act the corporate consciousness of the Church has been deepened. The Assembly Press and Publications Board is extremely useful in increasing the general knowledge about Church affairs, a very necessary preliminary to the securing of adequate financial support. In 1923 the dioceses contributed to the Central Board of Finance 61% of the apportionment invited from them: in 1925, 71%, 6 dioceses sending the full quota. The Diocesan Finance Boards are coming to regard their payment to the Central Board as a claim equal to that of their own diocesan needs.

In recent years, and particularly since the War, the sense of the scandal of divided Christendom has been much increased. Consciousness of the weakness of divided Christian witness has been one of the aids of repentance. Some Protestant Churches have achieved federation; the tendency to form new sects has disappeared. On the other hand, the hope of reunion with Rome makes it far harder to achieve it with other Churches. According to the Roman theory the Church cannot be divided; those who break away are outside it and must return to it by way of repentance and submission. For Rome "reunion" has no meaning. Nevertheless efforts in her direction are increasing. Since the Lambeth Conference of 1920 issued its "Appeal to all Christian People" they have been, on the Anglican side, more official in character. Bishop Gore, Dr. Frere (Bishop of Truro), Dr. Kidd (Warden of Keble College, Oxford) and others have held a series of "conversations" at Malines with certain Belgian and French clergy anxious for reunion. These "conversations" were under the chairmanship of Cardinal Mercier and, later, under that of his successor, Cardinal Van Roey. By Anglo-Catholics these attempts have been regarded with hope, by Evangelicals with fear and dislike, by Modernists with a languid interest devoid of hope. The later "conversations" were held with the "cognizance" of the Pope. But the differences between the Anglican Church and Rome are fundamental and afford as good an example of the law of contradiction as could be found, and they remain exactly what and where they were. The official Report of these "conversations" was published, after being in print and withheld for six months, in order (so the presumption must be) not to prejudice the calm consideration of the Prayer Book revision proposals. Almost at the same time came the Papal Encyclical *De Vera Religionis Unitate Fovenda*. It marks the end of all hope of reunion with Rome, and is as definite a condemnation of Anglo-Catholicism as was the *Pascendi* (1907) of Modernism. All assemblies for the discussion of reunion, such as were contemplated by the Lambeth Appeal, are forbidden to Catholics who, by taking part in them "will be giving countenance to a false Christianity quite alien to the one Church of Christ." The official organ of the Vatican, *Osservatore Romano,* declares that the Pope acknowledged the Malines "conversations" merely as an effort between private persons. "They were not invested with any sort of mandate." The same authority adds that the resumption of them will not occur by the consent or encouragement of the Pope.

INTER-CHURCH RELATIONS

Notwithstanding the hopelessness of efforts towards reunion with Rome, the connections of the Church of England, and friendly relations, with the rest of Christendom have grown considerably during the present century. Between Canterbury and the Eastern Orthodox there has been some *rapprochement;* in 1906 a Society of members of each obedience was formed to promote reunion; the years of the War brought the Church of England into contact with Churches abroad; later appeals were made to the Archbishop from the Russian Church in her trouble with the Soviet Government, and the support given may have done much to save the life of the Patriarch Tikhon. The Patriarchate of Constantinople has been officially represented in discussion of

Anglo-Orthodox relations, and in 1922 the Synod of Constantinople formally acknowledged the validity of Anglican Orders; the Churches of Jerusalem and Cyprus have since concurred. Old Catholics of Holland gave similar recognition in 1925. With these Churches, relations are being maintained. None the less, honesty compels the admission that the Eastern Churches would only consider organic union on a dogmatic basis, and that of a kind and content which, except to the more narrow of the Anglo-Catholic party, appears out of the question for the Church of England. In 1920, two Anglican Bishops assisted at the consecration of two Swedish Bishops and occasional intercommunion between the two Churches has been established. With the English Nonconformists the hope of reunion was brighter, but has recently passed under a cloud. All approaches to Rome, however tentative, retard this more practical hope. The Lambeth Conference of 1905 reaffirmed as the basis of reunion what is known as the Lambeth Quadrilateral, namely, the necessity of the acceptance of (a) Holy Scripture as the rule of faith, (b) The Apostles' and Nicene Creeds, (c) the Two Sacraments, (d) Episcopacy. The matter was brought prominently into notice by the Kikuyu Controversy in 1913 and 1914. With the encouragement and the consent of the Bishops of Uganda and Mombasa intercommunion had taken place with the Protestant Churches in East Africa. The Bishop of Zanzibar (Dr. Weston) appealed against it to the Archbishop. The result was a pronouncement that full intercommunion was at present impossible; nevertheless a welcome at Holy Communion in Anglican Churches was extended to non-episcopalians isolated from their own communions. Since the "Appeal to the Christian People" of 1920, Anglicans and Free Churchmen have conferred at Lambeth under the Chairmanship of the Archbishop of York; both Archbishops have given addresses at annual assemblies of Free Churchmen; Free Church ministers occasionally preach in Anglican Cathedrals and Churches with episcopal approval. None the less, the demand of Episcopal Ordination has proved an insurmountable barrier. The Lambeth appeal acknowledged Free Church Ministries to be real ministries within the Catholic Church: Free Churchmen naturally do not see the logic of the requirement of a fresh commission on their side, while Anglicans would receive only a formal recognition to make them acceptable within the present limits of the Free Churches. They feel that episcopal ordination could add nothing to the existing and acknowledged validity of their ministries. The Baptist Union has repudiated the proposals; the Congregationalist reply urged the necessity of loyalty to Reformation principles, and, while refusing ordination *sub conditione*, Congregationalists would be willing to accept a solemn act of mutual recognition. At the moment of writing, all official conferences are closed indefinitely. It is not easy to see what any of the churches are ready to surrender in order to attain union; but it is not rash to predict that the fact of episcopacy as an ancient and workable system of government and order will ultimately be accepted, provided that all theories of its divine authority and necessity are abandoned. In the mission field, and particularly in South India, schemes for reunion are more hopeful.

During the last 12 months (1928) no fewer than three international Conferences have been held—at Stockholm, at Lausanne and at Jerusalem. Though the Stockholm Conference was mainly directed towards the development of an international Christian consciousness in social matters, the basic hope of all three has been for closer and united co-operation between the Churches. The Lausanne Conference, after years of preparation, was attended by more than 500 representatives of some 90 denominations. Many questions of the Ministry and organization were discussed; advance was made towards a common understanding of the Gospel. The Eastern Church representatives made it clear that they could concede nothing in respect of the Creeds, or ever allow the validity of non-episcopal ministries. Lausanne was on too vast a scale to achieve anything definite: its chief value was in the ventilation of views and in promoting friendships.

There has been steady extension of missionary activity in every part of the world, but the growth in available men and money has not kept pace with the growth in opportunity, or even with the maintenance of work already undertaken: In 1903 the United Mission Boards approved the holding of a great pan-Anglican Congress, which met in London in June 1908, when 250 Bishops, with clerical and lay delegates from all parts of the world met for conference. Yet, by 1911, the most vigorous missionary society, the C.M.S., even after sacrificing the greater part of its Capital Fund in 1905, was faced with a deficit of £48,000, and restricted its work. The S.P.G. and the S.P.C.K. continue their work, not without great difficulty and anxiety. The Church cannot adequately cope with the great mass movements towards Christianity in India; she has not been able to keep pace with the acceleration of change in East Africa, and in the East generally. It is stated that nothing but an immediate and large increase in staff and funds will conserve or develop the work in tropical Africa. This state of affairs is not due to a falling off of interest. Home missionary endeavour has been centralised. The C.M.S. and S.P.G. have withdrawn their quarterly papers, and a new one, official for the Church of England, called "The Church Overseas" replaced them in January 1928. The Church Assembly has its Missionary Council. In 1926 a World Convention of 2,700 delegates assembled at St. Paul's. It was designed to arouse missionary interest on a large scale. The Assembly published four Reports or "Calls"—from the Far East, from Africa, from India, and from the Muslim World. A fifth Report dealing with the obligations of the Church towards her own countrymen overseas was published in 1927. These exhaustive Reports give an account of the achievements, present work and obligations of the Anglican Communion in the Mission Field. They reveal chiefly how great the changes have been in the recent past and how much has been accomplished from very slender resources. It is estimated that to keep up existing work, 433 new missionaries are needed at once, 120 more for urgent extension and 180 annually to replace the inevitable wastage. In money, at least £250,000 *per annum* is needed. There has been a progressive movement towards autonomy on the part of Dominion and Missionary Churches. The Church in India is now (since 1927) separate in law from the Home Church, though remaining in full communion with it. Canterbury remains the acknowledged Mother See, though neither claiming nor exercising a primacy comparable to that of the Pope.

THE CHURCH AND OUTSIDE PROBLEMS

Side by side with the increased consciousness of the place of missionary effort in the life of the Church increasing attention has also been given to political, social and economic problems. The Church cannot ignore the challenge of the Labour Party that it represents the true principles of Christianity more adequately than does the Church. The evidence of a deeper interest on the part of the Church is seen in the part her members have taken in the Industrial Christian Fellowship and in "Copec" organizations pledged to assist the Christianizing of the corporate life of mankind in all its activities. The Lambeth Conference of 1920 spoke of the need of "a fundamental change in the spirit and working of our economic life," and stated that "this change can only be effected by accepting as the basis of industrial relations the principle of co-operation in service for the common good in the place of unrestrained competition for private and sectional advantage." There would be general agreement among Christians about this: the difficulties and the differences appear over the question of how it can be accomplished. There is a widespread feeling, both inside and outside the Established Church, that the Church must foster and maintain the Christian spirit and preach Christian principles; but that the working out of these in concrete proposals requires expert knowledge which Christians, as such, do not necessarily possess. It is therefore often felt that the attachment of the Church to a definite programme of social reform, particularly one not devoid of political interests, is to be deprecated. The attempt of certain Bishops, acting in concert with Free Church leaders, to interfere in the dispute in the coal industry in 1926 met with much criticism, not all of which was either ignorant or dictated by political hostility.

The World War had far-reaching effects on the life of the Church, more fundamental than spectacular. The clergy acquitted themselves with honour. No fewer than 186 of them became

temporary Chaplains in the Navy, bringing the total in this service up to 318: 17 were killed in action. The Clergy also supplied 3,036 Temporary Chaplains in the Army of whom 112 were killed on active service. In all 419 decorations were awarded, as follows: V.C. 3; C.M.G. 10; D.S.O. 40; M.C. 250; C.B.E. 20; O.B.E. 69. The War revealed an appalling ignorance of the most elementary Christian truths on the part of ordinary men of the good type who joined the Temporary Army. It also meant the end of religion for thousands for whom religion was identified with the miraculous; rational faith in the supernatural was weakened and this has led to an alarming increase in superstition. Much thought and preparation was expended during the years 1916–18 for a National Mission of Repentance and Hope. It failed.

The most disturbing factor in the life of the Church of England to-day is the inadequate supply of Clergy. During the years 1877–1886 the annual number of those ordained rose steadily to 814. This figure has never since been attained. In the year 1923 when the supply of "Service Candidates" (*i.e.*, men who had served in the Army and Navy during the War) was at its height, 463 men were ordained. This number was 70 below the lowest record during the ten years before the War. Since 1924 there has been a small increase, but the numbers are smaller than between 1922–1924. Whereas from 1880–1911 the annual average was about 700, now it is about 350. Though the population is half as large again as it was in 1880, the Church has about the same number of clergy. In 1926 there were 12,906 incumbents and 4,478 assistant curates. The shortage is between 7,000 and 9,000, and if the new ordinands numbered 400 a year, the Church could not fill 12,000 benefices in the year 1940. Already there are many parishes of 10,000 people with no clerical assistant to the incumbent. The situation is clearly stated by the Editor of "Crockford," for 1927: "The average age of the existing clergy was said, a short time ago, to be nearer sixty than fifty, and this means that the rate of death and retirements, which appears at present to be about 550 *per annum*, will accelerate rapidly during the next ten years. . . . It is not too much to say that if the history of the last ten years is continued for another ten, the effective maintenance of the parochial system will have become impossible in all but a few favoured localities. Anything which can fairly be called *The Church of England* will have ceased to exist and its place will have been taken by the sporadic activities of a denomination." Various causes of this depressing state of affairs are assigned. There are misconceptions of the Ministerial office; other activities give better and less restricted openings for more useful service; intellectual difficulties about Christian doctrine no doubt keep many outside; sacrifices are demanded of those who come forward, and few inducements are offered. It is pointed out that the lack is rather of money than of candidates: societies like Mirfield, where free training is given, receive hundreds of applications every year. This does not explain why men with a certain amount of private means who used formerly to take Orders now so seldom do so. The reasons given for the shortage reveal, and some of them conceal, the fact that Christianity as exemplified in the Church of England does not elicit the same responsive service as it used to do. Much has been done, and is being done, to assist men who cannot pay for their own education. During the years 1921–1924, of the 1,637 men ordained, 660 were "Service Candidates," men who were assisted in accordance with an undertaking given by the Archbishop that no suitable man serving with the Forces should be denied Ordination merely for lack of private means. The Central Board of Finance makes Training for the Ministry one of the main charges upon its Funds. A scheme by which "Sponsors" were invited to make themselves responsible for individual Candidates recently raised £20,000 in 5 weeks. Much money is raised for the same purpose in the interests of particular schools of thought. At the same time some advance has been made in the intellectual standard of the actual examination demanded of Ordinands. To-day, nearly all Bishops accept the General Ordination Examination, conducted by an independent body of extra-Diocesan examiners. But men can still be ordained with practically no knowledge of the science and art of preaching, of the principles of education, of social problems, of the psychology of religion or of comparative religion. The higher standard in the actual examination subjects demanded, does not compensate for the fact that the general educational, cultural and social standard and status of ordinands is lower than formerly.

PRAYER BOOK REVISION

The subject in the affairs of the Church which has recently eclipsed all others has been that of Prayer Book revision, a work which has recently concluded in a double failure to obtain Parliamentary sanction for the proposed revision. The subject had occupied the not too hasty attention of Convocation from 1906–1920. Finally proposals were introduced into the Church Assembly, amended by the Houses of Clergy and Laity and handed to the Bishops for final revision. After months of secret conclave, the Bishops presented their final proposals to Convocation in February 1927, in the form of a Composite Book containing the Book of Common Prayer of 1662 with the Revision as a permissive alternative thereto. It omitted such rubrics as were superseded by a list of general rubrics applicable to both Books. These were all in the direction of greater liberty and concerned the services of Holy Communion, Public Baptism of Infants, Confirmation and Solemnization of Matrimony. The Ordinal of 1662 was replaced by that of 1927. Provision was made for additional services so long as they were not substituted for those of, or contrary to anything contained in, the Book of Common Prayer or the Revised Book. Numerous occasional prayers were added, also Thanksgivings, Collects, Epistles and Gospels. The Ornaments Rubric was reprinted, without interpretation, but a variety of vestures at Holy Communion was definitely allowed. Portions of the Psalms were permitted to be left out in public worship. A form of Compline was also included.

Keen controversy arose over the revision of the Communion Office. Herein the outstanding changes were (a) Permission to reserve a portion of the consecrated bread and wine for any sick persons unable to be present in Church, in order that the same should be taken to the sick person "on the same day and with as little delay as may be," (b) what is known as Perpetual Reservation; that is, the priest was to be allowed to set aside consecrated bread and wine for other and emergency cases of sickness, and of approaching death, if the Bishop gave a licence for so doing. The Bishops directed that such reservation should be "only for the Communion of the Sick, shall be administered in both kinds, and shall be used for no other purpose whatever. There shall be no service or ceremony in connection with the Sacrament so reserved, nor shall it be exposed or removed, except in order to be received in Communion, or otherwise reverently consumed." The manner in which such reservation should be made was to be determined by rules made by the Archbishops and Bishops of the Province. (c) To the Prayer of Consecration was added the Memorial or Anamnesis, and also (d) the Epiklesis—a prayer to the Holy Spirit "to bless and sanctify both us and these thy gifts of Bread and Wine, that they may be unto us the Body and Blood of thy Son our Saviour, Jesus Christ." There followed, without a break, the Prayer of Oblation of the Book of 1662.

The strongest opposition to these proposals came from (a) those who objected to the principle of *any alternative* form of the Communion Office, though they were not necessarily opposed to the revised form; (b) those who objected to Reservation in any form; (c) those who objected that the Epiklesis would suggest to the popular mind, and would be used to enforce, the idea of an actual change in the bread and wine approximating to the change defined in the doctrine of Transubstantiation (even though it might be the fact that, to the historical theologian, the Epiklesis tended in an opposite direction), (d) those who, from the opposite point of view, objected to Reservation being restricted to the Communion of the Sick only and desired it for (i.) those who, not being sick, were unable to attend the service in Church, and (ii.) as a focus for private prayer and (in some cases) for use at the service of "Devotions"—a modified form of the Roman devotion known as Benediction, (e) those who felt no security in the rule-making power reserved to the Bishops, and who, while admitting the need for reservation in large parishes, felt that if

the elements were reserved in the open church, nothing could prevent a form of "Devotions" in as much as provision for extempore prayer at Evensong was made.

Moderate Evangelicals and many Modernists were prepared to concede much that they disliked for the sake of peace and order. Anglo-Catholics, except extremists, recognized that "with certain amendments" they could support a book which was "tolerant of the Catholic standpoint." At the July (1927) session of the Assembly the Book was adopted, the voting being: For 517, Against 133. The majority vote was composed as follows: Bishops 34, Clergy 253, Laity 230; in the minority there voted 4 Bishops 37, Clergy and 92 Laity. In the House of Lords, after two days debate, the Book was passed by 241 votes to 88. Then came the bombshell of rejection by the Commons on December 15 by 238 votes to 205. There was no question that the vote was popular in the country. The speeches showed that there was the strongest feeling against the Book and, in particular, against Reservation and the proposed extention of episcopal power. The Bishops had claimed that there was no departure from the Reformation Settlement and that the Book would make for the restoration of order. The House of Commons believed the reverse. The Home Secretary pointed out that the Primate could not deal effectively with Romanizing clergy; on two notable occasions his Grace had promised to do so, but nothing had been accomplished. The Prayer Book was regarded as a surrender, legalizing the illegalities of lawbreakers. But the end was not yet. The Bishops met and decided that the rejection was due to certain "avoidable misunderstandings." They resolved to reintroduce the Book in substantially the same form with certain explanatory modifications. The changes proposed in March (1928) were: (a) Removal of the possibility of saying Matins or Evensong without praying for the King. (b) The insertion of the Black rubric from the Book of 1662 in that of 1928. (c) The undefined rule-making power of Bishops in regard to reservation was dropped, and the manner in which it was to be made was embodied in rubrics printed in the Office itself. It was advised to be made in the open Church, in an aumbry, which might not be fixed "immediately behind or above a Holy Table." (d) In the event of dispute between a clergyman and his Parochial Church Council about the adoption of the authorized alternative, the Bishops should decide between them, and before bringing into use any of the forms of service allowed in the Book the Minister must inform his Parochial Church Council. No appeal was allowed from the Bishop's decision. (e) Where there was any desire for it in the parish, Holy Communion according to the rite of 1662 must be celebrated once a month. (f) Emphasis was laid on the Bishop's duty to satisfy himself of real need for more than daily reservation before giving a licence for perpetual reservation. In this matter there was an appeal from the Bishop's decision to the Provincial Bench. (g) As it had been freely said that the demand for reservation was really due to the refusal of Anglo-Catholic clergy to celebrate when not fasting, a Declaration was inserted saying that to receive Holy Communion fasting was "an ancient and laudable custom of the Church," but that "such preparation may be used or not used, according to every man's conscience in the sight of God."

The only result of these amendments was the reduction of the measure of support for the Book. The more definite Anglo-Catholics were alienated; the Bishop of Truro, for example, withdrew his support. The mentality of the narrower type of Anglo-Catholicism was seen in the statements of *The Church Times* that priests who were now reserving would go on reserving whether they received a licence to do so or not, and in the description of the priest's obligation to consult the laity as "novel and most objectionable." Voting in the Assembly resulted in Final Approval by 396 votes to 157. Fewer voted than on the former occasion and the minority vote increased. Finally Parliament rejected the Book in June 1928, by 266 votes to 220.

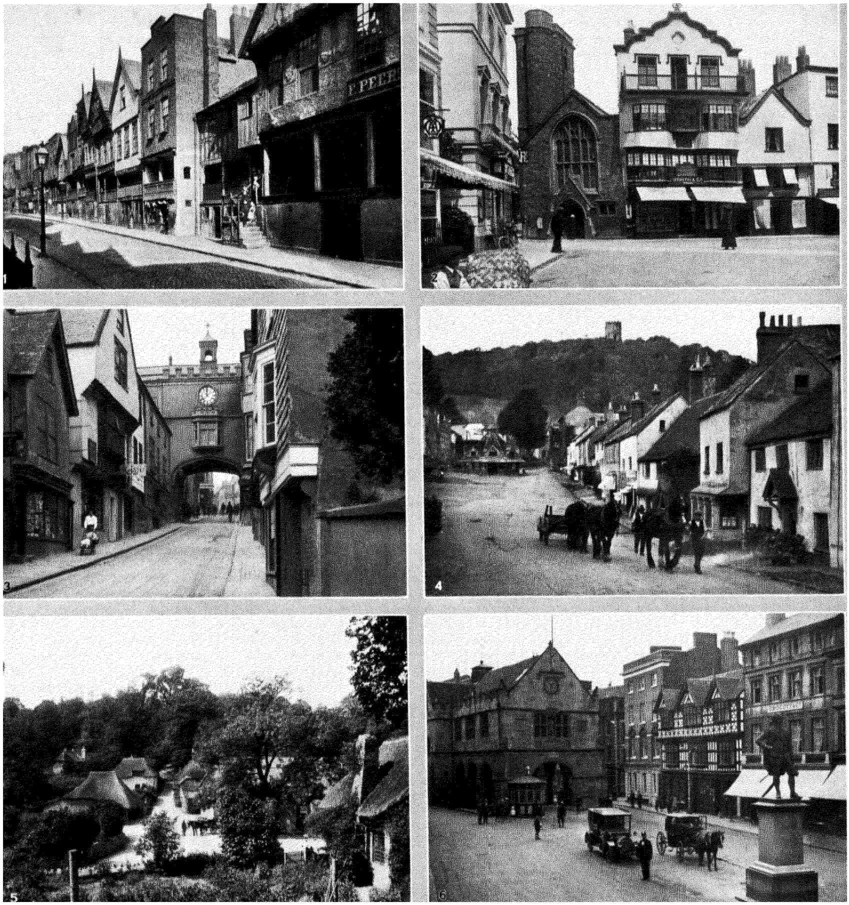
FURTHER PROCEDURE

Various lines of action are now open to the Bishops. (1) They may ask for Disestablishment. Nobody has anything to gain by this. A Parliament which rejected the revised Book would not grant terms of Disestablishment acceptable to the Book's promoters. Moreover, the Book was not so unanimously desired by the Church as to make Parliament's decision an intolerable interference with the spiritual liberties of the Church. (2) To permit the adoption of the new Book on their own authority. This is a counsel of despair. Those who were recently appearing as wishing to restore law cannot give a lead in law-breaking; moreover, if it were done, the restrictions in the Book would be ignored and noone could enforce them. (3) To proceed again with the largely non-controversial sections of the Book and to abandon the alternative Communion Office and all provision for reservation. By Jan. 1929 some bishops had declared for Disestablishment and most had consulted their Diocesan Synods by a *questionnaire*, the chief questions being (*a*) whether the Bishop, in his administrative discretion, should be guided by the Book of 1928; (*b*) whether he could expect support in requiring that practices consistent neither with the Book of 1662 nor with that of 1928 should cease. In general the clergy were ready to support the Bishops on both points; but the voting in twelve dioceses showed that on point (*a*) 2,717 ayes were cast (representing ten dioceses) and 1,573 noes (representing two). On point (*b*) the twelve dioceses returned an affirmative answer, but more than a thousand votes were cast in the negative; while a majority of the Synods, but a minority of their members, approved the 1928 Reservation Rubrics.

Since 1890, in addition to the 5 new dioceses created since the Enabling Acts, 8 others have been made in England: Bristol (reconstituted, 1897), Birmingham (1905), Southwark (1905), Sheffield, Chelmsford, St. Edmundsbury and Ipswich (1914), Coventry (1918), Bradford (1919). There are now 43 dioceses in England, 6 in Wales, 7 in Scotland and 13 in Ireland. There are Churches with Provinces and Dioceses in communion with the Church of England in the United States of America, in India and Ceylon, in South Africa, West Indies, Australia, New Zealand, East and West Africa, China and Japan, besides a number of separate dioceses and missionary episcopal jurisdictions holding missions from the Archbishop of Canterbury.

For the latest year for which the figures are available, 1926, the voluntary offerings of Church people amounted to £9,818,205. Of this, £4,030,912 was given to the general expenses of the Church and £5,787,293 was given in Church collections for parochial expenses. No less than £948,894 was spent in the building restoration and furnishing of Churches, the endowment of benefices, the building of parsonage houses, and the purchasing or extending of burial grounds. Since 1924 the number of baptisms has declined at the rate of about 10,000 a year, the total of 1926 being 455,142. Confirmations have declined at about the same rate to 209,565. On Easter Day 1926, 2,272,610 people made their communion. Despite all efforts to increase clerical incomes, it appears from a Church Assembly report that the purchasing power of clerical stipends is less than it was in 1910. The Ecclesiastical Commissioners hope to raise the income of every benefice to £300 a year. In cases where the population is under 300 this promise is conditional only upon the diocese raising half the necessary increase.

The dominant impression gained from a survey of the history of the Church of England during the last forty years is one of an immense development of organizational activity, to which there has been no corresponding extension of spiritual influence. Even in organisation, such vitally necessary work as the building of Churches in the new towns which are growing up outside all our large cities is extremely difficult. The cost of land in such areas even when the authorities provide favourable opportunities of acquiring it, is generally prohibitive. The most serious issue within the Church is the need of facing the choice presented by Anglo-Catholicism and Modernism. By shirking this issue within her own borders the Established Church is destroying the main reason for her independent existence, and is becoming more and more a training ground of future converts to Rome; and while this and the dearth in quantity and quality of ordination candidates continues, the enormous and sometimes hasty activities of the Church Assembly cannot wisely be regarded as evidence of abundant life.



BY COURTESY OF (3, 4, 5, 6) THE GREAT WESTERN RAILWAY; PHOTOGRAPHS (1) EWING GALLOWAY, (2) BURTON HOLMES FROM EWING GALLOWAY

HISTORIC TOWNS OF ENGLAND

1. Old houses in Chester, a town dating back to the Roman occupation of Britain, and still preserving a mediaeval appearance
2. View of the old close or cathedral yard at Exeter, the county town of Devon, showing St. Martin's church (15th–16th century), and beside it Mol's Coffee house (16th century), now a shop
3. East Gate of Totnes, Devon, one of the oldest municipal boroughs in England. Totnes lies on the side of a hill and consists mainly of one long street. Below the East Gate, in the pavement, is the "Brutus Stone," where, according to legend, Brutus of Troy first set foot on English soil
4. Dunster, Somersetshire, showing the ancient castle on the hill, dating from the 11th century. The village, like many others removed from large cities, has been untouched by modern conditions
5. Thatched houses at Cockington village, near Torquay
6. Market square in Shrewsbury, county town of Shropshire. In the centre background is the old Market Hall, an Elizabethan building dated 1596. In the foreground is a statue (by Marochetti; 1860) of Lord Clive, Member of Parliament for Shrewsbury and mayor of the town in 1792. To the right, among other old houses, is a fine example of Elizabethan half-timber work

Bibliography.—Of the very extensive literature only a selection can be given here. On the general history the most convenient reference is *A history of the Church of England,* in a series of 8 vols., viz., W. Hunt, *"The English Church from its Foundation to the Norman Conquest"* (1899); W. R. Stephens, *The English Church from the Norman Conquest to the accession of Edward I.* (1901); W. W. Capes, *The English Church in the 14th and 15th Centuries* (1900); J. Gairdner, *The English Church in the 16th Century* (1902); W. H. Frere, *The English Church in the Reigns of Elizabeth and James I.* (1904); W. H. Hutton, *The English Church from Charles I. to Anne* (1903); J. H. Overton and F. Relton, *The English Church from George I. to the end of the 18th Century* (1906); F. W. Cornish, *The English Church in the 19th Century* (1910); *See* also the *Official Year Book of the Church of England* (published annually by the S.P.C.K.); *Report of the Lambeth Conference* (1920); the *Proceedings and Publications of the Church Assembly;* Sir J. Marchant (ed. by), *The Future of the Church of England;* T. G. Rogers (ed. by), *Liberal Evangelicalism* (1923); *Essays Catholic and Critical,* by a group of Anglo-Catholics (1926); H. J. R. Major, *Modernism.* (J. S. Be.)

ENGLEFIELD, SIR FRANCIS (*c.* 1520–1596), English Roman Catholic politician, was the eldest son of Sir Thomas Englefield of Englefield, Berkshire, justice of the common pleas. Francis, who succeeded his father in 1537, took the oath of royal supremacy, serving as sheriff of Berkshire and Oxfordshire in 1546–47, and accepting in 1545 a grant of the manor of Tilehurst, which had belonged to Reading Abbey. He was even knighted at the coronation of Edward VI. But the progress of the Reformation alienated him, and he attached his fortunes to the cause of the princess Mary. On Mary's triumph, he was sworn a member of the privy council like many others who owed their promotion to their loyalty. He sat as M.P. for Berkshire in all Mary's parliaments except that of April 1554, but received no higher political office than the lucrative mastership of the court of wards.

At Elizabeth's succession, he retired to the continent. He induced the pope to send a legate to persuade Elizabeth to return to the fold, and later became the close confidant of Cardinal Allen, Parsons and of those Catholics who advocated forcible intervention by Spain and the succession of the infanta. In 1592 his estates were appropriated by the crown. Englefield died most probably at Valladolid.

ENGLEHEART, GEORGE (1752–1829), English miniature painter, the great rival of Richard Cosway, was born at Kew, Surrey, in Oct. 1752, and received his artistic training first under George Barret, R.A., and then under Sir Joshua Reynolds. He started on his own account in 1773 and exhibited in that year at the Royal Academy. He continued the active pursuit of his profession down to 1813, when he retired, and his fee-book, still in existence, records the names of his sitters and the amount paid for each portrait, proving that he painted 4,853 miniatures during that period of 39 years and that his professional income for many years exceeded £1,200 a year. During the greater part of his life he resided in Hertford Street, Mayfair, London, where he lived till he retired. He died at Blackheath in 1829 and was buried at Kew.

He painted 25 portraits of George III., and had a very extensive circle of patrons, comprising nearly all the important persons connected with the Court. He made careful copies in miniature of many of the famous paintings executed by Sir Joshua Reynolds, and in some cases these constitute the only information we possess respecting portraits by Sir Joshua that are now missing. His fee-book, colours, appliances and a large collection of his miniatures still remain in the possession of his descendants.

His nephew, John Cox Dillman Engleheart (1784–1862), also a miniature painter, entered George Engleheart's studio when he was but 14 years of age. He first exhibited at the Royal Academy in 1801 and sent in altogether 157 works. He was a man of substantial means and, in his time, a very popular painter, but his health broke down when he was 44 years old and he had to relinquish the pursuit of his profession. He lived at Tunbridge Wells for some years and died there in 1862.

See G. C. Williamson and H. L. D. Engleheart, *George Engleheart* (1902). (G. C. W.)

ENGLEWOOD, a city of Arapahoe county, Colorado, U.S.A., on the Santa Fe railway, adjoining Denver on the south. It is a residential suburb, and also has various manufacturing industries, including iron works, aeroplane and film factories, and a motion picture studio. The population was 4,356 in 1920, and was estimated locally at 7,500 in 1928.

ENGLEWOOD, a city of Bergen county, New Jersey, U.S.A., opposite the north end of New York city. It is served by the Erie railroad, electric trolley and motor-coach lines and ferries. The population was 11,627 in 1920 (21% foreign-born white and 10% negroes) and was estimated locally at nearly 20,000 in 1928. It is a delightful residential suburb, rising by terraces from the valley of the Hackensack to the top of the Palisades. Until 1859, when a town was laid out, there were only a few houses here, including the Liberty Pole tavern. In 1871 Englewood was incorporated as a separate township. It was chartered as a city in 1896 and in 1899 was rechartered by special act of the state legislature.

ENGLISH CHANNEL (commonly called "The Channel"; Fr. *La Manche,* "the sleeve"), the narrow sea separating England from France and lying entirely on the broad continental shelf which extends from Europe to Greenland. Its width is about 100 m. from Ushant to the Scilly isles and 20 m. at the Straits of Dover, and its length is about 350 m. The geological affinities are well marked on the two sides, as between the Devonian and granitic rocks of Cornwall and Brittany, the Jurassic of Portland and Calvados, and the Cretaceous of the Pays du Caux and the Isle of Wight and the Sussex coast as well as either shore of the Straits of Dover. The sea broke through the narrow neck at Dover in late Pleistocene times and the channel now covers what was once a wide valley. Coastal changes are still going on; Shakespeare cliff at Dover is said to have been cut back a mile during the Christian era, while Dungeness, Chesil Bank and the beach near Tréguier are still growing. The area draining to the channel is about 8,000 sq.m. on the English side and 41,000 sq.m. on the French.

The bottom slopes fairly regularly from 20 to 30 fathoms in the Straits of Dover to 60 fathoms in the western entrance. A remarkable narrow depression, Hurd's Deep, runs for 70 m. parallel to the general direction of the channel to the north and north west of the Channel islands and approaches one of them, the Casquets, within 5 m.; 94 fathoms is found in it north of the latter point. A hole with 105 fathoms occurs a few miles northwest of Ushant. The 100 fathom line, which here is also the edge of the continental shelf, approaches to within 120 m. south-south-west of the Scilly isles; it is generally marked by ripples and a change in the colour of the water. The bottom deposits are terrigenous:—white and yellow sand, often with black specks, fine broken shell, gravel and, less frequently, patches of larger stones or of mud. The channel is an important ground for both trawlers and drift net fishermen.

Salinity and Temperature.—Atlantic water with an average salinity of 35·4 per thousand enters the English channel through the southern part of the western entrance and flows eastwards almost continuously at an average speed of 1·5 m. per day. On its way it is diluted with river water so that the salinity falls to less than 35·0 along the coast eastward of Start point and to 34·0 or less near the Isle of Wight and in the Baie de la Seine. The salinity in the centre of the Straits of Dover is about 35·1 and a tongue of water with a salinity not less than 35·0 extends some distance into the narrows between England and the coasts of Belgium and Holland. Less water escapes eastwards or is removed by evaporation than enters from the Atlantic and from rivers, and the excess turns westwards and flows northwards between Lands End and the Scilly isles. Between the Bristol channel and Ireland it sets up a great anti-clockwise (cyclonic) circulation which brings diluted Atlantic water southwards across the entrance to the channel, sometimes as far south as the Bay of Biscay; part of this is carried eastwards again. The variations in the channel are due in part to variations in the inflow from the west and in part to seasonal and meteorological changes.

The salinity of the Atlantic water in the Bay of Biscay varies with the seasons and from year to year. The maximum salinity generally reaches the British Isles in late summer or early autumn.

and the maximum inflow into the channel from this source takes place between August and the end of February. The inflow from the Irish sea occurs generally in spring and summer. The salinity in the bay was high in 1902–03 and in 1921; in 1922–23 it was low. There is no evidence that the flow up channel varies with the salinity outside, nor that high salinities in the channel are proof of high salinities in the bay. The variations in the channel are considerable, and since 1921 in particular high figures have been recorded in the southern part of the North sea and in the eastern part of the channel, due in all probability to water which has entered along the bottom. There is evidence for a two-year period in the salinity, and possibly for a period of 18½ years.

The mean annual surface temperature increases from 11–11·5° C at the Straits of Dover to about 12° C at the western entrance. The annual range falls from 10–11° C in the eastern part to 5° C in the west. The mean maximum surface temperature, 16° C, occurs along the English coast at the beginning of September and a little later on the French side. In the western area the maximum is about 15°–16° and occurs in the first third of September. The mean minimum surface temperature is 5°–6° C in the Straits of Dover and 9° off the coast of Brittany. In the eastern part of the channel the water is well mixed by tidal action over the shallows, so that the salinity and temperature are generally uniform from surface to bottom at all times. In the western area, on the other hand, mixing is far less complete, especially in the summer, when the surface layer is so heated during the day that nightly radiation cannot cool the water enough to set up vertical convection currents extending to much deeper than 10–20 metres. The water becomes divided into two layers, separated by a very thin one in which the temperature falls rapidly and the salinity often increases; this layer is known as the thermocline or discontinuity layer. Owing to this layering the average temperature in August in the western entrance is 5° C less on the bottom than at the surface. The upper layer generally vanishes in the autumn by mixing with the deeper water; if it has been unusually shallow, as generally is the case in a hot calm summer, the mean temperature in the autumn of the vertical column from surface to bottom will be lower than usual. The larger part of the seasonal variation of the temperature is due to local meteorological causes, but a sudden inflow of warm water from the west may cause a rise of temperature at a time when it is usually falling.

The Tides of the English channel, that is, the rise and fall of the water, are due to an undulation from the Atlantic which reaches Ushant on the days of new and full moon at about 3 h. 40 m. and the Scilly isles at about 4 h. 20 m. As it passes up the channel it is retarded along the shores so that the crest presumably becomes convex eastwards. The range from trough to crest is always greater on the French than on the English side, 19 to 23 ft. between Ushant and Île de Bas but only 15 to 16 ft. between Lands End and Start point.

The time of high water is progressively later as far eastward as Portland, but from this place to Selsea Bill and near Havre on the French coast there are great irregularities, which take the form of double tides or of prolonged stands at one height. They are due to the increase in range and displacement in time, relatively to the semidiurnal tidal constituents, of the quarter-diurnal constituents, presumably by the bottom configuration (*see* TIDES).

Between the Isle of Wight and the mainland double tides do not occur east of Cowes; at Cowes there is occasionally a double high water but generally only a prolonged stand at high water. West of Cowes and in Southampton Water, as far as Hurst, double high waters occur with an interval between them of about 2 hours. This interval increases progressively westward and is about 2½ hours at Christchurch, 3½ hours at Poole and 4 hours at Swanage. West of Swanage the double tide coincides more nearly with low water and at Weymouth and Portland double low waters occur, with an interval of about 3 hours between them, locally known as the Gulder. Double tides do not occur on the French coast but there is a prolonged stand at high water at Havre. In the basin eastward of the narrows high tide occurs at nearly the same time everywhere and at Dover it is at 11 h. 24 m. at new and full moon.

Tidal Streams.—When the free tidal wave of the Atlantic ocean strikes the edge of the continental shelf in about 100 fathoms it is converted into a wave of translation which gives rise to the tidal *streams*. In the English channel the flow is on the whole parallel to the axis but there is a set into bays, in which the stream turns earlier than in the offing, sometimes as much as two hours earlier. The streams are described most easily by imagining the whole area to be divided into definite portions.

The Channel stream lies between the lines joining Start point to the Casquets in the Channel islands and Beachy Head to Pointe d'Ailly near Dieppe, the Intermediate stream occupies the Straits of Dover between the last line and another drawn from the North Foreland to Dunquerque, and the Southern North Sea stream lies between this and a line from the Leman and Ower lightship off the coast of Norfolk to the Hook of Holland. The reference time is the time of high water at Dover. The Channel stream and the North Sea stream set towards one another and the straits when the water is rising at Dover and in the opposite direction as it falls, meeting and separating on a moving line within the limits of the Intermediate stream. When the water begins to fall at Dover the line is off Beachy Head and during the fall it moves eastward and reaches the eastern limit of the Intermediate stream on the North Foreland-Dunquerque line at low water. By this time the two main streams have ceased to run but the Intermediate stream is still setting westwards. When the water begins to rise at Dover both main streams set towards the straits; the North Sea stream runs with the Intermediate and the line of junction is again off Beachy Head and moves eastwards to reach the North Foreland at high water, by which time the main streams have slacked and the Intermediate stream is running eastward alone. During the next hour the main streams begin to ebb, and Intermediate stream runs with the North Sea stream and the line of separation is again off Beachy Head.

The maximum speed in the Channel stream, apart from races off headlands, is about 3½ knots in the narrows south of the Isle of Wight. In the Straits of Dover it is not as a rule over 3 knots but rises to 5 knots at places near the Goodwin Sands. The flow into the North sea is greater than that in the opposite direction by an amount which on the average would carry a drifting body 2¾ m. in a lunar day, but this flow varies greatly with the wind and is sometimes reversed. At the other entrance to the channel, westward of a line drawn from the Scilly isles to Ushant, the stream continually changes its direction through north and east and makes a complete circuit of the compass in a tidal period, setting north and east when the water is falling at Dover and south and west when it is rising there. The maximum rate is 1½ knots and there is a slight predominating flow into the channel. In the area between this line and another drawn from Start point to the Casquets in the Channel islands there is a mixed stream partaking of the character of the streams on each side of it and the maximum rate in the open is 2½ knots. There is a strong set into the Gulf of St. Malo as the water falls at Dover and in the race of Alderney between the island and the French coast the speed reaches 7 to 8 knots. As the tide rises at Dover there is a strong set round Cape Barfleur into the Baie de la Seine.

The prevailing winds are westerly and greatly preponderate over easterly winds. Gales are generally due to the passage of a depression eastwards and are commonest from October to March inclusive. Calms are rare. Fogs are frequent at all places and are commonest when anticyclonic conditions prevail, especially in the winter. The winds have considerable influence on the tidal streams, especially in the Straits of Dover.

An account of the tides of the English channel according to the dynamical theory is given in the article TIDES.

The Channel Tunnel Scheme.—Unbroken railway communication between England and France would avoid the delay and expense incurred in the transhipment of goods and many schemes have been proposed to this end. Train ferries were proposed during the first half of the 19th century and were actually used for a time during the World War. On account of a small difference between the sizes of the English and French stock, English rolling stock could be used on the French lines but it

would not be possible to use French stock on English lines. A tunnel through the chalk was proposed at the beginning of the 19th century but the scheme was first put into practical form by Thomé, who exhibited a model of his tunnel at the Great Exhibition in 1867. Later he joined forces with William Lowe, an English engineer, who also had been preparing plans. Their scheme was adopted by an international committee which asked government aid in driving an experimental drift. A commission appointed by the French ministry of Public Works reported favourably on the plan but the outbreak of the Franco-Prussian war put an end to further progress. After the conclusion of peace negotiations were resumed between the British and French Governments and an agreement was reached on such points as jurisdiction, the right of blocking the tunnel, etc. In 1875 the Channel Tunnel company obtained an act authorizing it to undertake preliminary work near St. Margarets bay and the French Submarine railway obtained permission to begin work at Sangatte. The English company failed to raise the necessary money and was bought up in 1886 by the Submarine Continental Railway company which had been formed in 1881. In 1881 the South Eastern Railway company obtained an act giving powers for experimental borings and carried out some preliminary works which were taken over in 1882 by the Submarine Continental Railway company in return for cash and shares. In 1883 a joint committee of both Houses of Parliament decided that the building of the tunnel was inexpedient and brought the scheme to an end for a time. In 1886 the Submarine company absorbed the Channel Tunnel company, and in 1887 it changed its name to "The Channel Tunnel Company, Limited" with the sanction of the Board of Trade. It promoted an unsuccessful bill in 1906. After the World War the question was again raised, but in 1924 the Committee of Imperial Defence reported against the scheme. Early in 1929 however the matter was again brought up by the Tunnel Parliamentary Committee, and both Houses were circularized for an opinion. Considerable interest was aroused and suggestions were made for a bridge across the straits of Dover similar to those of MM. Schneider and Hersent in 1889, but this is not regarded favourably by experts.

The present scheme provides for a trial gallery, which would be enlarged into two tunnels, each carrying a single railway track. Geologically the conditions are good, since the boring would be made through Chalk Marl which is impervious to water, and between Dover and Calais the conformation is uniform. The total length of the tunnel would be 34 m., 24 m. of which would be under the sea, its greatest depth being 95 ft. below the channel bed (260 ft. below sea-level).

Bibliography.—For conformation and tides: *Channel Pilot; Tides and Tidal Streams of the British Islands;* Chart 1,598 and others on larger scales; Atlas of Tidal Streams of the British Isles; all published by the Admiralty. For temperature and salinity: H. W. Harvey, *Rap. et procès-verbaux,* vol. vi., xxxvii.; *Bull. Suppl.* (1908); all published by the Cons. Perm. Internat. pour l'Exploration de la Mer (Copenhagen). For Tunnel: *Blue Books* "Correspondence . . .," Commercial No. 6 (1875) and C. 3,358 (1882); *Rep. Joint. Sel. Comm. . . . Houses of Lords and Commons . . .* (1883); *Brit. Assoc. Reports* (1882), p. 404, Hawkshaw, and (1899), p. 750, Boyd Dawkins; Rodakowski, *The Channel Ferry* (London, 1905); Parl. Debates, vol. 175, 1782 (July 1924); memoranda by Channel Tunnel Company. (D. J. M.)

ENGLISH COLLEGIATE STYLE, in architecture, a style developed in the colleges of Oxford and Cambridge during the 15th, 16th and 17th centuries. It is characterized by the persistence of Gothic tradition (*see* Gothic Architecture) with only slight modifications due to the creeping in of Renaissance elements (*see* Renaissance Architecture); the grouping of buildings around quadrangles, entered by an arched gate in a tower, the combination of many window lights into one mullioned and transomed opening; parapets, sometimes battlemented; long rows of similar small gables; bay or oriel windows; and the frank exterior expression of the various types of halls, large rooms and small sleeping rooms which form the college. In general it is based on the domestic architecture of the time, in earlier examples resembling late Gothic manors, and in the later, the larger Elizabethan or Jacobean country houses; during the 17th century classic motives, often of great quaintness and crudeness, are general in the detail of doors, etc., without seriously changing the spirit of the entire style.

ENGLISH HISTORY. The general account of English history which follows does not cover the period anterior to the landing of St. Augustine. For this reference should be made to the article Britain. The nature of early English culture and social order, the origin of the first Germanic kingdoms founded in England, and the process of conversion which brought them into the fellowship of Western peoples, form the subjects of other articles. Much of the detail of their subsequent history is described in the biographies of the leading men of this period. It remains to indicate something of the process which created the first centralized monarchy in western Europe out of the group of separate and often hostile kingdoms between which England was divided at the beginning of the 7th century.

I. THE ESTABLISHMENT OF ENGLISH UNITY

From the outset there was one powerful factor making for unity. The Angles, Saxons, and Jutes may have been distinct in origin, but there can be no doubt of their close relationship. No fundamental differences separate the culture of Angles and Saxons, and the superior arts and crafts of the Jutes in eastern Kent and in the Isle of Wight were acquired probably during temporary residence in Frankish territory immediately before their migration to Britain. The language differences between these peoples can only have been slight in the 7th century. All three peoples, for example, used the same general stock of personal names, and recent investigation of local nomenclature has brought out an essential similarity in words denoting places of settlement and natural features throughout Britain. Kent indeed stands apart from the rest of England in legal custom, agrarian organization, and at a later time to some extent in language. But Kent, save for the reign of its greatest king, Ethelbert, was never an important kingdom, and though the distinctive features of its society may have intensified its particularism they did not seriously complicate the general uniformity of the English culture of the earliest period.

The Ancient Dynasties.—English history between the 6th and the 9th century is nevertheless the record of incessant wars, and for long afterwards jealousies between kingdoms once independent remained politically important; for instance, it was long before the men of the great Mercian kingdom finally acquiesced in the overlordship of the kings of Wessex. To the ordinary peasant these jealousies arose from no profounder source than instinctive distrust of strangers. His view was confined to the region of which he had personal knowledge, and we have no reason to believe that a West Saxon *ceorl* from Berkshire felt more antipathy to a Mercian of his own class than to another West Saxon from Somerset. The rivalry which was dangerous to peace, and delayed the accomplishment of English unity, was rivalry between kings. The number of separate dynasties established in England, each with its own reputed descent from ancient gods, was very remarkable. Among the Anglian peoples of the north and east there can be traced separate royal lines ruling in Bernicia, between Tees and Forth, in Deira, between Humber and Tees, in Lindsey, in East Anglia, and in Mercia, along the middle Trent. No doubt the degree of nobility implied by the pedigrees asserted by these families varied greatly. No royal house in England claimed so illustrious a descent as the kings of the Mercians, who included among their ancestors men who had ruled the Angles in their continental home. But every royal house asserted its descent from Woden, and therefore, none could acknowledge a fundamental superiority in any rival.

It has been argued often that the influence of the church counteracted this tendency, that the authority of the archbishop of Canterbury set an example which was ultimately followed in the temporal sphere. There is a measure of truth in this opinion. A great archbishop like Theodore of Tarsus was the effective ruler of the church everywhere among the English people. But no other archbishop was a man of Theodore's quality, and after 734, when an independent archbishopric of York was created, the organization of the church was a serious obstacle to the unifica-

tion of England. Moreover the administration of the church was closely adapted to the contemporary political divisions of the land. The typical bishop of the 7th century was bishop of a kingdom and counsellor of its king. It was only an exceptional man who in such a position could work for the establishment of a wider unity than prevailed in the world which alone he knew.

Reasons for West Saxon Supremacy.—On the eve of the Norman Conquest, Edward the Confessor, heir of the West Saxon dynasty, was the only king recognized in England. It is natural to attribute the ultimate supremacy of the West Saxon line to the unusual ability of kings like Alfred, Edward the Elder, and Athelstan, but they would never have achieved their place in history had it not been for the previous extinction of all competing dynasties. At the end of the 8th century, a highly competent observer, the Northumbrian scholar Alcuin, then resident in France, remarked that scarcely any men were left of the ancient stock of English kings. Two generations later, the West Saxon dynasty alone survived. The permanent establishment of a new royal line under the conditions which prevailed in the 9th century was an impossible task. A mere noble, however eminent his ancestry, never received the instinctive respect accorded to a man of royal birth. On three occasions before the Norman Conquest a man who was not of this class obtained temporary recognition as king, but on each occasion the attempt led to disaster. With the disappearance of the ancient dynasties the king of the West Saxons became the natural lord of kingless men elsewhere in England. Alfred and his successors had the ability to make their lordship a reality.

The Bretwaldas.—But long before Alfred's time individual kings had succeeded in establishing a degree of authority over other rulers which in the 8th century had brought the unity of England within measurable distance of realization. From the 5th century onwards it had been the custom for every king south of the Humber to acknowledge the authority of a common overlord. The title borne by these early overlords, the famous style of Bretwalda (*q.v.*) was vague, and of poetical origin, but the powers which it implied were real. When, for example, Edwin, king of the Deirans and Bernicians, had obtained recognition at Bretwalda from the kings of the south, he anticipated for a moment the position of a later king of all England. He could summon other kings to bring their followers to join him in war, he could take tribute from them, and his safe conduct ran in their countries. It is true that no Bretwalda before the 9th century could hand on his position to his son and successor. He had won it by his own skill and reputation in war, and it inevitably ended with him. Nevertheless the habit of obedience to a common overlord did more than any other custom to break down the isolation of the different southern kingdoms, and the succession of the Bretwaldas is the one thread which holds together the confused history of England between the invasion and the age of Bede.

Northumbria and Mercia.—The kings beyond the Humber stood outside the confederacy of which the Bretwalda was the head. Northumbria went its own way, brought only by exceptional circumstances into any intimate connection with southern England. It is probable that Northumbrian separatism goes back to the very age of the Anglian settlement, that two independent hosts of invaders used the Humber as their boundary. Be this as it may, this separatism long delayed the unity of the English peoples. In the ecclesiastical sphere its effects are still visible, for the archbishoprics of Canterbury and York represent the group of southern kingdoms which in the age of the conversion had owned a common overlord and the northern peoples who lay outside his authority. It was inevitable that sooner or later the isolation of Northumbria would be challenged. At first it seemed that a Northumbrian king might establish permanent supremacy over the south. Three Northumbrian kings of the 8th century, Edwin, Oswald and Oswiu were able to obtain recognition as Bretwalda from their southern contemporaries. When, for example, Cynegils king of Wessex gave Dorchester-on-Thames to Birinus for his bishop's seat, Oswald king of the Northumbrians was associated as overlord in the gift. But Edwin was overthrown by a British reaction in 633, Oswald fell before Penda, the heathen king of the Mercians, and though Oswiu defeated Penda in 655, and attempted to govern Mercia through Northumbrian nobles, his authority, not only in Mercia but throughout the south, was ended by a Mercian revolt in 658. It is significant that the next overlord of the southern English, Wulfhere king of the Mercians, attempted to enforce his supremacy over Northumbria by leading an army drawn against its king. Wulfhere was defeated, and for a generation the overlordship of the south itself was in abeyance. It was revived by Ethelbald king of the Mercians (715–757), and after him was carried to its highest point by his cousin Offa, the strongest king who hitherto had appeared in England.

Offa and His Successors.—In a sense, the reign of Offa marks the culmination of the old English monarchy. Later centuries produced more famous kings, such as Alfred, Athelstan and Edgar, but by their time a new racial element had been introduced into England by the Danish settlements of the 9th century, and the authority of the last old English kings over the Danelagh (*q.v.*) was dependent on the good will of its inhabitants. In the time of Offa, England was virtually homogeneous in race. Of the rival dynasties some were extinct, others had come to accept a position permanently subordinate to the head of the Mercian house, while the Northumbrian kingdom was collapsing into anarchy. Under these conditions, Offa was able to create a dominion which approximated far more nearly than is generally realized to a kingdom of all England. He was king of the Mercians, and Mercia in his time was by far the strongest of English kingdoms. But he was also overlord of the southern English, and in his hands overlordship was passing visibly into direct rule. The heirs of the surviving southern dynasties were his men, attended his courts and sought his confirmation of their grants of land. He dealt at his will with land within the subject kingdoms, and brought Northumbria under his control by giving a daughter to its king. Little is known of the detailed history of his reign. No chronicle has survived from his time, and the most important materials for its history are the charters by which he granted land to his followers or to churches which enjoyed his patronage. And one of these documents has unique importance, for in it Offa styles himself *rex totius Anglorum patriae,* "king of all England."

This is the first occasion on which this famous style is known to have been employed. But the kingdom of all England which Offa claimed to rule was not identical with England of the present day. In the far south-west Cornwall was still virtually independent, its subjection to the kingdom of Wessex belonging to the next generation. In the far north the Northumbrian kingdom still stretched to the Firth of Forth, and Lothian remained English for two centuries after Offa's time. Between the English and the Britons on the border of what is now Wales Offa's memory is still preserved by the great earthwork which bears the name "Offa's Dyke." This long entrenchment, the greatest public work in early English history, was undoubtedly intended as an artificial boundary line against the Britons of the West. The wars of later centuries created a different boundary but the dyke remains a remarkable illustration of the reality of the power possessed by the greatest king of the age before the Danish wars.

Egbert of Wessex.—Both Offa and his son Egfrith died in 796, and a remote cousin named Cenwulf became king of the Mercians. He reigned until 821, maintaining the integrity of the Mercian kingdom without the wider authority which had belonged to Offa. With his successor Ceolwulf (821–823), the direct line of the Mercian dynasty ended, and after a brief interval the overlordship of the southern English was won by Egbert king of Wessex, who alone among the English rulers of his day could claim direct descent from the kings of the migration time. It was to this fact that he owed his opportunity. At his accession Wessex was an unimportant kingdom, and Egbert himself, unlike Offa, remained to the last an insular figure. But his reign marks an important stage in the unification of England. As the heir of the last of the archaic English dynasties he obtained ready recognition as overlord in the smaller kingdoms of the south,

Kent, Sussex and Essex. In a battle fought at a place named Ellandun in north Wiltshire in 825 he overthrew Beornwulf, king of the Mercians, and the East Angles deliberately chose him as their protector against Mercian aggression. Four years later, he received the submission of the Mercians themselves, and immediately imposed his overlordship on the Northumbrians. By the close of his reign he had obtained a position virtually identical with that which Offa had held.

The Danish Wars.—This fact was destined to influence the whole course of early English history. Already in Egbert's reign, isolated companies of vikings were visiting the English coasts, and within thirty years of his death in 839 an organized army was ravaging the whole land. The real importance of Egbert's career lies in the fact that he was able to make the king of Wessex supreme over all other English peoples before the whole fabric of English society was attacked by the new invaders from the east. It was to the king of Wessex, that the men of Mercia, East Anglia, and even Northumbria turned when their own royal lines had been overthrown. And it so happened that the West Saxon royal house produced in Alfred, the youngest grandson of Egbert, the greatest military leader whom the Scandinavian raiders ever met in western Europe.

Alfred.—Alfred's aim was to prevent the settlement of Wessex by Scandinavian invaders, and in this he was helped by fortune. So long as the Danish armies kept together they could compel the West Saxons, like every other English people, to buy peace from them. But the weight of Danish attack fell on Mercia and Northumbria, and a great part of the original army which entered England in 865 had permanently settled between Tees and Welland before the remainder of the host attempted the conquest of Wessex ten years later. In 877 they overran all Wessex, and drove Alfred into the inaccessible stretches of higher ground along the river Parret. His victory at Edington in Wiltshire in the following year is one of the battles which have influenced the course of history. Had he been defeated, Wessex would have been settled by the invaders, and all England would have become a Scandinavian colony. The battle of Edington decided that the West Saxon dynasty should survive. When Alfred died in 899 he could be described with truth as "king over all the English people except the part that was under the power of the Danes." The next generation saw his dynasty establish its overlordship over the descendants of the Danish settlers everywhere in England.

With the reign of Alfred English history enters upon a new phase. The Danish army defeated at Edington moved in 879 to East Anglia, and settled this region as their former companions had already settled the country between Welland and Tees. Smaller groups of settlers who acknowledged the East Anglian king as their lord had established themselves in the south-eastern midlands. From the estuary of the Thames to the Rere Cross on Stainmore eastern England was a Danish land when Alfred died. For a hundred years afterwards the Danes in England retained much of their original military organization. In the 10th century men commonly spoke of the "army" of Northampton or Leicester when they referred to the men of Northamptonshire or Leicestershire. The most formidable of these "armies" was that established in the country round York, which at first had a king of its own, and raided English territory from time to time. But the kings of York never brought the more southerly Danes to accept their authority, and in the warfare of the next generation the initiative, almost from the first, rested with the English of Wessex and English Mercia.

Conquest of the Danelaw.—The conquest of Scandinavian England and its annexation to the West Saxon kingdom spread over twenty years. It would have been a remarkable achievement if the king of Wessex had been the ruler of an English people united in feeling and in traditions. But the ancient independence of Mercia and Northumbria was not yet forgotten. The English of Northumbria, threatened by Danes on the south and Scots on the north, naturally looked to the king of Wessex as their protector. The particularism of the Mercians was more serious. Barely a century had passed since Mercia had been the dominant kingdom in the land. Fortunately for the unity of England, Alfred had established a trusted noble, named Ethelred, as ealdorman of the Mercians, and had given him Aethelflaed, his eldest daughter, in marriage. The most remarkable feature of the wars which followed Alfred's death is the unbroken loyalty of Ethelred and his wife to their lord, Aethelflaed's brother, king Edward the Elder. Ethelred died in 910, but for the next seven years his widow cooperated with her brother in a gradual encroachment upon Danish territory which ended, after her death, in the acceptance of Edward as lord by all the Danes in England. Long after this time a clear distinction was maintained between the English of Wessex and of Mercia. In the 12th century the customary law of Mercia still differed in important points from that of Wessex. But after the reign of Edward the Elder the Mercians were normally content to form part of an English kingdom whose head was the West Saxon king.

Norwegian Invasions.—While Edward and Aethelflaed were engaged in their great campaigns against the Danes, a new element was being added to the complex of races which was to form the English people. In the first decade of the 10th century, a considerable number of Norwegian adventurers from Ireland invaded the north-west of England. From the region which now forms the shires of Cumberland and Westmorland the new settlers passed easily across the western hills into the North Riding of York, where their memory is still preserved by many place-names of definitely Norwegian character. In the next decade, the leader of the vikings of Waterford, Ragnall O'Ivar, made himself king of York, and thus began a connection between Northumbria and Ireland which threatened the whole work of Edward and Aethelflaed. But for the time it had little political result, and in 919 when Edward received the solemn submission of all the men of Northumbria, "English, Danes, Northmen, and others," of the kings of the Scots and of the Britons of Strathclyde, Ragnall also became his man.

Athelstan.—The position won by Edward the Elder was maintained by his son Athelstan, the most brilliant figure among the Old English kings. Early in his reign he expelled the Norse dynasty, then in possession of York, and brought the city and its dependent territory under his direct rule. Under him, relations between the king of Wessex and the Scandinavian nobility of the north and east became friendly, and numerous earls of Danish name can be traced at his court. He enforced a real overlordship over the Welsh princes of his day, and made Cornwall an integral part of the West Saxon kingdom. Abroad, his reputation was great. His sisters were married to the chief continental rulers of his time —to Otto king of the Germans, afterwards Emperor, to Charles king of the West Franks, the descendant of Charlemagne, and to Hugh duke of the Franks, the ancestor of the house of Capet. From time to time he intervened in French affairs, protecting Breton refugees driven from their homes by Norman invasion, and giving hospitality to Louis, the heir of the Carolingian dynasty. He enters for a moment into Norwegian history, for there is no reason to doubt the ancient tradition which asserts that Hakon, son of Harold Fairhair, the creator of the Norwegian kingdom, was brought up at Athelstan's court. Not since Offa had there been an English king who played so considerable a part in the eyes of men across the seas.

It also fell to him to win one of the greatest battles ever fought between an English and a Scandinavian host. In 937 Anlaf Guthfrithson, king of Dublin, in alliance with Constantine, king of Scots, penetrated far into England, but were utterly defeated by Athelstan at a place not now to be identified, then known by the name of Brunnanburh. Less important historically than Alfred's victory at Edington, the battle of Brunnanburh greatly impressed contemporaries. A memory of it was preserved in Norse tradition, and it gave occasion for a poem which reveals with singular fidelity the merits and defects of late Old English poetic style. The details of the battle, as of most Old English battles before the last fight of Hastings, are lost. Its most significant feature is that the Northumbrian Danes, who had been the greatest danger to the English monarchy in the days of Athelstan's father were not present with Anlaf and his Scotch allies.

The reign of Athelstan has moreover a place in the history of

English administration. Reference has been made from time to time to those charters by which the Old English kings granted estates to the nobles and churches of their kingdom. The series of these documents, which begins in the seventh century, is broken in the latter part of the long reign of Edward the Elder. It begins again under Athelstan and is never afterwards interrupted. The interest of Athelstan's charters does not lie in their subject matter, but in the highly technical form in which they are composed. There can be no question that Athelstan kept a body of clerks in attendance at his court, who developed rules of composition, a set of formulae, a technique of draftsmanship, to which there is nothing comparable in the royal charters of any earlier time. In other words it is in the reign of Athelstan that evidence for the existence of something which may be called a civil service first appears in England. The West Saxon monarchy was beginning to develop the rudiments of an administrative system.

Final Conquest of Danish Mercia.—Athelstan died in 939. The reign of his brother and successor Edmund is marked by a curious episode which shows how easily the monarchy, after a generation of laborious consolidation, could still be shaken by attack from without. In his first year, Anlaf Guthfrithson, the king defeated at Brunnanburh, invaded England again, became master of York, and compelled the king to agree to a partition of the country. Edmund accepted Watling Street as his boundary against Anlaf, and thereby acquiesced in the destruction of all the work of Edward the Elder. Anlaf's death in the following year gave Edmund an opportunity of recovering his position in the midlands, and in 942 he conquered all Mercia as far as the Northumbrian border, and including the five boroughs of Lincoln, Stamford, Leicester, Nottingham and Derby, which had been, and long continued to be the centres of Danish influence between Welland and Humber. A contemporary poem, fortunately preserved in the Old English Chronicle, brings out the important fact that the men of these boroughs regarded their conquest by Edmund as a deliverance from heathen bondage. The later development of the English monarchy was first assured when the descendants of the Danish settlers of the 9th century decided to throw in their lot with the king of Wessex against the new aggressive viking power established on the Irish coast.

Wessex and Northumbria.—In the following years a succession of ephemeral kings of Norse origin can be traced at York. The last of them disappeared in 954, when Edred, Edmund's brother, became, like Athelstan before him, the immediate lord of York and Yorkshire. Henceforward this region appears as an earldom, highly independent, but never breaking quite away from its allegiance to the king of Wessex. It was only on rare occasions that the latter intervened in Northumbrian affairs. He had little land beyond the Humber, and Northumbrian nobles rarely appeared at his court. But the Northumbrian earls were his men; he appointed the archbishop of York and the bishop of the country beyond Tees, whose seat became fixed at Durham before the century was over. The Northumbrian currency bore his name, and his writ ran in the north. The last kings of the West Saxon dynasty were lords of Northumbria in something more than name.

Significance of the Danish Settlement.—The years which passed between the accession of Edward the Elder and the death of Edred had been momentous for the development of a united England. They had witnessed the acceptance of Christianity by the descendants of the Danish settlers of Alfred's time, the failure of the Norse invasions from Ireland, and the recognition of the head of the West Saxon royal house as king of all England. Politically, the unity of England was accomplished by the end of this period. But this achievement, which in itself is one of the most remarkable facts in all English history, has often led historians to underestimate the significance of the Danish settlement of the previous century. Long after this period, long, indeed, after the Norman Conquest, the Danes in England remained in language, law and society a race apart. They were an intensely conservative people, tenacious of their ancient customs, jealous of interference from without. The region of their settlement, known from the 10th century onwards as the Danelaw, was sharply distinguished from Mercia and Wessex by peculiarities of customary law which long survived the overthrow of the Old English kingdom itself. In social order, the Danelaw was marked by the existence of large masses of independent peasants who never underwent the manorial discipline which converted the free *ceorls* of the south and west into the serfs of mediaeval economy. Even in the 13th century innumerable peasants of Scandinavian ancestry were still disposing freely of their small tenements by gift, sale or exchange without hindrance from their lords. In language, the Scandinavian speech of the Danelaw has left a permanent impression on the dialects of this region, and its personal nomenclature remained intensely Scandinavian until, late in the Middle Ages, the continental names which came in with the Norman Conquest found in Danish England the acceptance which they had long received in the South. Few things are more remarkable in English social history than the consistency with which the Scandinavian population of the North and East resisted the influences which were making for the assimilation of their customs to those prevalent in the South and West. The England which William of Normandy conquered formed a single monarchy, but it contained two races.

Weakness of the Monarchy.—The single monarchy itself was far stronger in appearance than in reality. Only four years after the disappearance of the last Norse Northumbrian king, the whole region north of Thames broke away from Wessex. Edred, who died in 955, left two young sons, Edwy and Edgar, of whom the former succeeded him. The most notable feature of his brief reign is the large number of grants of land made by royal charter to individual nobles. No reign in all early English history produced so many of these grants as the five years of Edwy's rule in Wessex. It is probable that Edwy was trying by their means to attach important persons to himself against his brother. In any case, a revolt of which Edgar was in name the head broke out in 958, and the men of Northumbria, East Anglia and Mercia chose Edgar for their king. In the following year Edwy died and the unity of England was restored by Edgar's reception as king in Wessex. But the episode shows that there was little cohesion as yet between the four great territorial units which comprised the English kingdom of the 10th century.

The Reign of Edgar.—The reign of Edgar is often regarded as marking the highest point of effective power reached by the Old English monarchy. In a sense this opinion is justified. Edgar inherited a wide dominion created by earlier kings, his reign was a time of peace for the greater part of England, and he was able to impose his overlordship upon the Celtic princes beyond the English border. But he was not a constructive ruler like Edward the Elder or Athelstan, and when their achievements are remembered his reign appears something of an anticlimax. In part his reputation is due to the evil time which fell upon England in the next generation, but it owes still more to his lavish patronage of the church, and to his encouragement which he gave to the great men, Dunstan, Ethelwold, and Oswald, who in his reign were reviving monastic life in England. A competent ruler, he left little mark upon the development of the monarchy.

Ethelred "the Unready."—But throughout the forty years which followed his death there was a singular lack of competence in high places. His eldest son, Edward "the Martyr," was murdered before he could prove either ability or incompetence. His second son, Ethelred "the Unready," appeared to contemporaries as the very type of an inefficient ruler, and there is no reason to attempt a reversal of their judgment. His troubles were not, indeed, of his own making. In the second year of his reign there began a succession of Danish raids upon England, which curiously resemble in their sporadic character and their wide range the visitations previous to the coming of the great army of Alfred's time. For more than a generation the monarchy, which Ethelred's great predecessors had created, resisted with remarkable firmness. Though there was treachery among men in high command, inefficient military organization and over-strained financial resources, the sense of political unity was never completely lost, and no trace of any tendency towards separatism is to be found in the Danes in England. The attitude of the men in charge of the great provincial governments is equally significant. Some of them,

notably Edric Streona the ealdorman of Mercia, obviously considered it their right to make terms with the enemy as their own interest might dictate, even if this involved the betrayal of their men in the field. But none of them made any attempt to secure political independence, or to revive the ancient kingdoms of which they were the immediate rulers. The kingdom of England was conquered, but it escaped disintegration.

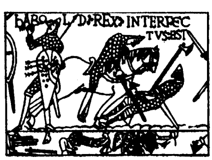
Danish Conquest of England.—The particular invasion which ended in conquest was precipitated by one of king Ethelred's innumerable changes of policy. He took into his service a large force of vikings who were the men of Swegn Forkbeard, king of Denmark. Swegn replied by invading England in the summer of 1013. He fixed his headquarters at Gainsborough in Lindsey, and there received the submission of the Northumbrians, of the men between Humber and Welland, and of every shire north of Watling Street. Before the year was over he was recognized as king everywhere in the land; Ethelred was in exile at the court of his brother-in-law, Richard duke of Normandy and the war was over for the moment. But Swegn died early in 1014, and the English nobility recalled Ethelred from Normandy. In the struggle which followed, the English protagonist was Edmund, Ethelred's eldest surviving son, called Ironside "for his courage" according to a poem of the next generation. On the death of Ethelred in the spring of 1016 part of the English nobility recognized Edmund as king, the rest adhered to Cnut, the second son of Swegn, and a brief period of indecisive fighting was ended by a treaty according to which Edmund received Wessex as his kingdom while Cnut took the rest of England. Soon afterwards Edmund died, Cnut was received as king in Wessex, and for nearly a generation England formed part of a vast dominion which included Denmark, a vague overlordship over the Slavonic peoples along the Baltic, and for a time the kingdom of Norway.

Cnut.—This singular episode had remarkably little influence on the later course of English history. The wealth and ancient civilization of England made it the centre of Cnut's incoherent empire. He ruled as an English king, with greater military power behind him than any of his predecessors, but governing with the same instruments which they had used. Individual Danes and Norwegians received high office from him. For a time Northumbria was governed under him by Eric son of Jarl Hakon of Norway, one of the heroic figures of Norwegian saga. But already in the early part of his reign Cnut was appointing Englishmen to important provincial governments. The two powerful families whose rivalry fills the reign of Edward the Confessor, the house of Godwine of Wessex and that of Leofric of Mercia, both owed their position to Cnut. He granted to all his English subjects of free condition the first charter of liberties in English history. The laws which he issued form the most detailed exposition of Old English legal custom which has survived, and formed the basis of the law which prevailed in England under the Norman kings. The grants of land which, in moderation, Cnut made to his Danish followers are drawn up according to English models of composition, and his coinage follows earlier English types. To Englishmen he soon became the pattern of a good king. By the eve of the Norman Conquest "Cnut's law" had become a synonym for a form of government in which ancient and approved custom was observed.

Recall of the West Saxon Dynasty.—Nevertheless it was impossible that England and Denmark should be united permanently. The wide dominion of Cnut defied geographical facts, and only a king of singular ability and good fortune could hope to maintain it. The political connection between England and Denmark only survived its creator for seven years, and on the death of Harthacnut, son of Cnut and Emma of Normandy, widow of Ethelred II., the English nobility recalled the heir of the house of Wessex.

Edward the Confessor.—The reign of Edward the Confessor, the heir thus restored, is the prelude to the Norman Conquest. Edward, who had grown up at the Norman court, throughout the first part of his reign gave every opportunity for the spread of Norman influence in England. He organized his household according to the contemporary French model, granted estates to individual Norman knights, and patronized Norman churchmen. As his life drew on, and he found himself childless, he undoubtedly came to wish that his cousin William, duke of the Normans, might follow him as king of England. Towards the middle of the reign he even promised the succession to William in explicit terms, and if Edward had died at this time the duke of Normandy might have become king of England without serious dispute. But the moment passed, and thenceforward until the end of the reign English influences represented by Godwine, earl of Wessex, and by Harold his son predominated at court. In 1052, Godwine and Harold, who had been exiled in the previous year, returned to England with a large force, and compelled the king to acquiesce in their restoration. The Norman archbishop of Canterbury was driven into flight, and a protégé of Godwine, named Stigand, was placed in his seat, an event which had momentous consequences, for it threw the continental advocates of ecclesiastical order into opposition to the régime which Godwine and Harold represented. Godwine died within a year, Harold succeeded to his wealth and office, and events gradually opened out to him the possibility of succession to the crown itself. He was far from commanding the support of all the English nobility. The earls of Mercia were the rivals of his house, and he had little influence in the North, the establishment of his brother Tostig as earl of the Northumbrians leading to a revolt which drove Tostig into exile and produced a Norwegian invasion. But when King Edward died at the beginning of 1066 Harold was immediately recognized as king by the nobles present in London and crowned by the archbishop of York.

The Norman Conquest.—Meanwhile the duke of Normandy had never lost sight of the prospect of succession to the English throne. The male line of the house of Wessex survived King Edward in the person of his cousin Edgar, the grandson of King Edmund Ironside. But Edgar was only a child; William represented the family which had protected the royal house of England throughout the time of Danish rule, he was King Edward's kinsman, and in his own duchy he had consistently favoured the rising movement of ecclesiastical reform which as yet had found little influence beyond the Channel. It was easy for him to obtain the moral support of the Papacy when the time came for an invasion of England. Moreover under the conditions which prevailed in the 11th century the exact relationship between a king and his successor was not a matter of the first importance. The essential task before any candidate for kingship was to obtain recognition from the leading men of the kingdom in view. Kinship was a title to recognition, and the thread of kindred which connected William and Edward the Confessor, exiguous as it seems to the modern student gave to William a fundamental advantage over his rival.



FROM "VETUSTA MONUMENTA," 1842

FIG. 1.—THE DEATH OF HAROLD AT THE BATTLE OF HASTINGS, DEPICTED ON THE BAYEUX TAPESTRY

Stamfordbridge and Hastings.—In the event, the Norman victory of 1066 was essentially due to accidental circumstances. Harold was at once accepted as king in the south; he met no overt opposition from the rival family of the earls of Mercia, and he succeeded in conciliating the Northumbrians. His chance of defence against the threatened Norman invasion was destroyed by a sudden and formidable invasion of England from the Scandinavian north. Harold Hardrada, king of Norway, who had inherited an indefinite claim to the English throne in virtue of a treaty between his predecessor and Harthacnut, the last Danish king of England, adopted the cause of Tostig, the exiled earl of Northumbria, entered the Humber and occupied York. His defeat at Stamfordbridge by Harold of England ranks with the battles of Edington and Brunnanburh among the events which ruled that England should not form part of the Scandinavian world. But the Norwegian invasion called King Harold from the south at the very time when invasion from Normandy was imminent. William of Normandy landed at Pevensey without serious opposition, Harold engaged him in battle seven miles north-west of Hastings with the

survivors of Stamfordbridge and the men who had joined him during a hurried march from York, and in a single day the cause of English independence was lost.

Position of William the Conqueror.—It was an ancient and wealthy kingdom of which William thus became the lord. Its integrity had survived all the disasters which had fallen on it in the ninety years since King Edgar's death. But the royal authority had become dangerously weak during the last generation, and the effective power now resided, not in the king, but in the rulers of the great earldoms called into being by the administrative necessities of an earlier time. King Edward had enjoyed the royal title, and possessed a royal demesne which made him the greatest landowner in the country, but on any grave occasion he was helpless without the support of such men as the earls of Wessex, Mercia or Northumbria. They on their part treated him with the respect due to the head of his ancient house, received their offices from his hand, and from time to time attended his court and gave him counsel. Nevertheless to the men of their respective governments it was they rather than the king who were responsible for public order, for the defence of the land, and for the maintenance of familiar custom. The unity of England, achieved by the great kings of the 10th century, had become very superficial when Edward the Confessor died.

At this point William of Normandy exercised a determining influence on English history. He was lord of the land by conquest, and from his time the king's court became the centre of English government. To him the ancient distinction between Wessex, Mercia and the Danelaw had no political significance, and successive revolts enabled him to break up the great earldoms. He was compelled to create compact military lordships in regions where especial danger threatened. The earldoms of Chester, Shrewsbury and Richmond closely resembled Norman countships, and the "rapes" of Sussex were castleries of French pattern. But each of these new military governments was given to a man whom William had reason to trust, and in his time their privileges did not impair its integrity. Indeed, it would be easy to exaggerate the centralization of the government in William's reign. Feudal custom expected a lord to do justice to his men in his own court, and the king was not yet required to intervene in private disputes between persons of modest station. William was representative of his generation, and knew instinctively the sphere in which his authority could be exercised without challenge. To him belonged an unquestioned initiative in policy, the right to send his ministers into every part of the land to ascertain his interests, and a claim upon the advice and support of his barons in any undertaking which he might plan. It was to him that his barons owed their position, and though irresponsible nobles might sometimes rebel, the definite opposition between crown and baronage which colours English history in the later middle ages could not arise while the Anglo-Norman monarchy was itself on the defensive. The new power which William had created had many enemies. It was a direct challenge to the kings of Norway and Denmark, it was regarded with great suspicion in France, and for a generation the possibility of a native rising was very real. Throughout the reigns of the Conqueror and his sons there was an essential community of interest between the king and his barons, and it was from this that the strength of the Anglo-Norman monarchy was ultimately derived.

FROM "VETUSTA MONUMENTA," 1842

FIG. 2.—ILLUSTRATION FROM BAYEUX TAPESTRY, SHOWING HAROLD SWEARING ON THE RELICS TO SUPPORT WILLIAM OF NORMANDY'S CLAIM

Character of Anglo-Norman History.—With the Norman Conquest English history assumes a new character. The unity of England was now assured, and the political history of the Anglo-Norman reigns seems curiously insignificant after the great events which culminated in the Conquest. The military adventures of William II. led to no decisive issue, and the prolonged peace which Henry I. gave to England meant that contemporary writers found few events of moment to record. The reign of Stephen is crowded with incident, but there is little coherence in the recorded succession of events, and the feudal anarchy which marks this period is in retrospect only a brief exception to the general trend of English history. The interest of the years which followed the Conquest lies outside the course of political or military incident. It is to be found in the organization of the English administrative system, the influence of feudal principles upon English society, the relations of the church in England to the Papacy, the emergence of England from isolation on the fringe of the western world into participation in the movements then influencing continental Europe.

By the end of 1070 the Norman rule had become finally established in England. French barons had received the lands forfeited by English rebels, and the North had been terrorised by the recent devastation of Yorkshire and northern Mercia. William was unwilling to allow military power to any man of English descent and the native element in the Anglo-Norman aristocracy, though strong in the North, had little political importance. But the Norman Conquest was not a national migration, and the modification of English law, language and social custom through French influence was a very gradual process. Fifty years after the Conquest the traditions of the time before that event were still strong, and Englishmen lived in the reign of Henry I. under what was still in substance and procedure essentially Old English law. To the last, England never became a mere province of the French speaking world.

The Monarchy and the Baronage.—The danger which confronted the Anglo-Norman kings was not English disaffection but the drift towards baronial independence characteristic of contemporary feudalism. In the forty years which followed the Conquest there were four serious baronial rebellions, each essentially the outcome of aristocratic jealousy towards a strong monarchy. Until the succession to the throne itself fell into dispute between Stephen and the empress Maud, the common interests of crown and baronage were always strong enough to prevent the disaffection of individuals from wrecking the settlement established by William I. But all the kings of this period were alive to the danger. In 1085 William himself received the homage of all the landholders of any account in England, thereby insisting that the vassal's fidelity to the king overrode his duty to his immediate lord. William II. understood the mental attitude of the irresponsible baron, and attracted into his own service many of the landless knights of northern France on whom the plotters of rebellion always relied. Henry I. was interested in the business of government, and under him the Anglo-Norman monarchy reached a degree of organization which placed it above the attack of any possible combination of barons. Under him, perhaps for the first time in its history, England enjoyed unbroken peace for a generation. With his death the direct line of the Norman kings ended, his successor ruined the national administration by alienating the church, and the dangerous forces latent in the constitution of feudal society at last found vent. The ensuing phase of feudal anarchy was brief and the inevitable reaction lasted long. The power of the crown, restored by Henry II., was never generally attached until the generation which had known the disorders of Stephen's time had disappeared. But the history of the years of confusion illustrates what might easily have become the normal condition of society under the new French dynasty and the baronage which it has established in England.

Anglo-Norman Administration.—If the authority of the Anglo-Norman kings depended in the last resort on the loyalty of the baronage, it was exercised through an administrative system

which centred upon the king's court. William I. had inherited more than the nucleus of an executive organization from his English predecessors. Already before the Norman Conquest England had developed a national system of taxation, and the unrivalled series of English financial records begins in William's reign with a document written in English which proves the earlier existence of a definite organization for the receipt of the royal revenue. The king's writ of later times goes back to an Old English model, and it was in English that the Conqueror in his earliest years normally addressed his subjects of every race. With few exceptions, the king's clerks of his reign are obscure people, but they and their successors were able to carry through the compilation of the greatest record in mediaeval history. From every point of view Domesday Book (*q.v.*) was a momentous achievement. It incorporates the result of a national survey which was itself a political event of the first importance, and its bearing upon the origins of English mediaeval administration is equally significant. It proves the existence in the king's service of a large body of clerks, skilled in administrative routine, and able to reduce to order the verdicts of innumerable local juries drawn from every part of England between the Tees and the Channel. The creation of specialized offices within this body was only a question of time, and early in the next century the history of the English departments of state begins with the appearance of the Exchequer, the central financial bureau destined to carry down to modern times the tradition, and much of the technique, of the Anglo-Norman administration.

Church and State.—In mediaeval history it is never easy to draw a clear line between the respective spheres of church and state, and in the history of England it is long before any definite separation becomes evident. The leading churchmen of pre-Conquest England had been immersed in secular business, ecclesiastical pleas were commonly treated in secular courts, and the king had been far more effectively the ruler of the church than of the state. With the Norman Conquest, church and state began to fall apart. Under William I. and his friend Lanfranc, archbishop of Canterbury, the organization of the church in England was remodelled according to continental ideas, the bishops gained a more direct authority over their clergy, and jurisdiction over matters affecting the cure of souls was transferred from the ancient hundred moot to the new bishop's court. But the conscious opposition between the monarchy and the church belongs to a later time. On questions of ecclesiastical policy William and Lanfranc were of one mind. Lanfranc realized that the work of ecclesiastical reform needed the support of the royal authority, that the deliverance of the church from subjection to the feudal world could only be accomplished by the exercise of the king's supremacy. It was not until the church itself was secure that a movement towards independence could arise within it.

The intimate alliance which William and Lanfranc had founded was broken under their successors. William II., himself as irreligious as the wildest baron of his time, placed a saint in the see of Canterbury. Intellectually among the greatest of mediaeval churchmen, Anselm (*q.v.*) throughout his primacy felt himself an alien in England. New questions of ecclesiastical politics, on which English churchmen were themselves divided, awaited his decision. Upon the most urgent of these questions, the great controversy over Investitures (*q.v.*), Anselm and Henry I. reached a compromise. But their success did not affect the essential fact that the ancient unity of church and state in England was incompatible with the new ideal of ecclesiastical independence from which the investiture controversy itself had arisen. For a time the inevitable conflict between church and state was postponed. Anselm's successors, archbishops Ralf and William were mainly occupied with the detailed work of ecclesiastical administration and reform. Under Theobald of Bec, the next archbishop, the church was for a time the only institution in the land which maintained the great Norman tradition of organized government. Throughout the reign of Stephen, the church and its ministers possessed a degree of power which made the assertion of general principles irrelevant. It was Theobald's successor, Thomas Becket, who challenged at last the ecclesiastical authority of the crown.

II. THE DEVELOPMENT OF CENTRALIZATION

The essential achievement of the Anglo-Norman kings had been the creation of an administrative system, centred on the royal court, which under Henry I. had destroyed all but the greatest baronial franchises and extended its influence into every department of local government. In the reign of Stephen, a disputed succession and civil war broke the continuity of this development. In some respects the position attained by the monarchy under Henry I. was never completely restored until Henry VIII. had imposed his supremacy upon the church in England. In the last resort, Stephen had owed his throne to papal recognition, and the popes of the next age maintained and indeed increased the influence thus won.

Henry II. and Thomas Becket.—Although Henry II. in the end carried the English monarchy to a point of power never before attained, his achievement even in the temporal sphere was long delayed by the spirit of feudal independence which had found expression in the anarchy. Fortunate in all his ministers save one, a single error in judgment destroyed for ever his chance of re-establishing the relations between church and state which had prevailed under the Anglo-Norman kings. The whole of his reign thereafter was coloured by the fact that Thomas Becket (*q.v.*), Henry's fellow worker as Chancellor, became the uncompromising champion of ecclesiastical privilege as archbishop. Through his opposition Henry's original aim of bringing all his subjects within the sphere of royal justice became unattainable. Hoping at first to move by the establishment of general principles through the settlement of individual cases, he was compelled by the opposition of Becket to propose to his bishops in the Constitutions of Clarendon (*q.v.*) of 1164 a comprehensive definition of the relationship which he wished to see established between church and state. The archbishop's flight prevented the settlement of the general questions raised by the Constitutions. His murder in 1070 produced a reaction which gave to the Pope a direct influence on the administration of ecclesiastical justice in England, and secured for the clergy immunities which still complicated the administration of English justice long after the middle ages.

Innovations in Criminal Procedure.—But even in the difficult years of Becket's exile and the crisis which followed his death the work of centralization was going on. Aided by the most remarkable group of ministers which ever served an English king, ministers drawn alike from the feudal nobility of every rank and from the new administrative class which had arisen earlier in the century, Henry was able to undertake the systematic reconstruction of the administration without alienating the mass of the English baronage. In 1166 in the Assize of Clarendon for the first time the king took from the individual the responsibility of instituting legal process against persons suspected of certain of the graver forms of crime. Such crimes in future came before the king's judges. Jurisdiction over them was taken from the sheriff and the feudal baronage alike. Ten years later the Assize of Northampton added further crimes to the list and made punishment more severe. By these ordinances what was in effect a new procedure was introduced into English criminal law. The jury or sworn inquest, which was henceforward employed to inform the king's judges about crimes or accusations of crime, was no new thing. Ever since the Norman Conquest it had been used for the ascertainment of royal rights and for the occasional settlement of disputes between individuals, but there had not been any place for it in ordinary legal procedure. Its regular employment could only be secured by such deliberate innovation as the royal ordinance of 1166. The change was sudden, but it was not pushed to an extreme, for the individual still had the right of appeal, and the native ordeal and the Norman duel still survived. As years went on the king's judges appeared almost annually in the shires, and gradually men came to realize the fundamental superiority of the king's justice. Gradually they attracted to the king's courts criminal business which formerly would have fallen to the feudal courts or the ancient courts of shire or hundred. Offences of little moment could be brought before the king's judges by the mere assertion of the plaintiff that they had been committed in

contempt of the king's peace.

New Forms of Action.—Simultaneously the king was extending the influence of his justice in the sphere of civil procedure. From the early years of his reign he was enforcing the doctrine later expressed by his chief justiciar, Rannulf de Glanville in the formula "No one need answer in his lord's touching his free tenement without the writ of the king or his chief justiciar." He rigorously followed up complaints of default of justice. He devised the first examples of those forms of action which dominated the law of real property until the nineteenth century was well advanced. Determined by the verdict of a local jury instead of the uncertain operation of archaic forms of procedure, these possessory assizes steadily grew in popularity. For those who desired a rapid settlement, even if it might be reversed on some future occasion, these summary processes were sufficient. For those who wished a final settlement in accordance with the verdict of a jury and in the king's court Henry provided a more solemn if less expeditious process in the Grand Assize which enabled the tenant of the land at issue to avoid the uncertain event of a judicial duel. It is not surprising that Henry's court was invoked by his free subjects of every condition. The essential step had now been taken towards the centralization of justice in England.

The King's Court and Local Officers.—The men through whom this work was carried out, the justices of Henry's court, were not experts in law alone. They were the king's executive officers to be employed on any task that the king might assign to them—administrators of the king's estates, keepers of the royal castles, financial officers of the crown. Above all they formed the essential link between the central government and the shires. Through them the king maintained control of the sheriffs; many of them were sheriffs themselves. Through visits of the justices on circuit the central court became informed as to the condition of the country. The ordinary freeman became acquainted with the personnel of the king's court and was continually reminded that there existed a power in the land greater than the feudal magnate who was his lord or the sheriff who presided over the ancient assemblies of his shire. On one great occasion in 1170 Henry instituted, through persons despatched from his court, an enquiry into the conduct of all local officers, and many sheriffs were dismissed as a result of this investigation. The independence of the local officer which had wrecked earlier Continental experiments in centralization was now destroyed. The king's court had become the instrument of all government in England.

It is in this development of royal power in England rather than in the magnitude of Henry's territorial position in western Europe that the greatness of his reign lies. Nevertheless, he was the strongest king of his time, inferior in rank to the Emperor, but far superior to him in material resources. His official title, King of England, Duke of Normandy and Aquitaine, count of Anjou, imperfectly expresses the significance of his position. A duke of Aquitaine was lord of one of the richest regions of the whole West whose traditions were more ancient than those which centred round the French monarchy itself. In Normandy it was not forgotten that his father's house had been the hereditary enemies of the Norman dukes. In this lay the weakness of his continental position, a weakness that the king of France knew only too well how to exploit. Conscious of the diverse traditions of the regions over which he ruled, Henry was unwilling to encourage local particularism by creating appanages for his sons. Their resentment at exclusion from power was perhaps inevitable, though they showed little sense of responsibility or family solidarity. Fortunately for Henry their political capacity was small. Their rebellion in 1174, though supported by the kings of France and of Scotland, failed alike in England and France. After fifteen years of continuous disaffection they brought Henry's reign to a close in confusion and distress, his empire passing entirely to Richard, his rebellious heir.

The Reign of Richard I.—The reigns of Richard I. and John form a single period. A real break in continuity comes between the reigns of Henry II. and Richard I. with a change in the great officers of state, of whom the Treasurer alone remained. But a more essential change lay in the different spirit with which the new king regarded his responsibilities. Henry II. desired above everything to establish his authority upon financial stability and a well ordered land. With Richard I. begins a long series of kings who failed to accommodate their policy to their financial resources. Richard cared for England only as a source of the money needed for his military adventures and only on two occasions appeared in England. Nevertheless, England was as well administered under him as under his father, for he commanded the services of a younger generation of officials who had received their training in his father's court. Perhaps the most important feature of his reign is the fact that the mass of his subjects came in his time to associate strong government with the king's ministers, not with the king himself.

Richard came to England in 1189 to be crowned and to raise money for the crusade to which he was already committed. Nothing illustrates more clearly the prosperity which England had reached under Henry II. than the way in which the country met the unprecedented financial demands of Richard. To the new king the settlement of England made necessary by his impending departure was a matter of finance. He sold offices and privileges to individuals, charters to towns, and his favour to persons whose loyalty was suspect.

The Count of Mortain and the King's Justices.—The unity of England itself was threatened by the settlement of 1189. The youngest son of Henry II., John count of Mortain, was a person to be conciliated, and he received from Richard an appanage of unprecedented extent. Six counties, Nottingham and Derby, Somerset and Dorset, Devon and Cornwall, were withdrawn from the control of the central government and placed under John's lordship. They accounted no longer at the royal exchequer but at that of the count of Mortain. He held also the honours of Lancaster, Tickhill, Peverel of Nottingham, Wallingford and Eye, which were among the greatest feudal lordships in England. In his wife's right he possessed the great inheritance of the earls of Gloucester, which gave him the formidable marcher principality of Glamorgan. Nevertheless, John was dissatisfied; he had not been recognized as his brother's heir and the greatest castles in his domain were held by his brother's officers. Inevitably he became a centre of disaffection, and the unpopularity of Richard's chief minister, William de Longchamps bishop of Ely, chancellor, Justiciar and Papal Legate, brought over the leading members of the king's council itself to the side of John. In the autumn of 1191 the Chancellor was driven from England by a movement led by John, and his place was taken by Walter archbishop of Rouen, who had been sent from abroad by Richard. Until January 1193, when the news reached England that Richard had fallen into captivity on his return from crusade, the archbishop carried on the government of England in Richard's name. Then in alliance with the king of France John broke into rebellion, and thenceforward until Richard himself returned to England early in 1194 and captured the last castles which held out for his brother the peace of the land was never completely re-established. But even in these difficult months, the representatives of Richard never lost control of the situation. They were even able in 1193 to collect and despatch to Germany a large portion of the ransom demanded by the Emperor for Richard's release. The administrative system which Henry II. had devised remained unshaken by threatened war with France, by the shock of the king's imprisonment, and by the rebellion of the man who stood nearest to the succession.

Hubert Walter, Archbishop of Canterbury.—The war with France in which Richard was thenceforward engaged belongs to French rather than to English history. In England, Hubert Walter archbishop of Canterbury, first as justiciar and afterwards as chancellor maintained the traditions of Henry II.'s court. If his immediate duty was to raise money and knights, his chief interest lay in improving governmental practice at Westminster and in the country. The great eyre of 1194 is a landmark in English administrative history; it created a new and permanent office, that of coroner, it set up new machinery for dealing with lands escheated into the king's hand, and instituted the department of government which soon became known as the

Exchequer of the Jews. The office of justice of the peace can be traced back upon one of its many lines of development to an edict issued by Hubert Walter in 1195. He reorganized the Chancery and began the systematic keeping of official records. His influence survived until the whole administrative system collapsed in the troubles which preceded the issue of Magna Carta.

King John.—Hubert Walter and his younger contemporary, Geoffrey fitz Peter, form a link between the reigns of Richard I. and John. With Richard's death and John's accession in 1199 the personality of the sovereign once more became the dominant factor in English politics. John has received hard measure from historians, and he deserved much that they have said against him. In personal conduct, like his father, he fell below the low standards of contemporary life, but he was a man of ability, interested in the routine of government and in the technique of law, and with real appreciation of forces which as yet most rulers of his time regarded with suspicion. It was not mere financial necessity which made him a patron of towns; long after his death the cities of Aquitaine regarded him as a benefactor. It was not weakness that made him call into occasional consultation men of less than baronial rank, there was something inevitable in the disasters which fell upon England in his time. He suffered from baronial reaction against efficient bureaucracy, from popular resentment against the heavy taxation incurred through his brother's spirited policy. Above all he was thrown by circumstances into opposition to two of the greatest mediaeval statesmen. As a young man Philip Augustus king of France had reduced the veteran Henry II. to submission, and though Richard I. had held his own against him it had been at a heavy price. In Innocent III. John faced a pope who brought wholly unusual qualities to the establishing of papal supremacy in western Europe. It was something more than the weakness of its king that made England a vassal state and brought upon it the first foreign invasion since 1066.

John and the Papacy.—The first significant event was the French conquest of Normandy in 1204. It marks the end of the system which had prevailed since the Conquest, by which the greatest feudal families were powerful on either side the Channel. It made possible the growth of an English national feeling, but its immediate consequence was a certain alienation of the baronage from the king. The next year saw the beginning of the events which were to lead to the central crisis of the reign. Archbishop Hubert Walter died on July 13, 1205, and a disputed election gave Innocent III. an unexpected opportunity. The struggle which began with the pope's nomination of Stephen Langton to the primacy and the refusal of John to accept him lasted till 1213. For long, the king gained rather than lost by the quarrel; he enjoyed the profits of the lands of those ecclesiastics who obeyed the Pope, and thus enriched, he was able to enforce his supremacy on Ireland and Wales and take hostages from the king of Scots. But his strength was more apparent than real. After his personal excommunication in 1209 he was left with but two supporters among the bishops, John, bishop of Norwich, absent ruling Ireland, and Peter des Roches, bishop of Winchester. Threatened by French invasion at the instigation of Innocent III., unnerved by current rumours of coming doom, uncertain of the attitude of some of his barons, John submitted unconditionally to the Pope in 1213. He promised to hold his kingdom as a papal fief and to pay a yearly tribute to his overlord. On his part, the Pope discountenanced the French invasion of England.

Magna Carta.—The coming of Stephen Langton as archbishop of Canterbury marks not only the end of the struggle between John and the Pope, but the beginning of the events which culminated in the issue of the charter in 1215. The course of these events, the place of the charter in English history, and the war which followed its issue are described in the article Magna Carta. Had John lived there is little doubt that he would have quelled the barons and their French allies, but his victory would have meant the triumph of absolutism, the indefinite postponement of constitutional experiment. With his death (Oct. 19, 1216) the authority of the crown was disassociated from the personality of an unpopular king.

Failure of the French Invasion.—John's inheritance passed to his son Henry, a child of nine, whose supporters established a regency under William Marshall, earl of Pembroke, the oldest and most generally trusted of the English earls. With him were associated Gualo, the papal legate, Hubert de Burgh, the Justiciar, Peter des Roches, most faithful of John's ministers, and Falkes de Breauté, the ablest of his mercenary leaders. In less than a year they had secured the withdrawal of the French invaders and brought over to Henry's side the great mass of the English baronage. Two notable victories marked the war, the battle which secured the relief of Lincoln castle, held for Henry by the heiress of its hereditary castellan, and a naval victory in the straits of Dover which prevented reinforcements from reaching the French army in England. On Sept. 11, 1217 the war ended in the treaty of Lambeth.

Henry III.—Till the Marshall's death in 1219 the interests of the young king were protected by the coalition of able men who had taken control of affairs. Gualo had been replaced by Pandulf as legate and on his deathbed it was to the care of the Pope in the person of Pandulf that the Marshall entrusted Henry. The return of Stephen Langton, driven from England by his unwillingness to excommunicate the rebel barons at the papal command, meant Pandulf's recall. But the necessity for the legate's presence was over. Much work remained to be done, but it was work of settlement. There were elements of unrest in the country represented by the mercenaries, in particular Falkes de Breauté, and the younger nobles, such as William de Forz, count of Aumâle, who were unwilling to accept a time of peace. But these forces of anarchy were easily suppressed. Within two years of the treaty of Lambeth, the administrative system, dislocated by war was once again in full operation. The elaborate series of records which illustrate in minute detail the government of England under Henry III. begins in his earliest years.

Hubert de Burgh and Peter des Roches.—From 1219 until 1232 Hubert de Burgh, the Justiciar, was ruler of England. He was far more powerful than any previous Justiciar, but was throughout confronted by the rivalry of Peter des Roches, bishop of Winchester and Henry's former tutor. The situation was still difficult, and Hubert was generally held responsible for the insecurity of the Welsh marches and the ill success of English policy in France. His resistance to papal demands upon the English church did not counteract the unpopularity which he earned from the older nobility by his determination to secure a strong territorial position for himself and his family. At length his domination became insupportable to the king, to whom he did not even allow the possession of a privy seal. In 1232 Peter des Roches triumphed. A supporter of his became Justiciar without political power; his nephew, Peter de Rivaux controlled the royal household, and the royal household through its executive department, the wardrobe, controlled the administration.

Regarded as Poitevin adventurers, the bishop of Winchester and his associates were even less popular than Hubert had been, their very loyalty to the king and their interest in administrative reform alienating the baronage. The leader of the opposition, Richard, earl of Pembroke, was killed in Ireland through their contrivance, and Edmund Rich, the new archbishop of Canterbury, brought about their dismissal. With the fall of Peter des Roches the last great figure of the minority disappears from English politics, and Henry's personal rule began (1234). Two years later Peter de Rivaux held office in the wardrobe again, though with less apparent power. His reappearance coincides with the coming of many foreign relatives of the new queen, Eleanor of Provence. It was followed by the gradual replacement of English by foreign clerks in the wardrobe and by six years of far-reaching administrative reform.

Character of Henry's Government.—Mainly interested in the efficiency of the central government this new school of administrators cared little for the welfare of the subject. Its very efficiency threatened baronial privilege, and the ancient feudal council was losing its power to a new body of intimate advisors of the king. In 1247 a second Poitevin invasion began with the appear-

ance in England of the king's half brothers and their dependents. Despite the financial reforms which had been recently introduced, the king was short of money. He could not check the rising power of Llewelyn of Wales, a war with France in which he entered in 1242 was expensive and ineffective, and requests to the baronial council for help were met with demands for the observance of the Charters. Meanwhile papal demands for money from the English church and papal provisions to English benefices were becoming insupportable to all alike.

The king himself was anxious to play a leading part in European politics. His sister's marriage to the Emperor, Frederick II., in 1235 produced an anomalous situation. Frederick was the declared enemy of the papacy and Henry had begun his reign as a papal protege. The ally of each antagonist, Henry was too weak to follow an independent policy. He depended on papal mediation for the maintenance of tolerable relations with the king of France. Harassed as he was by the inadequacy of his resources and by baronial opposition, Henry's ambition nevertheless led him in 1255 to accept from the pope the kingdom of Sicily on behalf of his infant son Edmund. Thus, if indirectly, was produced the great crisis of his reign.

Simon de Montfort.—Throughout all the difficulties of Henry's personal rule, his brother Richard earl of Cornwall had acted as the trusted mediator between crown and baronage. In 1257 he left England to attempt with papal support to win the position of emperor. He was a moderate man respected by all parties, and his withdrawal was unfortunate. Henceforward for eight years English politics are dominated by a very different personality. Coming to England with no other advantages than an agreeable address and a claim to an English earldom which might well have been ignored, Simon de Montfort had become one of the leading barons in the land. He had secured the earldom of Leicester and married the king's sister. The only successful governor of Gascony since the time of Richard I. he was ill rewarded by the king and joined the extreme section of the baronial opposition.

The Provisions of Oxford and the Baronial Council.—In April 1258 an opposition party was formed, and the Great Council, or Parliament, as it was coming to be called, put off the consideration of supplies until a plan of reform was agreed upon. Parliament was summoned to meet at Oxford in June, and there the Provisions of Oxford (*q.v.*) were drawn up, arranging for the government of the country by a baronial council. The baronial aim was to control and reform the central administration and the king's household, and to correct the abuses of local government. But before either object could be undertaken it was necessary to arrange peace with Wales and France. It is interesting to note that Simon de Montfort delayed negotiations with France because he would not give up his wife's remote claims to a share in the Norman and Angevin territories until he had been compensated by Henry III. But the main interest of the period from 1258 to 1261 lies in the baronial attempts to reform local administration; their preoccupation with the details of local government prevented them from dealing with the central administration. The office of Justiciar was revived, though with judicial rather than executive functions. The Treasury, Chancery and Household were little affected by the revolution. Peter de Rivaux lost office once more, but less important men, Englishmen or foreigners retained their positions. Even in regard to local government the baronial task was not easy. It was made more difficult by the fact that the king was working all the time for the recovery of power, and the baronial party was divided on the question of baronial franchises. Simon de Montfort won much popularity by insisting against the earl of Gloucester that not even the greatest baronial "liberty" should exclude the officers of the central government. Edward, the king's son, who was himself, as king, to legislate against both the oppressive local officer and the tyrannical baron was already showing the direction of his sympathies. He supported the movement among the "bachelors," the unestablished members of feudal families, who demanded the extension of the reforms. The result was the issue of the Provisions of Westminster in Oct. 1259 defining the relations between royal and seignorial justice and strengthening the power of the council over the government. For a time in 1259 Edward was closely allied with Simon de Montfort. But by the influence of his uncle, Richard king of the Romans, Edward was led to see that he was endangering royal authority for the sake of an idea, and brought back into his natural association with the king. A papal Bull of April 13, 1261, absolved Henry from his oath to observe the Provisions of Oxford. Neither side was anxious for war, and for a time the wider questions at issue were postponed to a struggle over the details of local government. The earl of Gloucester died in the next year. His heir was an enthusiastic follower of de Montfort, so that Simon's leadership of the opposition was unquestioned. On the other hand Edward had won the marchers to the royal side. The inevitable war was averted for a time by an agreement to submit to the arbitration of Louis IX. of France, but despite the oaths taken by the leaders of each party to abide by the king's judgment, his decision against the Provisions of Oxford meant war. The king was stronger in 1264 than he had been in 1258, for many of the greater barons had now come over to him. Simon's followers were mainly young men full of ideas of reform, and his close alliance with Llewelyn of Wales was as much a source of weakness as of strength. Nevertheless, the battle of Lewes on May 14, 1264, was a defeat for the king, who was captured. England was again, as in 1258, ruled by a baronial committee, but Earl Simon was now its dominating spirit.

The Parliament of 1265.—The Model Parliament of 1265, to which Earl Simon owes his fame, was intended to buttress a position which he knew was none too strong. It was essentially a meeting of his supporters. Its place in English history is due to the simultaneous summons of borough representatives and knights of the shires. This precedent was not, indeed, immediately or uniformly followed. The assemblies of the next thirty years still have the experimental character of those which had preceded Simon's parliament. They were still in the transition stage between the feudal council and the national parliament. It was not till 1295 that Edward I., in acute need of national support reverted to the example set by Earl Simon. Contemporary opinion could not have realized that a new instrument of government was in process of development, but the germ of the future House of Commons lay in the Parliament of 1265.

Renewal and End of War.—When the Parliament met Simon's power was beginning to fail. He quarrelled publicly in Parliament with the earl of Derby, and even the earl of Gloucester's loyalty broke under the strain of accommodation to his arbitrary behaviour. Edward escaped from supervision, raised forces in the Welsh marches, and at Evesham in August 1265 Simon was killed and his army annihilated. The uncompromising attitude of the royalists deterred the baronial leaders from submission, and the war was now resolved into the desperate defence of isolated centres of resistance, Kenilworth castle, the Isle of Axholme, and the Isle of Ely. Among the royalist barons there was difference of opinion as to the policy to be adopted towards those implicated in the rebellion. The marcher lords would have proceeded to all extremes against them, but the more moderate opinion represented by the earl of Gloucester prevailed upon Edward and in 1267 terms of settlement were reached and expressed in the *Dictum de Kenilworth.* A long series of judicial visitations at length determined the penalties to be inflicted on individual rebels and settled the ownership of much land and many chattels seized in the war.

Earl Simon's Place in History.—Simon de Montfort should be remembered less for his work as a founder of the English Parliament than for the fact that despite his personal ambition, his arbitrary character, and his insistence on his personal rights he aimed at the reform of real abuses and tried to impose upon the holders of the great feudal franchises a responsibility not less than that of the king. Good work was done in the time of baronial rule, which led directly to the administrative achievements of the reign of Edward I. The Statute of Marlborough (1267) and the statutes of the next generation work out in detail ideas which had already found expression under the régime of Simon. The nature of the central government as it had been elaborated during the minority and personal rule of Henry III., was not materially changed by the rebellion. The reign had seen the development of

the Wardrobe into a principal department of state, and baronial jealousy of this new household bureau in no way affected its administrative importance. Edward I. found in it the essential instrument of his rule. This continuity is only natural. The shadowy personality of Henry III. was always influenced by someone stronger than himself. At first Hubert de Burgh, then Peter des Roches, and in the last years of the reign the future Edward I. dominate English politics. Three years after the settlement at Kenilworth the royal power was so fully re-established that Edward could leave England upon Crusade. His father died in his absence on Nov. 16, 1272. (F. M. S.)

III. DEFINITION, EXPANSION AND REVOLT

The succeeding reign was perhaps the most important epoch of all English mediaeval history in the way of the definition and settlement of the constitution.

Edward I.—Edward was a remarkable figure. He was a great soldier, and his conquest of Wales forms one of the most notable military achievements in mediaeval history. But the real importance of his reign lies in the spheres of legal and constitutional development. Edward understood the problem that was before him, the construction of a working constitution from the old ancestral customs of the English monarchy plus the newer ideas that had been embodied in the Great Charter, the Provisions of Oxford, and the scanty legislation of Simon de Montfort. He loved power, but saw that he could best secure the loyalty of his subjects by assenting to so many of the new constitutional restraints as were compatible with his own practical control of the policy of the realm. He was prepared to refer all important matters to his parliament, and in the Model Parliament of 1295 reproduced the essential features of de Montfort's assembly of thirty years before—the summons of borough representatives simultaneously with the summons of knights of the shires. The constitutional quarrels of his reign were conducted with order, because the king knew his limitations, and because his subjects trusted to his wisdom in times of crisis. Edward indeed was a man worthy of respect, if not of affection. His private life was grave and seemly; his chosen ministers were wise and experienced officials, whom no man could call favourites or accuse of maladministration. He was sincerely religious, self-restrained and courteous, though occasionally, under provocation, he could burst out into a royal rage. He was a good master and a firm friend. Moreover, he had a genuine regard for the sanctity of a promise, the one thing in which his father had been most wanting. It is true that sometimes he kept his oaths or carried out his pledges with the literal punctuality of a lawyer, rather than with the chivalrous generosity of a knight.

Edward's reign lasted for thirty-five years. The first period of it, 1272–90, was mainly notable for his great series of legislative enactments and his conquest of Wales. The second, 1290–1307, contains his long and ultimately unsuccessful attempt to incorporate Scotland into his realm, and his quarrels with his parliament.

Statutes of Westminster and Gloucester.—The changes made by Edward in constitutional law by his great series of statutes were intended to strengthen the power of the crown by judicious and orderly definition of its privileges. The great enactments start with the First Statute of Westminster (1275), a measure directed to the improvement of administrative details, which was accompanied by a grant to the king of a permanent customs-revenue on imports and exports, which soon became more valuable to the royal exchequer than the old feudal taxes on land. In 1278 followed the Statute of Gloucester, an act empowering the king to make inquiry as to the right by which old royal estates, or exceptional franchises which infringed on the royal prerogative of justice or taxation, had passed into the hands of their present owners. This inquest was made by the writ *Quo Warranto,* by which each landholder was invited to show the charter or warrant on which his claims rested. The barons were suspicious, for many of their customary rights rested on immemorial and unchartered antiquity, while others were usurpations from the weakness of John or Henry III. They showed signs of an intention to make open resistance; but to their surprise the king contented himself with making complete lists of all franchises then existing, and did no more; this being his method of preventing the growth of any further trespasses on his prerogative.

Statute of Mortmain.—Edward's next move was against clerical encroachments. In 1279 he compelled Archbishop Peckham to withdraw some legislation made in a synod called without the royal permission—a breach of one of the three great canons of William the Conqueror. Then he took the offensive himself, by persuading his parliament to pass the Statute of Mortmain (de religiosis). This was an act to prevent the further accumulation of landed property in the "dead hand" of religious persons and communities. The more land the church acquired, the less feudal taxation came into the royal exchequer. For undying corporations paid the king neither "reliefs" (death duties) nor fees on wardship and marriage, and their property would never escheat to the crown for want of an heir. The Statute of Mortmain forbade any man to alienate land to the church without royal licence. A distinct check in the hitherto steady growth of clerical endowments began from this time, though licences in mortmain were by no means impossible to obtain.

Second Statute of Westminster.—The great group of statutes that date from Edward's earlier years ends with the legislative enactments of 1285, the Second Statute of Westminster and the Statute of Winchester. The former contains the clause *De Donis Conditionalibus,* a notable landmark in the history of English law, since it favoured the system of entailing estates. Hitherto life-owners of land, holding as subtenants, had possessed large powers of alienating it, to the detriment of their superior lords, who would otherwise have recovered it, when their vassals died heirless, as an "escheat." This custom was primarily harmful to the king—the greatest territorial magnate and the one most prone to distribute rewards in land to his servants. But it was also prejudicial to all tenants-in-chief. By *De Donis* the tenant for life was prevented from selling his estate, which could only pass to his lawful heir; if he had none, it fell back to his feudal superior. Five years later this legislation was supplemented by the statute *Quia Emptores,* equally beneficial to king and barons, which provided that subtenants should not be allowed to make over land to other persons, retaining the nominal possession and feudal rights over it, but should be compelled to sell it out and out, so that their successor in title stood to the overlord exactly as the seller had done. Hitherto they had been wont to dispose of the whole or parts of their estates while maintaining their feudal rights over it, so that the ultimate landlord could not deal directly with the new occupant, whose reliefs, wardship, etc., fell to the intermediate holder who had sold away the land. The main result of this was that, when a baron parted with any one of his estates, the acquirer became a tenant-in-chief directly dependent on the king, instead of being left a vassal of the person who had passed over the land to him. Subinfeudation came to a complete stop, and whenever great family estates broke up the king obtained new tenants-in-chief. The number of persons holding immediately of the Crown began at once to multiply by leaps and bounds. As the process of the partition of lands continued, the fractions grew smaller and smaller, and many of the tenants-in-chief were ere long very small and unimportant persons. These, of course, would not form part of the baronial interest, and could not be distinguished from any other subjects of the crown.

Statute of Winchester.—The Statute of Winchester, the other great legislative act of 1285, was mainly concerned with the keeping of the peace of the realm. It revised the arming and organization of the national militia, the lineal descendant of the old *fyrd,* and provided a useful police force for the repression of disorder and robbery by the reorganization of *watch and ward.* This was, of course, one more device for strengthening the power of the crown.

Conquest of Wales.—During the first half of his reign, Edward was often distracted by external matters. He was, on the whole, on good terms with his first cousin, Philip III. of France;

the trouble did not come from this direction, though there was the usual crop of feudal rebellions in Gascony. Nor did Edward's relations with the more remote states of the continent lead to any important results, though he had many treaties and alliances in hand. It was with Wales that his most troublesome relations occurred. Llewelyn-ap-Gruffydd, the old ally of de Montfort, had come with profit out of the civil wars of 1263–66, and had won much land and more influence during the evil days of Henry III. Friction had begun the moment that Edward returned from the crusade. Llewelyn would not appear before him to render the customary homage due from Wales to the English crown, but sent a series of futile excuses lasting over three years. In 1277, however, the king grew tired of waiting, invaded the principality and drove his recalcitrant vassal up into the fastnesses of Snowdon, where famine compelled him to surrender. Llewelyn was pardoned, but deprived of all the lands he had gained during the civil war, and restricted to his old North Welsh dominions. He remained quiescent for five years, but busied himself in knitting up secret alliances with the Welsh of the South, who were resenting the introduction of English laws and customs by the strong-handed king. In 1282 there was a sudden and well-planned rising, which extended from the gates of Chester to those of Carmarthen; several castles were captured by the insurgents, and Edward had to rescue the lords-marchers with a large army. After much checkered fighting Llewelyn was slain at the skirmish of Orewyn Bridge near Builth on Dec. 11, 1282. On his death the southern rebels submitted, but David his brother continued the struggle for three months longer in the Snowdon district, till he was taken prisoner. Edward beheaded him at Shrewsbury as a traitor, having the excuse that David had submitted once before, had been endowed with lands in the Marches, and had nevertheless joined his brother in rebellion. After this the king abode for more than a year in Wales, organizing it into a group of counties, and founding many castles, with dependent towns, within its limits. The "statute of Wales," issued at Rhuddlan in 1284, provided for the introduction of English law into the country, though a certain amount of Celtic customs was allowed to survive. For the next two centuries and a half the lands west of Dee and Wye were divided between the new counties, forming the "principality" of Wales, and the "marches" where the old feudal franchises continued, till the marcher-lordships gradually fell by forfeiture or marriage to the crown. In 1287 and 1294–95 there were desperate and widespread revolts, which were checked only by the existence of the new castles, and subdued by the concentration of large royal armies. In 1301 the king's eldest surviving son Edward, who had been born at Carnarvon in 1284, was created "prince of Wales," and invested with the principality, which henceforth became the regular appanage of the heirs of the English crown. This device was apparently intended to soothe Welsh national pride, by reviving in form, if not in reality, the separate existence of the old Cymric State. For four generations the land was comparatively quiet, but the great rebellion of Owen Glendower in the reign of Henry IV. was to show how far the spirit of particularism was from extinction.

Expulsion of the Jews.—Some two years after his long sojourn in Wales Edward crossed to Bordeaux in 1286, and abode in Guienne for no less than three years, reducing the duchy to such order as it had never known before, settling all disputed border questions with the new king of France, Philip IV., founding many new towns, and issuing many useful statutes and ordinances. He returned suddenly in 1289, called home by complaints as to the administration of justice by his officials, who were slighting the authority of his cousin Edmund of Cornwall, whom he had left behind as regent. He dismissed almost the whole bench of judges, and made other changes among his ministers. At the same time he fell fiercely upon the great lords of the Welsh Marches, who had been indulging in private wars; when they returned to their evil practice he imprisoned the chief offenders, the earls of Hereford and Gloucester, forfeited their estates, and only gave them back when they had paid vast fines (1291). Another act of this period was Edward's celebrated expulsion of the Jews from England (1290). This was the continuation of a policy which he had already carried out in Guienne. It would seem that his reasons were partly religious, but partly economic. No earlier king could have afforded to drive forth a race who had been so useful to the crown as bankers and money-lenders; but by the end of the 13th century the financial monopoly of the Jews had been broken by the great Italian banking firms, whom Edward had been employing already during his Welsh wars. Finding them no less accommodating than their rivals, he gratified the prejudices of his subjects and himself by forcing the Hebrews to quit England. The Italians in a few years became as unpopular as their predecessors in the trade of usury, their practices being the same, if their creed was not.

Edward I. and Scotland.—The latter part of Edward's reign was coloured throughout by the question of the Scotch succession, raised in 1286 by the death of Alexander III., the last king of the northern dynasty. Edward's attempt to enforce English overlordship over Scotland, the wars which followed, and the establishment of Robert Bruce as king of Scots form the turning point in Scotch history, and are discussed in articles relating to that subject (*see* SCOTLAND, WALLACE, BRUCE). But these events had a permanent effect on English history also. They created a new antagonism between England and Scotland, and gave a valuable ally in the north to the king of France. They seriously weakened Edward I. in his dealings with his barons. The dangerous Scotch rising under William Wallace, coming at a time when Edward was deeply involved in continental politics, compelled him to seek baronial support for the renewal of the war. Events in Scotland thus explain Edward's re-issue of Magna Carta and the Charter of the Forest in 1297, and account for his agreement at the same time to a material limitation of the royal power of taxation. Above all, the Scotch wars of Edward I. strained the national finances to the breaking point. The task of raising and equipping armies for protracted wars in a remote land overthrew the uncertain equilibrium which had previously been maintained between revenue and expenditure. The debts thus incurred by Edward I. contributed more than is usually realized to produce the crisis which arose in the next reign.

Despite the chequered fortunes of his later years the reign of Edward had been a time of progress for England. He had given his realm good and strong governance; according to his lights he had striven to keep faith and to observe his coronation oath. He had on more than one occasion quarrelled with his subjects, but matters had never been pushed to an open rupture. The nation, however much it might murmur, would never have been willing to rebel against a sovereign whose only fault was that he occasionally pressed his prerogative too far. Edward's rule was seldom or never oppressive; the seizure of the merchants' wool in 1297 was the only one of his acts which caused really widespread indignation. The realm was on the whole contented and even flourishing. Population and commerce were increasing; the intellectual activity which had marked the reign of Henry III. was still alive; architecture, religious and military, was in its prime. He himself was a great builder, and many of the perfected castles of that concentric style, which later ages have called the "Edwardian type," were of his own planning. In ecclesiastical architecture his reign represents the early flower of the "Decorated" order, perhaps the most beautiful of all the developments of English art. The reign may be regarded as the culmination and crowning point of the ages. It certainly gave a promise of greatness and steady progress which the 14th century was far from justifying.

Edward II.—With the great king's death in July 1307 a sudden change for the worse was at once visible. The individual character of the reigning king was still the main factor in political history, and Edward II. was in every respect a contrast to his father. He was incorrigibly frivolous, idle and apathetic, although his father had given him much stern schooling. He has been well described as "the first king since the Conquest who was not a man of business." He hated all kingly duties; he detested war, but he detested even more the routine work of administration. He was most at his ease in low company, his favourite diversion was gambling, his best trait a love for farming and the mechanical

arts of the smith and the gardener.

Piers Gaveston.—Edward's first acts on coming to the throne caused patriotic Englishmen to despair. His father, on his deathbed, had made him swear to conduct the Scottish expedition to its end. But he marched no further than Dumfries, and then turned back, on the pretext that he must conduct his parent's funeral in person. Leaving Bruce to gather fresh strength and to commence the tedious process of reducing the numerous English garrisons in Scotland, he betook himself to London, and was not seen on the border again for more than three years. He then dismissed all his father's old ministers, and replaced them by incompetent creatures of his own. But his most offensive act was to promote to the position of chief councillor of the crown, and disperser of the royal favours, a clever but vain and ostentatious Gascon knight, one Piers Gaveston, who had been the companion of his boyhood, and had been banished by Edward I. for encouraging him in his follies and frivolity. Piers was given the royal title of earl of Cornwall, and married to the king's niece; when Edward went over to France to do homage for Gascony, he even made his friend regent during his absence, in preference to any of his kinsmen.

The "Lords Ordainers."—The antagonism between Edward and the baronial opposition which had arisen at the beginning of the reign reached a climax in 1311 when the king's adversaries succeeded in placing him under the tutelage of twenty-one "lords ordainers," a baronial committee like that which had been appointed by the Provisions of Oxford, fifty years back. Edward was not to levy an army, appoint an official, raise a tax, or quit the realm without their leave. He had also to swear an obedience to a long string of constitutional limitations of his power, to promise to remove many practical grievances of administration and to agree to drastic changes in the personnel of his household. But there were two great faults in the proceedings of Thomas of Lancaster and his friends, The first was that they ignored the rights of the commons—save indeed that they got their ordinances confirmed by parliament—and put all power into the hands of a council which represented nothing but the baronial interest. The second, and more fatal, was that this council of "ordainers," when installed in office, showed energy in nothing save in persecuting the friends of Edward and Gaveston; it neglected the general welfare of the realm, and in particular made no effort whatever to end the Scottish war. It was clearly their duty either to make peace with Robert Bruce, or to exert themselves to crush him; but they would do neither.

Gaveston's unhappy career came to an end in 1312. After he had been twice exiled, and had been twice recalled by the king, he was besieged in Scarborough and captured by the earl of Pembroke. He was being conducted to London to be tried in parliament, when his two greatest enemies, Thomas of Lancaster and Guy, earl of Warwick, took him out of the hands of his escort, and beheaded him by the wayside without any legal authority or justification. The unhappy king was compelled to promise to forget and forgive this offence, and was then restored to a certain amount of freedom and power; the barons believed that when freed from the influence of Gaveston he would prove a less unsatisfactory sovereign. The experiment did not turn out happily. Bruce having at last made an almost complete end of the English garrisons within his realm, laid siege to Stirling, the last and strongest of them all, in the spring of 1313. Compelled by public opinion to attempt its relief, Edward crossed the border in June 1314 and the battle of Bannockburn, which secured the independence of Scotland, placed Edward at the mercy of the baronial opposition in England.

Thomas, Earl of Lancaster.—Thomas of Lancaster, who had refused to join in the late campaign, took advantage of its results to place the king once more in complete tutelage. His household was dismissed, and all his ministers and officials were changed. For more than three years Lancaster practically reigned in his cousin's name; it was soon found that the realm got no profit thereby, for Earl Thomas, though neither so apathetic nor so frivolous as Edward, was not a whit more competent to conduct either war or domestic administration. The Scots swept everything before them, ravaging the north at their will, and capturing Berwick. They even made a great expedition to Ireland, where Bruce's brother Edward was proclaimed king by the rebellious Celtic septs (*see* IRELAND, *History*). Meanwhile public order in England itself was falling into abeyance. The most extraordinary symptom of the time was a civic revolt at Bristol (1316), where the townsfolk expelled the royal judges, and actually stood a siege before they would submit. Such revolts of great towns were normal in Germany or Italy, but almost unknown on this side of the Channel. All this unrest might well be ascribed to Lancaster's want of ability, but he had also to bear—with less justice—the discontent caused by two years of famine and pestilence. In August 1318 he was removed from power by a league formed by Pembroke, Warenne, Arundel and others of the lords ordainers, who put a new council in power, and showed themselves somewhat less hostile to the king than Earl Thomas had been. Edward was allowed to raise an army for the siege of Berwick, and was lying before its walls, when the Scots, turning his flank, made a fierce foray into Yorkshire, and routed the shire-levy under Archbishop Melton at the battle of Myton. This so disheartened the king and the council that controlled him that they concluded a two years truce with Robert of Scotland, thus for the first time acknowledging him as a regular enemy and no mere rebel (1319).

The Despensers.—The time of comparative quiet that followed was utilized by the king in an attempt to win back some of his lost authority. For a short space Edward showed more capacity and energy than he had ever been supposed to possess. Probably this was due entirely to the fact that he had come under the influence of two able men who had won his confidence and had promised him revenge for the murdered Gaveston. These were the two Hugh Despensers, father and son; the elder was an ambitious baron who hated Lancaster, the younger had been made Edward's chamberlain in 1318 and had become his secret councillor and constant companion. Finding that the king was ready to back them in all their enterprises, the Despensers resolved to take the fearful risk of snatching at supreme power by using their master's name to oust the barons who were now directing affairs from their position. The task was the more easy because Lancaster was at open discord with the men who had supplanted him, so that the baronial party was divided; while the mishaps of the last six years had convinced the nation that other rulers could be as incompetent and as unlucky as the king. Indeed, there was a decided reaction in Edward's favour, since Lancaster and his friends had been tried and found wanting. Moreover, the Despensers felt that they had a great advantage over Gaveston in that they were native-born barons of ancient ancestry and good estate: the younger Hugh, indeed, through his marriage with the sister of the earl of Gloucester who fell at Bannockburn, was one of the greatest landowners on the Welsh border: they could not be styled upstarts or adventurers. Edward's growing confidence in the Despensers at last provoked the notice and jealousy of the dominant party. The barons brought up many armed retainers to the parliament of 1321, and forced the king to dismiss and to condemn them to exile. But their discomfiture was only to last a few months; in the following October a wanton outrage and assault on the person and retinue of Edward's queen, Isabella of France, by the retainers of Lord Badlesmere, one of Pembroke's associates, provoked universal reprobation. The king made it an excuse for gathering an army to besiege Badlesmere's castle at Leeds; he took it and hanged the garrison. He then declared the Despensers pardoned, and invited them to return to England. On this Thomas of Lancaster and the more resolute of his associates took arms, but the majority both of the baronage and of the commons remained quiescent, public opinion being rather with than against the king. The rebels displayed great indecision, and Lancaster proved such a bad general that he was finally driven into the north and beaten at the battle of Boroughbridge (March 16, 1322), where his chief associate, the earl of Hereford, was slain. Next day he surrendered, with the wreck of his host. But the king, who showed himself unexpectedly vindictive, beheaded him at once; three other peers, Badlesmere, Clifford and Mowbray, were sub-

sequently executed, with a score of knights.

Rebellion of Queen Isabella and Mortimer.—For the moment the king seemed triumphant; he called a parliament which revoked the "ordinances" of 1311, and replaced the Despensers in power. For the remaining four years of his reign they were omnipotent; but, able and unscrupulous as they were, they could not solve the problem of successful governance. To their misfortune the Scottish war once more recommenced, King Robert having refused to continue the truce. The fortune of Edward II. now hung on the chance that he might be able to maintain the struggle with success; he raised a large army and invaded Lothian, but Bruce refused a pitched battle, and drove him off with loss by devastating the countryside around him. Thereupon Edward, to the deep humiliation of the people, sued for another cessation of hostilities, and obtained it by conceding all that Robert asked, save the formal acknowledgment of his kingly title. But peace did not suffice to end Edward's troubles; he dropped back into his usual apathy, and the Despensers showed themselves so harsh and greedy that the general indignation only required a new leader in order to take once more the form of open insurrection. The end came in an unexpected fashion. Edward had quarrelled with his wife Isabella, who complained that he made her the "handmaid of the Despensers," and excluded her from her proper place and honour. Yet in 1325 he was unwise enough to send her over to France on an embassy to her brother Charles IV., and to allow his eldest son Edward, prince of Wales, to follow her to Paris. Having the boy in her power, and being surrounded by the exiles of Lancaster's faction, she set herself to plot against her husband, and opened up communications with the discontented in England. It was in vain that Edward besought her to return and to restore him his son; she came back at last, but at the head of an army commanded by Roger, Lord Mortimer, the most prominent survivor of the party of Earl Thomas, with whom she had formed an adulterous connection.

When she landed with her son in Suffolk in Sept. 1326, she was at once joined by Henry of Lancaster, the heir of Earl Thomas, and most of the baronage of the eastern counties. Edward and the Despensers, after trying in vain to raise an army, fled into the west. They were all caught by their pursuers; the two Despensers were executed—the one at Bristol, the other at Hereford. Several more of Edward's scanty band of friends—the earl of Arundel and the bishop of Exeter and others—were also slain. Their unhappy master was forced to abdicate on Jan. 20, 1327, his fourteen-year-old son being proclaimed king in his stead. Shortly afterwards he disappeared into close confinement, and though the circumstances of his end are obscure, there is little doubt that he was murdered before the end of the year by the orders of the queen and Mortimer.

The three years regency of Isabella, during the minority of Edward III., formed a disgraceful episode in the history of England. She was as much the tool of Mortimer as her husband had been the tool of the Despensers, and their relations became gradually evident to the whole nation. A new and formidable dignity was conferred on Mortimer when he was made both justiciar of the principality of Wales, and also earl of March, in which lay both his own broad lands and the estates of Despenser and Arundel, which he had recently annexed. The one politic act of Mortimer's administration, the conclusion of a permanent peace with Scotland by acknowledging Bruce as king (1328), was not one which made him more popular. But he easily overcame a conspiracy led by Edmund, Earl of Kent, the half brother of Edward II., and maintained himself in power until the young king felt strong enough to attempt a *coup de main.* On the night of Oct. 19, 1330, Mortimer was seized by a body of the king's friends while resident at Nottingham castle during a session of the great council, and was executed in the following month. The queen lived thenceforward in retirement and the effective reign of Edward III. began.

Edward III.—Edward showed none of his father's weakness and much of his grandfather's capacity. He fell short of Edward I. in steadiness of character and organizing power, but possessed all his military capacity and his love of work. Unfortunately for England his ambition was to be the mirror of chivalry rather than a model administrator. But his knightly virtues, his courage, his ready courtesy and his love of adventure made him popular with the nobility and the mass of his subjects were fully conscious of his military reputation. In most respects he was a perfect exponent of the ideals and foibles of his age, and it was not without reason that not England only but all western Europe looked up to him as the greatest king of his generation.

His first victories were won in Scotland. Robert Bruce was now dead and his throne was occupied by the young David II., whose factious nobles were occupied in civil strife when, in 1332, a pretender made a snatch at the Scottish throne. This was Edward, the son of John Baliol, an adventurous baron who collected all the "disinherited" Scots lords, the members of the old English faction who had been expelled by Bruce, and invaded the realm at their head. He beat the regent Mar at the battle of Dupplin, seized Perth and Edinburgh, and crowned himself at Scone. But knowing that his seat was precarious he did homage to the English king, and made him all the promises that his father had given to Edward I. The temptation was too great for the young king to refuse; he accepted the homage, and offered the aid of his arms. It was soon required, for Baliol was ere long expelled from Scotland. Edward won the battle of Halidon Hill (July 19, 1333)—where he displayed considerable tactical skill—captured Berwick, and reconquered a considerable portion of Scotland for his vassal. But he demanded too much from Baliol—forcing him to cede Lothian, Tweeddale and the larger part of Galloway, and to promise a tribute, and a Scotch reaction ended in his final expulsion. Nevertheless the fighting was all on Scottish ground, and Edward repeatedly made incursions into the very heart of the northern realm; on one occasion he reached Inverness unopposed. He held Perth till 1339, Edinburgh till 1341, and was actually in possession of much Scottish territory when his attention was called off from this minor war to the greater question of the struggle with France. Meanwhile he had acquired no small military reputation, had collected a large body of professional soldiers whose experience was to be invaluable to him in the continental war, and had practised in Scotland tactics evolved in the previous generation, which were to win Creçy and Poitiers. For the devices employed against the Scottish "schiltrons" of pikemen at Dupplin and Halidon, were the same as those which won all the great battles of the Hundred Years' War—the combination of archery, not with cavalry (the old system of Hastings and Falkirk), but with dismounted men-at-arms. The nation, meanwhile prosperous, not vexed by overmuch taxation, and proud of its young king, was ready to follow him into any adventure.

IV. THE HUNDRED YEARS' WAR (1337–1453)

The root of the Hundred Years' War must be sought in the affairs of Guienne. Already in the time of Edward I. the insecurity of the English position in south-western France was becoming manifest. Philip IV. of France had made serious encroachments upon English territory in that region, and for a moment had come near to its permanent acquisition. The Hundred Years' War was essentially due to the feeling that nothing but an attack upon the French monarchy could save the south-west of France for England. Other grounds of hostility between England and France were quite subsidiary to this, important as they were in themselves. The most obvious was the aid which Philip VI. had given to the exiled David Bruce, when he was driven out of Scotland by Edward and his ally Baliol. The English king replied by welcoming and harbouring Robert of Artois, a cousin whom Philip VI. had expelled from France. He also made alliances with several of the dukes and counts of the Netherlands, and with the emperor Louis the Bavarian, obviously with the intention of raising trouble for France on her northern and eastern frontiers.

It was Philip, however, who actually began the war, by declaring Guienne and the other continental dominions of Edward III. forfeited to the French crown, and sending out a fleet which ravaged the south coast of England in 1337. In return Edward raised a claim to the throne of France, because such a claim was in several ways a useful asset to him both in war and in diplomacy. It

was first turned to account when the Flemings, who had scruples about opposing their liege lord, the king of France, found it convenient to discover that, since Edward was the real king and not Philip, their allegiance was due in the same direction whither their commercial interests drew them. Led by the great demagogue dictator, Jacob van Artevelde, they became the mainstay of the English party in the Netherlands.

Edward's claim—such as it was—rested on the assertion that his mother, Isabella, was nearer of kin to her brother Charles IV., the last king of the main line of the house of Capet, than was Charles's cousin Philip of Valois. The French lawyers ruled that heiresses could not succeed to the crown themselves, but Edward pleaded that they could nevertheless transmit their right to their sons. He found it convenient to forget that the elder brother of Charles IV., King Louis X., had left a daughter, whose son, the king of Navarre, had on this theory a title preferable to his own. This prince, he said, had not been born at the time of his grandfather's death, and so lost any rights that might have passed to him had he been alive at that time. A far more fatal bar to Edward's claim than the existence of Charles of Navarre was the fact that the peers of France, when summoned to decide the succession question nine years before, had decided that Philip of Valois had the sole valid claim to the crown, and that Edward had then done homage to him for Guienne. If he pleaded that in 1328 he had been the mere tool of his mother and Mortimer, he could be reminded of the unfortunate fact that in 1331, after he had crushed Mortimer, and taken the power into his own hands, he had deliberately renewed his oath to King Philip.

Battle of Sluys.—In the commencement of his continental war Edward took little profit either from his assumption of the French royal title, or from the lengthy list of princes of the Low Countries whom he enrolled beneath his banner. His two expensive land-campaigns of 1339 and 1340 led to no victories or conquests. The Netherland allies brought large contingents and took high pay from the king, but they showed neither energy nor enthusiasm in his cause. When Philip of Valois refused battle in the open, and confined his operations to defending fortified towns, or stockading himself in entrenched camps, the allies drifted off, leaving the king with his English troops in force too small to accomplish anything. The sole achievement of the early years of the war which was of any profit to Edward or his realm was the great naval triumph of Sluys (June 24, 1340), which gave the English the command of the sea for the next twenty years. The French king had an enormous fleet, and with it threatened to invade England. Seeing that he could do nothing on land while his communications with the Low Countries were endangered by the existence of this armada, Edward levied every ship that was to be found, and brought the enemy to action in the Flemish harbour of Sluys. After a day of desperate hand to hand fighting the French fleet was annihilated. Henceforth England was safe from coast raids, could conduct her commerce with Flanders without danger, and could strike without difficulty at any point of the French littoral. As long as he persevered in the attempt to conduct the invasion of the northern frontier of France Edward achieved nothing.

Such schemes were finally abandoned because the king discovered that his allies were worthless and his money spent. On his return from Flanders in 1340 he became involved in an angry controversy with his ministers, whom he accused, quite unjustly, of wasting his revenue and wrecking his campaign thereby. He imprisoned some of them, and wished to try his late chancellor Archbishop Stratford, for embezzlement, in the court of the exchequer. But the primate contended very vigorously for the right to be tried before his peers, and since the king could get no subsidies from his parliament till he acknowledged the justice of this claim, he was forced to concede. Stratford was acquitted—the king's thriftlessness and not the chancellor's maladministration had emptied the treasury. Edward drifted on along the path to financial ruin till he actually went bankrupt in 1345, when he repudiated his debts, and ruined several great Italian banking houses, who had been unwise enough to continue lending him money to the last. The Flemings were also hard hit by this collapse of the king's credit, and very naturally lost their enthusiasm for the English alliance. Van Artevelde, its chief advocate, was murdered by his own townsmen in this same year.

War in Brittany. —The second act of the Hundred Years' War, after King Edward had abandoned in despair his idea of invading France from the side of the Netherlands, was fought out in another quarter—the duchy of Brittany. Here a war of succession had broken out in which (oddly enough) Edward took up the cause of the pretender who had male descent, while Philip supported the one who represented a female line—each thus backing the theory of heritage by which his rival claimed the throne of France. By espousing the cause of John of Montfort Edward obtained a good foothold on the flank of France, for many of the Breton fortresses were put into his hands. But he failed to win any decisive advantage thereby over King Philip. It was not till 1346, when he adopted the new policy of trusting nothing to allies, and striking at the heart of France with a purely English army, that Edward found the fortune of war turning in his favour.

Creçy and Calais.—In this year he landed in Normandy, where the English banner had not been seen since the days of King John, and executed a destructive raid through the duchy, and up the Seine, till he almost reached the gates of Paris. This brought out the king of France against him, with a mighty host, before which Edward retreated northward, apparently intending to retire to Flanders. But after crossing the Somme he halted at Creçy, near Abbeville, and offered battle to the pursuing enemy. Relying on the tactics which had been tried against the Scots at Dupplin and Halidon Hill, he drew up his army with masses of dismounted men-at-arms flanked on either side by archery. This array proved as effective against the disorderly charges of the French noblesse as it had been against the heavy columns of the Scottish pikemen. Fourteen times the squadrons of King Philip came back to the charge; but mowed down by the arrow-shower, they seldom could get to handstrokes with the English knights, and at last rode off the field in disorder. This astonishing victory over fourfold numbers was no mere chivalrous feat of arms; it had the solid result of giving the victors a foothold in northern France. For Edward took his army to beleaguer Calais, and after blockading it for nearly a year forced it to surrender. King Philip, after his experience at Creçy, refused to fight again in order to raise the siege. From henceforth the English possessed a secure landing-place in northern France, at the most convenient point possible, immediately opposite Dover. They held it for over two hundred years, to their own inestimable advantage in every recurring war.

The years 1345–1347 saw the zenith of King Edward's prosperity; in them fell not only his own triumphs at Creçy and Calais, but a victory at Auberoche in Périgord won by his cousin Henry of Lancaster, which restored many long-lost regions of Guienne to the English suzerainty (Oct. 21, 1345), and another and more famous battle in the far north. At Neville's Cross, near Durham, the lords of the Border defeated and captured David Bruce, king of Scotland (Oct. 17, 1346). The loss of their king and the destruction of a fine army took the heart out of the resistance of the Scots, who for many years to come could give their French allies little assistance.

Truce with France. The Black Death.—The renewal of the struggle in France was delayed by the appearance in England of the pestilence now generally known as the "Black Death." Its economic significance has been much exaggerated. It was sporadic in its incidence and heavy as was the mortality which it caused, it did not produce any dislocation of the national life. Its importance lies in the fact that it produced the most famous of mediaeval attempts to regulate wages and prices by law. The Statute of Labourers of 1351 tried, with more success than was once realized to restore the economic conditions which had prevailed before the pestilence by establishing the rates of wages current in 1347. Despite much evasion, the statute succeeded in its main object and forms an important landmark in the history of English local government.

Renewal of the War with France.—Before the renewal of the war with France, Philip VI. died (1350), and was succeeded by his son John. The war did not entirely cease, but became local and spasmodic. In Brittany the factions which supported the two

claimants to the ducal title were so embittered that they never laid down their arms. In 1351 the French noblesse of Picardy, apparently without their master's knowledge or consent, made an attempt to surprise Calais, which was beaten off with some difficulty by King Edward in person. There was also constant bickering on the borders of Guienne. But the main forces on both sides were not brought into action till the series of truces ran out in 1355. From that time onward the English took the offensive with great vigour. Edward, prince of Wales, ravaged Languedoc as far as the Mediterranean, while his younger brother John of Gaunt, duke of Lancaster, executed a less ambitious raid in Picardy and Artois. In the south this campaign marked real progress, not mere objectless plunder, for it was followed by the reconquest of great districts in Périgord and the Agenais, which had been lost to England since the 13th century. A similar double invasion of France led to even greater results in the following year, 1356. While Lancaster landed in Normandy, and with the aid of local rebels occupied the greater part of the peninsula of the Côtentin, the prince of Wales accomplished greater things on the borders of Aquitaine. After executing a great circular sweep through Périgord, Limousin and Berry, he was returning to Bordeaux laden with plunder, when he was intercepted by the king of France near Poitiers.

Battle of Poitiers and Peace of Brétigny.—The battle that followed was the most astonishing of all the English victories during the Hundred Years' War. The odds against the prince were far heavier than those of Creçy, but by taking up a strong position and using the national tactics which combined the use of archery and dismounted men-at-arms, the younger Edward not merely beat off his assailants in a long defensive fight, but finally charged out upon them, scattered them, and took King John prisoner (Sept. 19, 1356).

This fortunate capture put an enormous advantage in the hands of the English; for John, a facile and selfish prince, was ready to buy his freedom by almost any concessions. He signed two successive treaties which gave such advantageous terms to Edward III. that the dauphin Charles, who was acting as regent, and the French states-general refused to confirm them. This drove the English king to put still further pressure on the enemy; in 1359 he led out from Calais the largest English army that had been seen during the war, devastated all northern France as far as Reims and the borders of Burgundy, and then—continuing the campaign through the heart of the winter—presented himself before the gates of Paris and ravaged the Île de France. This brought the regent Charles and his counsellors to the verge of despair; they yielded, and on May 8, 1360, signed an agreement at Brétigny near Chartres, by which nearly all Edward's demands were granted. These preliminaries were ratified by the definitive peace of Calais (Oct. 24, 1360), which brought the first stage of the Hundred Years' War to an end.

By this treaty Edward formally gave up his claim to the French throne, which he had always intended to use merely as an asset for barter, and was to receive in return not only a sum of 3,000,000 gold crowns for King John's personal ransom, but an immense cession of territory which—in southern France at least—almost restored the old boundaries of the time of Henry II. The duchy of Aquitaine was reconstructed, so as to include not only the lands that Edward had inherited, and his recent conquests, but all Poitou, Limousin, Angoumois, Quercy, Rouergue and Saintonge—a full half of France south of the Loire. This vast duchy the English king bestowed not long after on his son Edward, the victor of Poitiers. Northern France, Calais and the county of Guînes, and also the isolated county of Ponthieu were ceded to Edward. All these regions were exempted for the future from all feudal dependence upon the French crown.

Submission of David of Scotland.—To complete the picture of the triumph of Edward III. at this culminating point of his reign, it must be mentioned that some time before the peace of Calais he had made terms with Scotland. David Bruce was to cede Roxburgh and Berwick, but to keep the rest of his dominions on condition of paying a ransom of 100,000 marks. This sum could never be raised, and Edward could always bring pressure to bear on the king of Scots by demanding the instalments. David gave no further trouble; indeed he became so friendly to England that he offered to proclaim Lionel of Clarence, Edward's second son, as his heir, and would have done so but for the vigorous opposition of his parliament.

English Rule in France.—For a few years after the peace of 1360 the political influence of Edward III. in western Europe seemed to be supreme. France, prostrated by the results of the English raids, by peasant revolts, and municipal and baronial turbulence, did not begin to recover strength till the thriftless king John had been succeeded by his capable if unchivalrous son Charles V. (1364). Yet the state of the English dominions on the continent was not satisfactory. Instead of creating a homogeneous Gascon State, which might have grown together into a solid unit, Edward had annexed broad regions which had been for a century and a half united to France. The disaffection of the south-western noblesse led to a renewal of the war before the peace had lasted for a decade. In 1367 the prince of Wales, to maintain English influence in Castile, led an army into that kingdom in support of its exiled ruler Peter "the Cruel," and in the battle of Najera defeated the rival claimant Henry of Trastamara, whose sympathies were with the French court. The expedition seemed necessary for the security of Aquitaine, but it led to the imposition of heavy taxation on this region and in 1368 the counts of Armagnac, Périgord and Comminges, appealed to the king of France as their suzerain against the legality of Edward's imposts. The French overlordship had been formally abolished by the treaty of Calais and when Charles V. cited Edward to appear before his *parlement* to answer the complaints of the counts, he was challenging England to renewed war.

Further Renewal of the War.—War, therefore, broke out again in 1369. Edward III. assumed once more the title of king of France, while Charles V. declared that the whole duchy of Aquitaine had been forfeited for treason and rebellion on the part of its present holder. The second period of war, which was to last till the death of the English king, and for some years after, was destined to prove wholly disastrous to England. All the conditions had changed since 1360. Edward, though only in his fifty-seventh year, was entering into a premature old age. The guidance of the war should have fallen into the hands of his eldest son, the victor of Poitiers and Najera, but the younger Edward had never recovered from the fatigues of his Spanish campaign; his disease having developed into a form of dropsy, he had became a confirmed invalid and could no longer take the field. The charge of the military operations of the English armies had passed to John of Gaunt, duke of Lancaster, the king's younger son, whose strategy, in the early years of the renewed war, consisted mainly of attempts to wear down the force of France by devastating raids; he hoped to provoke the enemy to battle by striking at the heart of his realm, but never achieved his purpose. Warned by the disasters of Creçy and Poitiers, Charles V. and his great captain Bertrand du Guesclin would never commit themselves to an engagement in the open field. They let the English invaders pass by, garrisoning the towns but abandoning the countryside. But while the duke was executing useless marches across France, the outlying lands of Aquitaine were falling away, one after the other, to the enemy. The limit of the territory which still remained loyal was ever shrinking, and what was once lost was hardly ever regained. Almost the only reconquest made was that of the city of Limoges, which was stormed in Sept. 1370 by the troops of the Black Prince, who rose from his sick-bed to strike his last blow at the rebels. His success did almost as much harm as good to his cause, for the deliberate sack of the city was carried out with such ruthless severity that it roused wild wrath rather than terror in the neighbouring regions. Next spring the prince returned to England, feeling himself physically unable to administer or defend his duchy any longer.

The greater part of Poitou, Quercy and Rouergue had been lost, and the English cause was everywhere losing ground, when a new danger was developed. Henry of Trastamara, the French ally, had now established himself as king of Castile, and in 1372

a Spanish fleet joined the French, and destroyed off La Rochelle a squadron which was bringing reinforcements for Guienne. From this date onward Franco-Spanish fleets were perpetually to be met not only in the Bay of Biscay but in the Channel; they made the voyage to Bordeaux unsafe, and often executed descents on the shores of Kent, Sussex, Devon and Cornwall. It was to no effect that, in the year after the battle of La Rochelle, Lancaster carried out the last, the most expensive, and the most fruitless of his great raids across France. He marched from Calais to Bordeaux, inflicted great misery on Picardy, Champagne and Berry, and left half his army dead by the way.

This did not prevent Bertrand du Guesclin from expelling from his dominions John of Brittany, the one ally whom King Edward possessed in France, or from pursuing a consistent career of petty conquest in the heart of Aquitaine. By 1374 little was left of the great possessions which the English had held beyond the Channel save Calais, and the coast slip from Bordeaux to Bayonne, which formed the only loyal part of the duchy of Guienne. Next year Edward sued for peace—he failed to obtain it, finding the French terms too hard for acceptance—but a truce at least was signed at Bruges (Jan. 1375) which endured till a few weeks before his death.

In the last two years of the reign interest is once more centred on political issues. The ill success of the French war led to an attack on the king's ministers, and in 1376 the opposition found constitutional expression. In the "Good Parliament" of this year the leading ministers were impeached, a council of twelve peers was created to assist and control the king, and an elaborate programme of reform was set out in a series of petitions. The king himself was too infirm to deal with the situation, but the duke of Lancaster handled it competently on his behalf, and prevented any permanent encroachment on the royal power. The political struggle was complicated by the anti-clerical movement of the time (*see* LOLLARDS); and the duke for a short period allied himself with the critics of the ecclesiastical order and their leader John Wycliffe (*q.v.*) against the churchmen who formed the centre of opposition to the court party. In the middle of the crisis the old king died (June 21, 1377), his successor Richard son of Edward prince of Wales was a child of nine, and a rough balance between the various parties at court was maintained in the council which was appointed to govern England in his name.

Richard II.—The first parliament of Richard met in October under the most gloomy auspices. It showed its temper by taking up the work of the "Good Parliament." Lancaster's adherents were turned out of the council; the persons condemned in 1376 were declared incapable of serving in it, and the little king was made to repudiate the declaration whereby his uncle had quashed the statutes of 1376 by declaring that "no act of parliament can be repealed save with parliament's consent." John of Gaunt bowed before the storm, retired to his estates, and for some time took little part in affairs of State.

Unfortunately the new government proved wholly unable either to conduct the struggle with France successfully or to pluck up courage to make a humiliating peace—the only wise course before them. The nation was too proud to accept defeat, and persevered in the unhappy attempt to reverse the fortunes of war. An almost unbroken series of petty disasters marked the first three years of King Richard. The worst was the failure of the last great devastating raid which the English launched against France. Thomas of Woodstock, the youngest son of Edward III., took a powerful army to Calais, and marched through Picardy and Champagne, past Orleans, and finally to Rennes in Brittany, but accomplished nothing save the ruin of his own troops and the wasting of a vast sum of money. Meanwhile taxation was heavy, the whole nation was seething with discontent, and—what was worse—no way out of the miserable situation was visible; ministers and councillors were repeatedly displaced, but their successors always proved equally incompetent to find a remedy.

The Great Revolt of 1381.—This period of murmuring and misery culminated in the Great Revolt of 1381, a phenomenon whose origins must be sought in the most complicated causes, but whose outbreak was due in the main to a general feeling that the realm was being misgoverned. It was actually provoked by the unwise and unjust poll-tax of one shilling a head on all adult persons, voted by the parliament of Northampton in Nov. 1380. The last poll-tax had been carefully graduated on a sliding scale so as to press lightly on the poorest classes; in this one a shilling for each person had to be exacted from every township, though it was provided that "the strong should help the weak" to a certain extent. But in hundreds of villages there were no "strong" residents, and the poorest cottager had to pay his three groats. The peasantry defended themselves by the simple device of understating the numbers of their families; the returns made it appear that the adult population of England had gone down from 1,355,000 to 896,000 since the poll-tax of 1379. Thereupon the government sent out commissioners to revise the returns and exact the missing shillings. Their appearance led to a series of widespread and preconcerted riots, which soon spread over all England from the Wash to the Channel, and in a few days developed into a formidable rebellion. The poll-tax was no more than the spark which fired the mine; it merely provided a good general grievance on which all malcontents could unite. In the districts which took arms two main causes of insurrection may be differentiated; the first and the most widespread was the discontent of the rural population with the landowners and the Statute of Labourers. Their aim was to abolish all villein-service, and to wring from their lords the commutation of all manorial customs and obligations for a small rent—fourpence an acre was generally the sum suggested. But there was a simultaneous outbreak in many urban districts. In Winchester, London, St. Albans, Canterbury, Bury, Beverley, Scarborough and many other places the rioting was as violent as in the countryside. Here the object of the insurgents was in most cases to break down the local oligarchy, who engrossed all municipal office and oppressed the meaner citizens; but in less numerous instances their end was to win charters from lords (almost always ecclesiastical lords) who had hitherto refused to grant them. But it must not be forgotten that there was also a tinge of purely political discontent about the rising; the insurgents everywhere proclaimed their intention to destroy "traitors," of whom the most generally condemned were the chancellor, Archbishop Sudbury, and the treasurer, Sir Robert Hailes, the two persons most responsible for the levy of the poll-tax. Often the rebels added the name of John of Gaunt to the list, looking upon him as the person ultimately responsible for the mismanagement of the war and the misgovernment of the realm. It must be added that though the leaders of the revolt were for the most part local demagogues, the creatures of the moment, there were among them a few fanatics like the "mad priest of Kent," John Ball, who had long preached socialist doctrines from the old text:

> When Adam delved and Eve span
> Who was then the gentleman?

and clamoured for the abolition of all differences of rank, status and property. Though many clerics were found among the rebels, it does not seem that any of them were Wycliffites, or that the reformer's teaching had played any part in exciting the peasantry at this time. No contemporary authority ascribes the rising to the Lollards.

The riots had begun, almost simultaneously in Kent and Essex: from thence they spread through East Anglia and the home counties. In the west and north there were only isolated and sporadic outbreaks, confined to a few turbulent towns. In the countryside the insurrection was accompanied by wholesale burnings of manor-rolls, the hunting down of unpopular bailiffs and landlords, and a special crusade against the commissioners of the poll-tax and the justices who had been enforcing the Statute of Labourers. There was more arson and blackmailing than murder, though some prominent persons perished, such as the judge, Sir John Cavendish, and the prior of Bury. In many regions the rising was purely disorderly and destitute of organization. This was not, however, the case in Kent and London. The mob which had gathered at Maidstone and Canterbury marched on the capital many thousands strong, headed by a local demagogue named Wat Tyler, whom they had chosen as their captain; his

most prominent lieutenant was the preacher John Ball. They announced their intention of executing all "traitors," seizing the person of the king, and setting up a new government for the realm. The royal council and ministers showed grievous incapacity and cowardice—they made no attempt to raise an army, and opened negotiations with the rebels. While these were in progress the malcontent party in London, headed by three aldermen, opened the gates of the city to Tyler and his horde. They poured in, and, joined by the London mob, sacked John of Gaunt's palace of the Savoy, the Temple, and many other buildings, while the ministers took refuge with the young king in the Tower. It was well known that not only the capital and the neighbouring counties but all eastern England was ablaze, and the council in despair sent out the young king to parley with Tyler at Mile End. The rebels at first demanded no more than that Richard should declare villeinage abolished, and that all feudal dues and services should be commuted for a rent of fourpence an acre. This was readily conceded, and charters were drawn up to that effect and sealed by the king. But, while the meeting was still going on, Tyler went off to the Tower with a part of his horde, entered the fortress unopposed, and murdered the unhappy chancellor, Archbishop Sudbury, the treasurer, and several victims more. This was only the beginning of massacre. Instead of dispersing with their charters, as did many of the peasants, Tyler and his confederates ran riot through London, burning houses and slaying lawyers, officials, foreign merchants and other unpopular persons. This had the effect of frightening the propertied classes in the city, who had hitherto observed a timid neutrality, and turned public opinion against the insurgents. Next day the rebel leaders again invited the king to a conference, in the open space of Smithfield, and laid before him a programme very different from that propounded at Mile End. Tyler demanded that all differences of rank and status should cease, that all church lands should be confiscated and divided up among the laity, that the game laws should be abolished, and that "no lord should any longer hold lordship except civilly." Apparently he was set on provoking a refusal, and thus getting an excuse for seizing the person of the king. But matters went otherwise than he had expected; when he waxed unmannerly, and unsheathed his dagger to strike one of the royal retinue who had dared to answer him back, the mayor of London, William Walworth, drew his cutlass and cut him down. The mob strung their bows, and were about to shoot down the king and his suite. But Richard—who showed astounding nerve and presence of mind for a lad of fourteen—cantered up to them and shouting that he would be their chief and captain and would give them their rights. The conference was continued, but, while it was in progress, the mayor brought up the whole civic militia of London, who had taken arms when they saw that the triumph of the rebels meant anarchy, and rescued the king out of the hands of the mob. Seeing such a formidable body of armed men opposed to them, the insurgents dispersed—without their reckless and ready-witted captain they were helpless (June 15, 1381).

This was the turning-point of the rebellion; within a few days the council had collected a considerable army, which marched through Essex scattering such rebel bands as still held together. Kent was pacified at the same time; and Henry Despenser, the warlike bishop of Norwich, made a separate campaign against the East Anglian insurgents, defeating them at the skirmish of North Walsham, and hanging the local leader Geoffrey Lister, who had declared himself "king of the commons" (June 25, 1381). After this there was nothing remaining save to punish the leaders of the revolt; a good many scores of them were hanged, though the vengeance exacted does not seem to have been greater than was justified by the numerous murders and burnings of which they had been guilty; the fanatic Ball was, of course, among the first to suffer. On Aug. 30, the rough methods of martial law were suspended, and on Dec. 14, the king issued an amnesty to all save certain leaders who had hitherto escaped capture. A parliament had been called in November; it voted that all the charters given by the king at Mile End were null and void, no manumissions or grants of privileges could have been valid without the consent of the estates of the realm, "and for their own parts they would never consent to such, of their own free will nor otherwise, even to save themselves from sudden death."

The rebellion, therefore, had failed either to abolish villeinage in the countryside or to end municipal oligarchy in the towns. Nevertheless serfdom continued to decline all through the latter years of the 14th century, and was growing obsolete in the 15th. This, however, was the result of economic causes and of the establishment of the legal principle which gave the tenant in villeinage security of tenure so long as he performed the services due from his holdings. The course of English social history was little affected by the events of 1381. The manorial system was already doomed, and the rent-paying tenant farmers, who had begun to appear after the Black Death, gradually superseded the villeins as the normal type of peasantry during the two generations that followed the outbreak that is generally known as "Wat Tyler's rebellion."

Richard's Personal Rule.—King Richard, though he had shown such courage and ready resource at Smithfield, was still only a lad of fourteen. The subsequent course of events in his reign was to a great extent determined by his personal character. He was wayward, high-spirited and self-confident. He wished to restore the royal powers which had slipped into the hands of the council and parliament during his minority, and had small doubts of his capacity to restore it. His chosen instruments were two men whom his enemies called his "favourites," though it was absurd to apply the name either to an elderly statesman like Michael de la Pole, who was made chancellor in 1384, or to Robert de Vere, earl of Oxford, a young noble of the oldest lineage, who was the king's other confidant. Neither of them was an upstart, and both, the one from his experience and the other from his high station, were persons who might legitimately aspire to a place among the advisers of the king. But Richard was tactless; he openly flouted his two uncles, John of Gaunt and Thomas of Woodstock, and took no pains to conciliate either the baronage or the commons. His autocratic airs and his ostentatious preference for his confidants—of whom he made the one earl of Suffolk and the other marquess of Dublin—provoked both lords and commons. Pole was impeached on a groundless charge of corruption and condemned, but Richard at once pardoned him and restored him to favour. De Vere was banished to Ireland, but at his master's desire omitted to leave the realm. The contemptuous disregard for the will of parliament which the king displayed brought on him a worse fate than he deserved. His youngest uncle, Thomas of Woodstock, duke of Gloucester, was a designing and ambitious prince who saw his own advantage in embittering the strife between Richard and his parliament. John of Gaunt having departed to Spain, where he was stirring up civil strife in the name of his wife, the heiress of Peter the Cruel, Gloucester put himself at the head of the opposition. Playing the part of the demagogue, and exaggerating all his nephew's petulant acts and sayings, he declared the constitution in danger, and took arms at the head of a party of peers, the earls of Warwick, Arundel and Nottingham, and Henry, earl of Derby, the son of John of Gaunt, who called themselves the lords appellant, because they were ready to "appeal" Richard's councillors of treason. Public opinion was against the king, and the small army which his confidant De Vere raised under the royal banner was easily scattered by Gloucester's forces at the rout of Radcot Bridge (Dec. 20, 1387). Oxford and Suffolk succeeded in escaping to France, but the king and the rest of his adherents fell into the hands of the lords appellant. They threatened for a moment to depose him, but finally placed him under the control of a council and ministers chosen by themselves, and to put him in a proper state of terror, executed Lord Beauchamp, Sir Robert Tressilian the chief justice, and six or seven more of his chief friends. This was a piece of gratuitous cruelty, for the king, though wayward and unwise, had done nothing to justify such treatment.

To the surprise of the nation Richard took his humiliation quietly. But he was merely biding his time; he had sworn revenge in his heart, but he was ready to wait long for it. For the next nine years he appeared an unexceptionable sovereign, anxious only to conciliate the nation and parliament. He got rid of the

ministers imposed upon him by the lords appellant, but replaced them by Bishop Wykeham and other old statesmen against whom no objection could be raised. He disarmed Gloucester by making a close alliance with his elder uncle John of Gaunt, who had been absent in Spain during the troubles of 1387–88, and was displeased at the violent doings of his brother. His rule was mild and moderate, and he succeeded at last in freeing himself from the incubus of the French war—the source of most of the evils of the time, for it was the heavy taxation required to feed this struggle which embittered all the domestic politics of the realm. After two long truces, which filled the years 1390–95, a definitive peace was at last concluded, by which the English king kept Calais and the coast strip of Guienne, from Bordeaux to Bayonne, which had never been lost to the enemy. To confirm the peace, he married Isabella, the young daughter of Charles VI. (Nov. 1396); he had lost his first wife, the excellent Anne of Bohemia, two years before.

Richard and Ireland.—The king seemed firmly seated on his throne—so much so that in 1395 he had found leisure for a long expedition to Ireland, which none of his ancestors had visited since King John. He compelled all the native princes to do him homage, and exercised the royal authority in such a firm manner as had never before been known in the island. But those who looked forward to quiet and prosperous times both for Ireland and for England were destined to be undeceived. In 1397 Richard carried out an extraordinary and unexpected *coup d'état,* which he had evidently premeditated for years. Having lived down his unpopularity, and made himself many powerful friends, he arrested the duke of Gloucester and sent him over to Calais, where he was secretly murdered. At the same time Gloucester's two chief confederates of 1387, the earls of Arundel and Warwick, were sentenced to death: the former was actually executed, the latter imprisoned for life. The other two lords appellant, Mowbray, duke of Norfolk, and Henry of Bolingbroke, the son of John of Gaunt, were dealt with a year later, when Richard used a private quarrel between them as a justification for their banishment.

Arbitrary Rule of Richard.—Having thus completed his vengeance on those who had slain his friends ten years before, Richard felt himself secure. He might have been so, if he had continued to rule as cautiously as during the time when he was nursing his scheme of revenge. But in the last phase of his reign he alarmed the conservative elements in the kingdom by language which implied that he regarded himself as an absolute king, and by the violence of his action. He declared that all pardons issued since 1387 were invalid, and imposed heavy fines on persons, and even on whole shires, that had given the lords appellant aid. He made huge forced loans, and employed recklessly the abuse of purveyance. He browbeat the judges on the bench, and kept many persons under arrest for indefinite periods without a trial. In 1398 he compelled a parliament at Shrewsbury to entrust its powers to a small committee of ten persons, all creatures of his own. This body he used as his instrument of government, treating its assent as equivalent to that of a whole parliament in session. There seemed to be an end to the constitutional liberties of England.

Henry of Bolingbroke Returns to England.—Such violence, however, speedily brought its own punishment. In 1399 Richard sailed over to Ireland to put down a revolt of the native princes, who had defeated and slain the earl of March, his cousin and their lord-lieutenant. While he was absent Henry of Bolingbroke landed at Ravenspur with a small body of exiles and mercenaries. He pretended that he had merely come to claim the estates and title of his father John of Gaunt, who had died a few months before. The adventurer was at once joined by the earl of Northumberland and all the lords of the north; the army which was called out against him refused to fight, and joined his banner, and in a few days he was master of all England (July 1399). King Richard, hurrying back from Ireland, landed at Milford Haven just in time to learn that the levies raised in his name had dispersed or joined the enemy. He deserted his army by night, and fled into the Welsh mountains, apparently with the intention of collecting fresh adherents from North Wales and Cheshire, the only regions where he was popular. But Bolingbroke had already seized Chester, and was marching against him at the head of such a large army that the countryside refused to stir. At last Richard surrendered to his cousin at Flint, on Aug. 19, 1399, having previously stipulated that if he consented to abdicate his life should be spared, his adherents pardoned, and an honourable livelihood assured to him.

Accession of Henry IV.—Richard duly abdicated, and the throne was declared vacant. There was small doubt as to the personality of his successor; possession is nine points of the law, and Henry of Bolingbroke for the moment had the whole nation at his back. His hereditary title indeed was imperfect; though he was the eldest descendant of Edward III. in the male line after Richard, yet there was a whole family which stood between him and the crown. From Lionel of Clarence, the second son of Edward III. (John of Gaunt was only the third) descended the house of March, and the late king had proclaimed that Edmund of March would be his heir if he should die childless. Fortunately for Bolingbroke the young earl was only six years of age; not a voice was raised in his favour in parliament. When Henry stood forward and claimed the vacant throne by right of conquest and also by right of descent, no one gainsaid him. Lords and commons voted that they would have him for their king, and he was duly crowned on Oct. 13, 1399. No faith was kept with the unhappy Richard; he was placed in secret confinement, and denied the ordinary comforts of life. Moreover the adherents for whose safety he had stipulated were at once impeached of treason.

Henry of Lancaster came to the throne, for all intents and purposes as an elective king; he had to depend for the future on his ability to conciliate and satisfy the baronage and the commons by his governance. For by his usurpation he had sanctioned the theory that kings can be deposed for incapacity and maladministration. If he himself should become unpopular, all the arguments that he had employed against Richard might be turned against himself. The prospect was not reassuring; his revenue was small, and parliament would certainly murmur if he tried to increase it. The late king was not without partisans and admirers. There was a considerable chance that the French king might declare war—nominally to avenge his son-in-law, really to win Calais and Bordeaux. Of the partisans who had placed Henry on the throne many were greedy, and some were wholly unreasonable. But he trusted to his tact and his energy, and cheerfully undertook the task of ruling as a constitutional king—the friend of the parliament that had placed him on the throne.

Rebellion of the Earls.—The problem proved more weary and exhausting than he had suspected. From the very first his reign was a time of war, foreign and domestic, of murmuring, and of humiliating shifts and devices. Henry commenced his career by granting the adherents of Richard II. their lives, after they had been first declared guilty of treason and had been deprived of the titles, lands and endowments given them by the late king. Their reply to this very modified show of mercy was to engage in a desperate conspiracy against him. If they had waited till his popularity had waned, they might have had some chance of success, but in anger and resentment they struck too soon. The earls of Kent and Huntingdon, close kinsmen of Richard on his mother's side, the earl of Salisbury—a noted Lollard—and the lords Despenser and Lumley took arms at midwinter (Jan. 4, 1400) and attempted to seize the king at Windsor. They captured the castle, but Henry escaped, raised the levies of London against them, and beat them into the west. Kent and Salisbury were slain at Cirencester, the others captured and executed with many of their followers. Their rebellion sealed the fate of the master in whose cause they had risen. Henry and his counsellors were determined that there should be no further use made of the name of the "lawful king," and Richard was deliberately murdered by privation—insufficient clothing, food and warmth—in his dungeon at Pontefract Castle (Feb. 17, 1400). It is impossible not to pity his fate. He had been wayward, unwise and occasionally revengeful; but his provocation had been great, and if few tyrants have used more violent and offensive language, few have committed such a small list of actual crimes. It was a curious commentary on Hen-

ry's policy, that Richard, even when dead, did not cease to give him trouble. Rumour got abroad, owing to the secrecy of his end, that he was not really dead, and an impostor long lived at the Scottish court who claimed to be the missing king, and was recognized as Richard by many malcontents who wished to be deceived.

Welsh Rising Under Owen Glendower.—The rising of the earls was only the first and least dangerous of the trials of Henry IV. Only a few months after their death a rebellion of a far more formidable sort broke out in Wales—where Richard II. had been popular, and the house of March, his natural heirs, held large estates. The leader was a gentleman named Owen Glendower, who had the blood of the ancient kings of Gwynedd in his veins. Originally he had taken to the hills as a mere outlaw, in consequence of a quarrel with one of the marcher barons; but after many small successes he began to be recognized as a national leader by his countrymen, and proclaimed himself prince of Wales. The king marched against him in person in 1400 and 1401, but Glendower showed himself a master of guerrilla warfare; he refused battle, and defied pursuit in his mountains, till the stores of the English army were exhausted and Henry was forced to retire. His prestige as a general was shaken, and his treasury exhausted by these fruitless irregular campaigns.

War with Scotland.—External troubles continued to multiply during Henry's earlier years. The Scots had declared war, and there was every sign that the French would soon follow suit, for the king's failure to crush Glendower had destroyed his reputation for capacity. The rebel achieved his greatest success in June 1402, when he surprised and routed the whole levy of the marcher lords at Bryn G'las, between Pilleth and Knighton, capturing (among many other prisoners) Sir Edmund Mortimer, the uncle and guardian of the young earl of March, whom all malcontents regarded as the rightful monarch of England. A few months after the king's fortune seemed to take a turn for the better, when the Scots were defeated at Homildon Hill by the earl of Northumberland and his son Henry Percy, the celebrated "Hotspur." But this victory was to be the prelude to new dangers: half the nobility of Scotland had been captured in the battle, and Northumberland intended to fill his coffers with their ransoms; but the king looked upon them as state prisoners and announced his intention of taking them out of the earl's hands. Northumberland was a greedy and unscrupulous Border chief, who regarded himself as entitled to exact whatever he chose from his master, because he had been the first to join him at his landing in 1399, and had lent him a consistent support ever since. He had been amply rewarded by grants of land and money, but was not yet satisfied. In indignation at the first refusal that he had met, the earl conspired with Glendower to raise rebellion in the name of the rightful heirs of King Richard, the house of March. The third party in the plot was Sir Edmund Mortimer, Glendower's captive, who was easily persuaded to join a movement for the aggrandizement of his own family. He married Owen's daughter, and became his trusted lieutenant. Northumberland also enlisted the services of his chief Scottish prisoner, the earl of Douglas, who promised him aid from beyond Tweed.

Insurrection in the North and West.—In July 1403 came the crisis of Henry's reign; while Glendower burst into South Wales, and overran the whole countryside as far as Cardiff and Carmarthen, the Percies raised their banner in the North. The old earl set himself to subdue Yorkshire; his son Hotspur and the earl of Douglas marched south and opened communication with the Welsh. All Cheshire, a district always faithful to the name of Richard II., rose in their favour, and they were joined by Hotspur's uncle, the earl of Worcester. They then advanced towards Shrewsbury, where they hoped that Glendower might meet them. But long ere the Welsh could appear, King Henry was on the spot; he brought the rebels to action at Hately Field, just outside the gates of Shrewsbury, and inflicted on them a complete defeat, in which his young son Henry of Monmouth first won his reputation as a fighting man. Hotspur was slain, Worcester taken and beheaded, Douglas desperately wounded (July 23, 1403). On receiving this disastrous news the earl of Northumberland sued for pardon; the king was unwise enough to grant it, merely punishing him by fining him and taking all his castles out of his hands.

War with France Renewed.—By winning the battle of Shrewsbury Henry IV. had saved his crown, but his troubles were yet far from an end. The long-expected breach with France had at last come to pass; the duke of Orleans, without any declaration of war, had entered Guienne, while a French fleet attacked the south-west of England, and burnt Plymouth. Even more menacing to the king's prosperity was the news that another squadron had appeared off the coast of Wales, and landed stores and succours for Glendower, who had now conquered the whole principality save a few isolated fortresses. The drain of money to meet this combination of foreign war and domestic rebellion was more than the king's exchequer could meet. He was driven into unconstitutional ways of raising money, which recalled all the misdoings of his predecessor. Hence came a series of rancorous quarrels with his parliaments, which grew more disloyal and clamorous at every new session. The cry was raised that the taxes were heavy not because of the French or Welsh wars, but because Henry lavished his money on favourites and unworthy dependents. He was forced to bow before the storm, though the charge had small foundation: the greater part of his household was dismissed, and the war-taxes were paid not to his treasurer but to a financial committee appointed by parliament.

Rising of 1405 in the North.—It was not till 1405 that the worst of Henry's troubles came to an end. This year saw the last of the convulsions that threatened to overturn him,—a rising in the North headed by the old earl of Northumberland, by Richard Scrope, archbishop of York, and by Thomas Mowbray the earl marshal. It might have proved even more dangerous than the rebellion of 1403, if Henry's unscrupulous general Ralph, earl of Westmorland, had not lured Scrope and Mowbray to a conference, and then arrested them under circumstances of the vilest treachery. He handed them over to the king, who beheaded them both outside the gate of York, without any proper trial before their peers. Northumberland thereupon fled to Scotland without further fighting. He remained in exile till January 1408, when he made a final attempt to raise rebellion in the North, and was defeated and slain at the battle of Bramham Moor.

Suppression of the Welsh Rising.—Long before this last-named fight Henry's fortunes had begun to mend. Glendower was at last checked by the king's eldest son, Henry of Monmouth, who had been given charge of the Welsh war. Even when French aid was sent him, the rebel chief proved unable to maintain his grip on South Wales. He was beaten out of it in 1406, and Aberystwyth Castle, where his garrison made a desperate defence for two years, became the southern limit of his dominions. In the end of 1408 Prince Henry captured this place, and six weeks later Harlech, the greatest stronghold of the rebels, where Sir Edmund Mortimer, Owen's son-in-law and most trusted captain, held out till he died of starvation. From this time onwards the Welsh rebellion gradually died down, till Owen relapsed into the position from which he had started, that of a guerrilla chief maintaining a predatory warfare in the mountains. From 1409 onward he ceased to be a public danger to the realm, yet so great was his cunning and activity that he was never caught.

End of the French and Scottish Wars.—The French war died down about the same time that the Welsh rebellion became insignificant. Louis of Orleans, the head of the French war party, was murdered by his cousin John, duke of Burgundy, in November 1407, and after his death the French turned from the struggle with England to indulge in furious civil wars. Calais, Bordeaux and Bayonne still remained safe under the English banner. The Scottish war had ended even earlier. Prince James, the heir of Robert III., had been captured at sea in 1406. From 1408 till his death in 1413 Henry was freed from all the dangers which had beset his earlier years. But from 1409 onwards he became a mere invalid, only able to assert himself in rare intervals of convalescence and the domestic politics of his last five years have little interest or significance.

Accession of Henry V.—On March 20, 1413, his long illness at last reached a fatal issue, and his eldest son ascended the throne.

The new king had everything in his favour; his father had borne the odium of usurpation and fought down the forces of anarchy. The memory of Richard II. had been forgotten; the young earl of March had grown up into the most harmless and unenterprising of men, and the nation seemed satisfied with the new dynasty, whose first sovereign had shown himself, under much provocation, the most moderate and accommodating of constitutional monarchs.

Henry V. on his accession bade farewell to the faults of his youth. He seems to have felt a genuine regret for the unfilial conduct which had vexed his father's last years, and showed a careful determination to turn over a new leaf and give his enemies no scope for criticism. From the first he showed a sober and grave bearing; he reconciled himself to all his enemies, gave up his youthful follies, and became a model king according to the ideas of his day. There is no doubt that he had a strong sense of moral responsibility, and that he was sincerely pious. But his piety inspired him to redouble the persecution of the unfortunate Lollards (*q.v.*) and his sense of moral responsibility did not prevent him from taking the utmost advantage of the civil wars of his unhappy neighbours of France.

Battle of Agincourt.—After preliminary negotiations Henry sailed for France in August 1415, with an army compact but not very numerous. On the eve of his departure he detected and quelled a plot framed by his cousin, Richard, earl of Cambridge, Lord Scrope and Sir Thomas Grey, a kinsman of the Percies. They had planned to raise a rebellion in the name of the earl of March, in whose cause Wales and the North were to have been called to arms. But March himself refused to stir, and betrayed them to the king, who promptly beheaded them, and set sail five days later. He landed near the mouth of the Seine, and commenced his campaign by besieging and capturing Harfleur, which the Orleanists made no attempt to succour. But such a large number of his troops perished in the trenches by a pestilential disorder, that he found himself too weak to march on Paris, and took his way to Calais across Picardy, hoping, as it seems, to lure the French to battle by exposing his small army to attack. The plan was hazardous, for the Orleanists turned out in great numbers and almost cut him off in the marshes of the Somme. When he had struggled across them, and was half-way to Calais, the enemy beset him in the fields of Agincourt (Oct. 25, 1415). Here Henry vindicated his military reputation by winning a victory even more surprising than those of Creçy and Poitiers, for he was outnumbered in an even greater proportion than the two Edwards had been in 1346 and 1356, and had to take the offensive instead of being attacked in a strong position. The heavily armoured French noblesse, embogged in miry meadows, proved helpless before the lightly equipped English archery. The slaughter in their ranks was terrible, and the young duke of Orleans, the head of the predominant faction of the moment, was taken prisoner with many great nobles. However, so exhausted was the victorious army that Henry merely led it back to Calais, without attempting anything more in this year. The sole tangible asset of the campaign was the possession of Harfleur, the gate of Normandy, a second Calais in its advantages when future invasions were taken in hand. The moral effects were more important. The Orleanist party was shaken in its power; the rival Burgundian faction became more inclined to commit itself to the English cause, and the terror of the English arms weighed heavily upon both.

Conquest of Normandy.—In July 1417 Henry began his second invasion of France. He landed at the mouth of the Seine with a powerful army of 17,000 men, and aimed from the first at the steady and gradual conquest of Normandy. This he was able to accomplish without any interference from the government at Paris, for the constable Armagnac, who had succeeded the captive Orleans at the head of the anti-Burgundian party, had no troops to spare. He was engaged in a separate campaign with Henry's ally John the Fearless, and left Normandy to shift for itself. One after another all the towns of the duchy were reduced, save Rouen, the siege of which, as the hardest task, King Henry postponed till the rest of the countryside was in his hands. He sat down to besiege it in 1418, and was detained before its walls for many months, for the citizens made an admirable defence. Meanwhile a change had taken place in the domestic politics of France; the Burgundians seized Paris in May 1418; the constable Armagnac and many of his partisans were massacred, and John the Fearless got possession of the person of the mad Charles VI., and became the responsible ruler of France. He had then to choose between buying off his English allies by great concessions, or taking up the position of champion of French interests. He selected the latter rôle, broke with Henry, and tried to relieve Rouen. But all his efforts were foiled, and the Norman capital surrendered, completely starved out, on Jan. 19, 1419. On this Burgundy resolved to open negotiations with Henry; he wished to free his hands for an attack on his domestic enemies, who had rallied beyond the Loire under the leadership of the dauphin Charles—from whom the party, previously known first as Orleanists and then as Armagnacs, gets for the future the name of the "Dauphinois." The English king, however, seeing the manifest advantage of his position, tried to drive too hard a bargain; he demanded the old boundaries of 1360, with his new conquest of Normandy, the hand of the princess Catherine, and a great sum of ready money. Burgundy dared not concede so much, under pain of alienating all his more patriotic supporters. He broke off the conference of Meulan, and tried to patch up a peace with the dauphin, in order to unite all Frenchmen against the foreign invader. This laudable intention was wrecked by the treachery of the young heir to the French throne; on the bridge of Montereau Charles deliberately murdered the suppliant duke, as he knelt to do homage, thinking thereby that he would make an end of the Burgundian party (Sept. 9, 1419).

Treaty of Troyes.—This abominable deed gave northern France for twenty years to an English master. The young duke of Burgundy, Philip the Good, and his supporters in Paris and the north, were so incensed with the dauphin's cruel treachery that they resolved that he should never inherit his father's crown. They proffered peace to King Henry, and offered to recognize his claim to the French throne, on condition that he should marry the princess Catherine and guarantee the constitutional liberties of the realm. The insane Charles VI. should keep nominal possession of the royal title till his death, but meanwhile the Burgundians would do homage to Henry as "heir of France." These terms were welcomed by the English king, and ratified at the treaty of Troyes (May 21, 1420). Henry married the princess Catherine, received the oaths of Duke Philip and his partisans, and started forth to conquer the Dauphinois at the head of an army of which half was composed of Burgundian levies. Paris, Picardy, Champagne, and indeed the greater part of France north of the Loire, acknowledged him as their sovereign.

Henry had only two years longer to live; they were spent in incessant and successful campaigning against the partisans of his brother-in-law, the dauphin Charles; by a long series of sieges the partisans of that worthless prince were evicted from all their northern strongholds. They fought long and bitterly, nor was this to be marvelled at, for Henry had a custom of executing as traitors all who withstood him, and those who had once defied him did well to fight to the last gasp, in order to avoid the block or the halter. In the longest and most desperate of these sieges, that of Meaux (Oct. 1421–March 1422), the king contracted a dysenteric ailment which he could never shake off. He survived for a few months, but died, worn out by his incessant campaigning, on Aug. 31, 1422, leaving the crown of England and the heirship of France to his only child Henry of Windsor, an infant less than two years old.

Few sovereigns in history have accomplished such a disastrous life's work as this much-admired prince. If he had not been a soldier of the first ability and a diplomatist of the most unscrupulous sort, he could never have advanced so far towards his ill-chosen goal, the conquest of France. His genius and the dauphin's murderous act of folly at Montereau conspired to make the incredible almost possible. Indeed, if Henry had lived five years longer, he would probably have carried his arms to the Mediterranean, and have united France and England in uneasy union for some short space of time. It is clear that they could not have been held together after his death, for none but a king of exceptional

powers could have resisted their natural impulse to break apart. As it was, Henry had accomplished just enough to tempt his countrymen to persevere for nearly thirty years in the endeavour to complete the task he had begun. France was ruined for a generation, England was exhausted by her effort, and (what was worse) her governing classes learnt in the long and pitiless war lessons of demoralization which were to bear fruit in the ensuing struggle of the two Roses.

Henry VI.—The guardianship of the infant Henry VI. fell to his two uncles, John of Bedford and Humphrey of Gloucester, the two surviving brothers of the late king. Bedford became regent in France, and took over the heritage of the war, in which he was vigorously aided by the young Philip of Burgundy, whose sister he soon after married. Almost his first duty was to bury the insane Charles VI., who only survived his son-in-law for a few months, and to proclaim his little nephew king of France under the name of Henry II. Gloucester, however, had personal charge of the child, who was to be reared in England; he had also hoped to become protector of the realm, and to use the position for his own private interests, for he was a selfish and ambitious prince. But the council refused to let him assume the full powers of a regent, and bound him with many checks and restrictions, because they were well aware of his character. The tiresome and monotonous domestic history of England during the next twenty years consisted of little else than quarrels between Gloucester and the lords of the council, of whom the chief was the duke's half-uncle Henry Beaufort, bishop of Winchester, the last to survive of all the sons of John of Gaunt. The duke and the bishop were both unscrupulous; but the churchman, with all his faults, was a patriotic statesman, while Gloucester cared far more for his own private ends than for the welfare of the realm.

Bedford's Rule in France.—Meanwhile Bedford, a capable general and a wise administrator, was doing his best to carry out the task which the dying Henry V. had laid upon him, by crushing the dauphin, or Charles VII. as he now called himself since his father's death. As long as the Burgundian party lent the regent their aid, the limits of the land still unsubdued continued to shrink, though the process was slow. Two considerable victories, Cravant (1423) and Verneuil (1424), marked the early years of Bedford's campaigning; at each, it may be noted, a very large proportion of his army was composed of Burgundian auxiliaries. The alliance was threatened by the reckless marriage of Gloucester with Jacqueline, the heiress of Hainault (*q.v.*) whose lands were needed for the rounding off of the Burgundian territories. But Bedford was able to pacify the duke by disassociating himself from his brother's schemes, and the alliance was maintained until the English position in France had been radically altered by the French revival which followed the appearance of Joan of Arc.

Her brief career belongs to French rather than to English history. But it affected the whole future of the war. With the relief of Orleans (1429) the tide turned, and the English began to lose their hold upon the north of France. French victories at Jarqeau and Beaugency (1429) were early signs of the change, and the coronation of Charles VII. was a direct challenge to the French supporters of Henry VI. The movement was not seriously checked by the capture of Joan by the Burgundian allies of England in 1430, and a final English victory became impossible when the duke of Burgundy in 1435 made terms with Charles VII. by the treaty of Arras.

Truce with France.—Bedford died at Rouen immediately afterward, and with him died the best hope of the English party in France, for he had been well loved by the Burgundians, and many had adhered to the cause of Henry VI. solely because of their personal attachment to him. Yet the next eight years of the war were in some respects the most astonishing period of its interminable length. The English fought out the losing game with a wonderful obstinacy. Though every town that they held was eager to revolt, and though they were hopelessly outnumbered in every quarter, they kept a tight grip on the greater part of Normandy, and on their old domain in the Bordelais and about Bayonne. They lost nearly all their outlying possessions, but still made head against the generals of Charles VII. in these two regions. The leaders of this period of the war were the duke of York, and the aged Lord Talbot, afterwards earl of Shrewsbury. The struggle only ceased in 1444, when the English council, in which a peace party had at last been formed, concluded a two-year truce with King Charles, which they hoped to turn into a permanent treaty, on the condition that their king should retain what he held in Normandy and Guienne, but sign away his claim to the French crown, and relinquish the few places outside the two duchies which were still in his power. To mark the reconciliation of the two powers Henry VI. was betrothed to the French king's niece, Margaret of Anjou. The two years' truce was repeatedly prorogued, and lasted till 1449, but no definitive treaty was ever concluded, owing to the bad faith with which both parties kept their promises.

Supremacy of the Beauforts in England.—The government in England was now in the hands of the faction which Bishop Beaufort had originally led, for after long struggles the churchman had at last crushed his nephew Humphrey. King Henry, though he had reached the age of 23 at the time of his marriage, counted for nothing. He was a pious young man, simple to the verge of imbecility; a little later he developed actual insanity, the heritage of his grandfather Charles VI. His wife Margaret of Anjou, though she possessed all the fire and energy which her husband lacked, was equally devoted to these two ministers, and soon came to share their unpopularity.

The truce with France had offended the natural pride of the nation, which still refused to own itself beaten. The evacuation of the French fortresses in Maine and elsewhere, which was the price paid for the suspension of arms, was bitterly resented. Indeed the garrisons had to be threatened with the use of force before they would quit their strongholds. A violent clamour was raised against the ministers responsible for the truce, the dukes of Suffolk and Somerset, and the duke of Gloucester emerged from his retirement to head the agitation. But he was arrested by the order of the queen and the ministers at the parliament of Bury, and five days later he died suddenly in prison. Six weeks afterwards the death of Bishop Henry Beaufort removed the last important survivor from the generation of Henry V. The truce with France lasted two years after the death of Duke Humphrey. In July 1449 the French king invaded Normandy, and in a few months the duchy was lost. The final blow came when a small army of relief sent over from England was absolutely exterminated by the French at the battle of Formigny (April 15, 1450). Somerset, who had retired into Caen, surrendered two months later after a feeble defence, and the English power in northern France came to an end.

Jack Cade's Rebellion.—Even before this final disaster the indignation felt against Suffolk and Somerset had raised violent disturbances at home. Suffolk was impeached, and although allowed to sail for France before his trial, he was intercepted and murdered on the sea. But, though Suffolk was gone, Somerset yet survived, and their partisans still engrossed the confidence of the king. To clear out the government, and punish those responsible for the late disasters, the commons of Kent rose in insurrection under a captain who called himself John Mortimer, though his real name seems to have been John Cade. He was a soldier of fortune who had served in the French wars, and claimed to be in the confidence of the duke of York, the person to whom the eyes of all who hated Somerset and the present régime were now directed.

Cade was not a social reformer, like his predecessor Wat Tyler, with whom he has often been compared, but a politician. Though he called himself "John Amend-all," and promised to put down abuses of every kind, the main part of the programme which he issued was intended to appeal to national sentiment, not to class feeling. Whether he was the tool of other and more highly placed malcontents, or whether he was simply a ready-witted adventurer playing his own game, it is hard to determine. His first success was marvellous; he defeated the king's troops, made a triumphant entry into London and held the city for two days. He beheaded Lord Saye, the treasurer, and several other unpopular persons, and might have continued his dictatorship for some time if the Kentish mob that followed him had not fallen to general

pillage and arson. This led to the same results that had been seen in Tyler's day. The propertied classes in London took arms to suppress anarchy, and beat the insurgents out of the city. Cade, striving to keep up the rising outside the walls, was killed in a skirmish a month later and his bands dispersed.

Richard, Duke of York, Heads the Opposition.—But the troubles of England were only just beginning; the protest against the misgovernment of Somerset and the rest of the confidants of the king and queen was now taken up by a more important personage than the adventurer Cade. Richard, duke of York, the heir to the claims of the house of Mortimer—his mother was the sister of the last earl of March—now placed himself at the head of the opposition. He had plausible grounds for doing so; though he had distinguished himself in the French wars, and was, since the death of Humphrey of Gloucester, the first prince of the blood royal, he had been ignored and flouted by the king's ministers, who had sent him into a kind of honourable banishment as lord-lieutenant of Ireland, and had forbidden him to re-enter the realm. When, in defiance of this mandate, he came home and announced his intention of impeaching Somerset, he took the first step which was to lead to the Wars of the Roses.

Yet he was a cautious and in the main a well-intentioned prince, and the extreme moderation of his original demands seems to prove that he did not at first aim at the crown. He merely required that Somerset and his friends should be dismissed from office and made to answer for their misgovernment. Though he backed his demands by armed demonstration—twice calling out his friends and retainers to support his policy—he carefully refrained for five long years from actual violence. Indeed in 1452 he consented to abandon his protests, and to lend his aid to the other party for a great national object, the recovery of Guienne. For a moment the quarrel of York and Somerset was suspended, and the last English army that crossed the seas during the Hundred Years' War landed in Guienne, and for a time swept all before it. But on July 17, 1453 the veteran earl of Shrewsbury and the greater part of his Anglo-Gascon host were cut to pieces at the hard-fought battle of Castillon. Bordeaux, though left to defend itself, held out for eighty days after Talbot's defeat and death, and then made its final submission to the French. The long struggle was over, and England now retained nothing of her old transmarine possessions save Calais and the Channel Islands. The ambition of Henry V. had finally cost her the long-loyal Guienne, as well as all the ephemeral conquests of his own sword.

The last crowning disaster of the administration of the favourites of Henry VI. put an end to the chance that a way out of domestic strife might be found in the vigorous prosecution of the French war. For the next twenty years the battles of England were to be fought on her own soil, and between her own sons. It was a righteous punishment for her interference in the unnatural strife of Orleanists and Burgundians that the struggle between York and Lancaster was to be as bitter and as bloody as that between the two French factions.

V. THE WARS OF THE ROSES (1453–97)

The Wars of the Roses have been ascribed to many different causes by different historians. To some their origin is mainly constitutional. It is argued that the question of the succession was raised because the king persisted in retaining as his ministers men, such as the duke of Somerset, whom the nation considered responsible for the failure of the French war. To others, the key of the problem is the question of the succession itself. The hereditary claim of Richard duke of York became important when the failure of the French war had discredited the Lancastrian dynasty. From yet a third standpoint, the Wars of the Roses were essentially a fight between two powerful groups of baronial allies. It is at least certain that Richard of York was not merely the head of a constitutional opposition, nor was he merely a legitimist claimant to the crown; he was also the head of a powerful baronial league, of which the most prominent members were his kinsmen, the Nevilles, Mowbrays and Bourchiers. The Nevilles alone, enriched with the ancient estates of the Beauchamps and Montagus, and with five of their name in the House of Lords, were a sufficient nucleus for a faction. They were headed by the two most capable politicians and soldiers then alive in England, the two Richards, father and son, who held the earldoms of Salisbury and Warwick, and were respectively brother-in-law and nephew to York. It must be remembered that a baron of 1450 was not strong merely by reason of the spears and bows of his household and his tenantry, like a baron of the 13th century. The pernicious practice of "livery and maintenance" was now at its zenith; all over England in times of stress the knighthood and gentry were wont to pledge themselves, by sealed bonds of indenture, to follow the magnate whom they thought best able to protect them. A soldier and statesman of the ability and ambition of Richard of Warwick counted hundreds of such adherents, scattered over twenty shires. An alliance of half-a-dozen of these over-powerful subjects was a serious danger to the crown, for the king could no longer count on raising a national army against them.

Defeat of the Lancastrians at Northampton.—Despite all this, there was still, when the wars began, a very strong feeling in favour of compromise and moderation. For this there can be no doubt that Richard of York was mainly responsible. When he was twice placed in power, during the two protectorates which followed Henry's two long fits of insanity in 1454 and 1455–56, he carefully avoided any oppression of his enemies, though he naturally took care to put his own friends in office. Most of all did he show his sincere wish for peace by twice laying down the protectorate when the king was restored to sanity. He was undoubtedly goaded into his last rebellion of 1459 by the queen's undisguised preparations for attacking him. Yet because he struck first, without waiting for a definite *casus belli,* public opinion declared so much against him that half his followers refused to rally to his banner. The revulsion only came when the queen, victorious after the rout of Ludford, applied to the vanquished Yorkists those penalties of confiscation and attainder which Duke Richard had always refused to employ in his day of power. After the harsh doings at the parliament of Coventry (1459), and the commencement of political executions by the sending of Roger Neville and his fellows to the scaffold, the trend of public opinion veered round, and Margaret and her friends were rightly held responsible for the embittered nature of the strife. Hence came the marvellous success of the Yorkist counterstroke in June 1460, when the exiled Warwick, landing in Kent with a mere handful of men, was suddenly joined by the whole of the south of England and the citizens of London, and inflicted a crushing defeat on the Lancastrians at Northampton before he had been fifteen days on shore (July 10, 1460). The growing rancour of the struggle was marked by the fact that the Yorkists, after Northampton, showed themselves by no means so scrupulous as in their earlier days. Retaliatory executions began, though on a small scale, and when York reached London he at last began to talk of his rights to the crown, and to propose the deposition of Henry VI. Yet moderation was still so far prevalent in the ranks of his adherents that they refused to follow him to such lengths. Warwick and the other leading men of the party dictated a compromise, by which Henry was to reign for the term of his natural life, but Duke Richard was to be recognized as his heir and to succeed him on the throne. They had obviously borrowed the expedient from the terms of the treaty of Troyes. But the act of parliament which embodied it did not formally disinherit the reigning king's son, as the treaty of Troyes had done, but merely ignored his existence.

Battle of Wakefield. Richard of York Slain.—It would have been well for England if this agreement had held, and the crown had passed peaceably to the house of York, after the comparatively short and bloodless struggle which had just ended. But Duke Richard had forgotten to reckon with the fierce and unscrupulous energy of Queen Margaret, when she was at bay in defence of her son's rights. Marching with a trifling force to expel her from the north, he was surprised and slain at Wakefield (Dec. 30, 1460). But it was not his death that was the main misfortune, but the fact that in the battle the Lancastrians gave no quarter to small or great, and that after it they put to death

York's brother-in-law Salisbury and other prisoners. The heads of the duke and the earl were set up over the gates of York. This ferocity was repeated when Margaret and her northern host beat Warwick at the second battle of St. Albans (Feb. 17, 1461), where they had the good fortune to recover possession of the person of King Henry. Lord Bonville and the other captives of rank were beheaded next morning.

Edward, Earl of March, Proclaimed as Edward IV.—After this it was but natural that the struggle became a mere record of massacres and executions. The Yorkists proclaimed Edward, Duke Richard's heir, king of England; they took no further heed of the claims of King Henry, declared their leader the true successor of Richard II., and stigmatized the whole period of the Lancastrian rule as a mere usurpation. They adopted a strict legitimist theory of the descent of the crown, and denied the right of parliament to deal with the succession. This was the first step in the direction of absolute monarchy which England had seen since the short months of King Richard's tyranny in 1397–99. It was but the first of many encroachments of the new dynasty upon the liberties that had been enjoyed by the nation under the house of Lancaster.

The revenge taken by the new king and his cousin Richard of Warwick for the slaughter at Wakefield and St. Albans was prompt and dreadful. They were now well supported by the whole of southern England; for not only had the queen's ferocity shocked the nation, but the reckless plundering of her northern moss-troopers in the home counties had roused the peasantry and townsfolk to an interest in the struggle which they had never before displayed. Up to this moment the civil war had been conducted like a great faction fight; the barons and their liveried retainers had been wont to seek some convenient heath or hill and there to fight out their quarrel with the minimum of damage to the countryside. The deliberate harrying of the Midlands by Margaret's northern levies was a new departure, and one bitterly resented. The Yorkist army that marched in pursuit of the raiders, and won the bloody field of Towton under Warwick's guidance, gave no quarter. Not only was the slaughter in that battle and the pursuit more cruel than anything that had been seen since the day of Evesham, but the executions that followed were ruthless. Ere Edward turned south he had beheaded two earls—Devon and Wiltshire—and forty-two knights, and had hanged many prisoners of lesser estate. The Yorkist parliament of November 1461 carried on the work by attainting 133 persons, ranging from Henry VI. and Queen Margaret down through the peerage and the knighthood to the clerks and household retainers of the late king. All the estates of the Lancastrian lords, living or dead, were confiscated, and their blood was declared corrupted. This brought into the king's hands such a mass of plunder as no one had handled since William the Conqueror. Edward IV. could not only reward his adherents with it, so as to create a whole new court *noblesse*, but had enough over to fill his exchequer for many years, and to enable him to dispense with parliamentary grants of money for an unexampled period. Between 1461 and 1465 he asked for only £37,000 from the nation—and won no small popularity thereby. For, in their joy at being quit of taxation, men forgot that they were losing the lever by which their fathers had been wont to move the crown to constitutional concessions.

Civil War in the North and West.—After Towton peace prevailed south of the Tyne and east of the Severn, for it was only in Northumberland and in Wales that the survivors of the Lancastrian faction succeeded in keeping the war alive. King Edward, as indolent and pleasure-loving in times of ease as he was active and ruthless in times of stress and battle, set himself to enjoy life, handing over the suppression of the rebels to his ambitious and untiring cousin Richard of Warwick. The annals of the few contemporary chroniclers are so entirely devoted to the bickerings in the extreme north and west, that it is necessary to insist on the fact that from 1461 onwards the civil war was purely local. The campaigns of 1462–63–64, though full of incident and bloodshed, were not of first-rate political importance. The cause of Lancaster had been lost at Towton, and all that Queen Margaret succeeded in accomplishing was to keep Northumberland in revolt, mainly by means of French and Scottish succours. Her last English partisans, attainted men who had lost their lands and lived with the shadow of the axe ever before them, fought bitterly enough. But the obstinate and hard-handed Warwick beat them down again and again, and the old Lancastrian party was almost exterminated when the last of its chiefs went to the block in the series of wholesale executions that followed the battle of Hexham (May 15, 1464). A year later Henry VI. himself fell into the hands of his enemies, as he lurked in Lancashire, and with his consignment to the Tower the dynastic question seemed finally solved in favour of the house of York.

Richard Neville, Earl of Warwick.—The first ten years of the reign of Edward IV. fall into two parts, the dividing point being the avowal of the king's marriage to Elizabeth Woodville in November 1464. During the first of these periods Edward reigned but Warwick governed; he was not only the fighting man, but the statesman and diplomatist of the Yorkist party, and enjoyed a complete ascendancy over his young master, who long preferred thriftless ease to the toils of personal monarchy. Warwick represented the better side of the victorious cause; he was no mere factious king-maker, and his later nickname of "the last of the barons" by no means expresses his character or his position. He was strong, not so much by reason of his vast estates and his numerous retainers, as by reason of the confidence which the greater part of the nation placed in him. He never forgot that the Yorkist party had started as the advocates of sound and strong administration, and the mandatories of the popular will against the queen's incapable and corrupt ministers. "He ever had the goodwill of the people because he knew how to give them fair words, and always spoke not of himself but of the augmentation and good governance of the kingdom, for which he would spend his life; and thus he had the goodwill of England, so that in all the land he was the lord who was held in most esteem and faith and credence." As long as he remained supreme, parliaments were regularly held, and the house of York appeared to be keeping its bargain with the nation. His policy was sound; peace with France, the rehabilitation of the dwindling foreign trade of England, and the maintenance of law and justice by strong-handed governance were his main aims.

But Warwick was one of those ministers who love to do everything for themselves, and chafe at masters and colleagues who presume to check or to criticize their actions. He was surrounded and supported, moreover, by a group of brothers and cousins, to whom he gave most of his confidence, and most of the preferment that came to his hands. England has always chafed against a family oligarchy, however well it may do its work. The Yorkist magnates who did not belong to the clan of the Nevilles were not unnaturally jealous of that house, and Edward IV. himself gradually came to realize the ignominious position of a king who is managed and overruled by a strong-willed and arbitrary minister.

Breach Between Warwick and the King.—His first sign of revolt was his secret marriage to Elizabeth Woodville, a lady of decidedly Lancastrian connections, for her father and her first husband were both members of the defeated faction. Warwick was at the moment suing for the hand of Louis XI.'s sister-in-law in his master's name, and had to back out of his negotiations in a sudden and somewhat ridiculous fashion. His pride was hurt, but for two years more there was no open breach between him and his master, though their estrangement grew more and more marked when Edward continued to heap titles and estates on his wife's numerous relatives, and to conclude for them marriage alliances with all the great Yorkist families who were not of the Neville connection. In this way he built up for himself a personal following within the Yorkist party; but the relative strength of this faction and of that which still looked upon Warwick as the true representative of the cause had yet to be tried. The king had in his favour the prestige of the royal name, and a popularity won by his easy-going affability and his liberal gifts. The earl had his established reputation for disinterested devotion to the welfare of the realm, and his brilliant record as a soldier and statesman. In districts as far apart as Kent and Yorkshire, his word counted for a good deal more than that of his sovereign.

Warwick Organizes a Rebellion.—Unhappily for England and for himself, Warwick's loyalty was not sufficient to restrain his ambition and his resentment. He felt the ingratitude of the king, whom he had made, so bitterly that he stooped ere long to intrigue and treason. Edward in 1467 openly broke with him by dismissing his brother George Neville from the chancellorship, by repudiating a treaty with France which the earl had just negotiated, and by concluding an alliance with Burgundy against which he had always protested. Warwick enlisted in his cause the king's younger brother George of Clarence, who desired to marry his daughter and heiress Isabella Neville, and with the aid of this unscrupulous but unstable young man began to organize rebellion. His first experiment in treason was the so-called "rising of Robin of Redesdale," which was ostensibly an armed protest by the gentry and commons of Yorkshire against the maladministration of the realm by the king's favourites—his wife's relatives, and the courtiers whom he had lately promoted to high rank and office. The rebellion was headed by well-known adherents of the earl, and the nickname of "Robin of Redesdale" seems to have covered the personality of his kinsman Sir John Conyers. When the rising was well started Warwick declared his sympathy with the aims of the insurgents, wedded his daughter to Clarence despite the king's prohibition of the match, and raised a force at Calais with which he landed in Kent.

But his plot was already successful before he reached the scene of operations. The Yorkshire rebels beat the royalist army at the battle of Edgecott (July 6, 1469). A few days later Edward himself was captured at Olney and put into the earl's hands. Many of his chief supporters, including the queen's father, Lord Rivers, and her brother, John Woodville, as well as the newly-created earls of Pembroke and Devon, were put to death with Warwick's connivance, if not by his direct orders. The king was confined for some weeks in the great Neville stronghold of Middleham Castle, but presently released on conditions, being compelled to accept new ministers nominated by Warwick. The earl supposed that his cousin's spirit was broken and that he would give no further trouble. In this he erred grievously. Edward vowed revenge for his slaughtered favourites, and waited his opportunity. Warwick had lost credit by using such underhand methods in his attack on his master, and had not taken sufficient care to conciliate public opinion when he reconstructed the government. His conduct had destroyed his old reputation for disinterestedness and honesty.

Warwick in Exile Takes Up the Cause of Henry VI.—In March 1470 the king seized the first chance of avenging himself. Some unimportant riots had broken out in Lincolnshire, originating probably in mere local quarrels, but possibly in Lancastrian intrigues. To suppress this rising the king gathered a great force, carefully calling in to his banner all the peers who were offended with Warwick or, at any rate, did not belong to his family alliance. Having scattered the Lincolnshire bands, he suddenly turned upon Warwick with his army, and caught him wholly unprepared. The earl and his son-in-law Clarence were hunted out of the realm before they could collect their partisans, and fled to France: Edward seemed for the first time to be master in his own realm.

But the Wars of the Roses had one more phase to come. Warwick's name was still a power in the land, and his expulsion had been so sudden that he had not been given an opportunity of trying his strength. His old enmity for the house of Lancaster was completely swallowed up in his new grudge against the king whom he had made. He opened negotiations with the exiled Queen Margaret, and offered to place his sword at her disposition for the purpose of overthrowing King Edward and restoring King Henry. The queen had much difficulty in forcing herself to come to terms with the man who had been the bane of her cause, but finally, was induced by Louis XI. to conclude a bargain. Warwick married his younger daughter to her son Edward, prince of Wales, as a pledge of his good faith, and swore allegiance to King Henry in the cathedral of Angers. He then set himself to stir up the Yorkshire adherents of the house of Neville to distract the attention of Edward IV. When the king had gone northward to attack them, the earl landed at Dartmouth (Sept. 1470) with a small force partly composed of Lancastrian exiles, partly of his own men. His appearance had the effect on which he had calculated. Devon rose in the Lancastrian interest; Kent, where the earl's name had always been popular, took arms a few days later; and London opened its gates. King Edward, hurrying south to oppose the invader, found his army melting away from his banner, and hastily took ship at Lynn and fled to Holland. He found a refuge with his brother-in-law and ally, Charles the Bold, the great duke of Burgundy.

Restoration of Henry VI.—King Henry was released and replaced on the throne, and for six months Warwick ruled England as his lieutenant. But there was bitterness and mistrust between the old Lancastrian faction and the Nevilles, and Queen Margaret refused to cross to England or to trust her son in the king-maker's hands. Her partisans doubted his sincerity, while many of the Yorkists who had hitherto followed Warwick in blind admiration found it impossible to reconcile themselves to the new régime. The duke of Clarence in particular, discontented at the triumph of Lancaster, betrayed his father-in-law, and opened secret negotiations with his exiled brother. Encouraged by the news of the dissensions among his enemies, Edward IV. resolved to try his fortune once more, and landed near Hull on March 15, 1471 with a body of mercenaries lent him by the duke of Burgundy.

Battle of Barnet. Death of Warwick.—The campaign that followed was most creditable to Edward's generalship, but must have been fatal to him if Warwick had been honestly supported by his lieutenants. But the duke of Clarence betrayed to his brother the army which had gathered in King Henry's name, and many of the Lancastrians were slow to join the earl, from their distrust of his loyalty. Edward, dashing through the midst of the slowly gathering levies of his opponents, seized London, and two days later defeated and slew Warwick at the battle of Barnet (April 13, 1471).

Battle of Tewkesbury. Death of Edward, Prince of Wales and Murder of Henry VI.—On the same day Queen Margaret and her son landed at Weymouth, only to hear that the earl was dead and his army scattered. But she refused to consider the struggle ended, and gathered the Lancastrians of the west for a final rally. On the fatal day of Tewkesbury (May 3, 1471) her army was beaten, her son was slain in the flight, and the greater part of her chief captains were taken prisoners. She herself was captured next day. The victorious Edward sent to the block the last Beaufort duke of Somerset, and nearly all the other captains of rank, whether Lancastrians or followers of Warwick. He then moved to London, which was being threatened by Kentish levies raised in Warwick's name, delivered the city, and next day caused the unhappy Henry VI. to be murdered in the Tower (May 21, 1471).

The Reign of Edward IV.—The descendants of Henry IV. were now extinct, and the succession question seemed settled for ever. No one dreamed of raising against King Edward the claims of the remoter heirs of John of Gaunt—the young earl of Richmond, who represented the Beauforts by a female descent, or the king of Portugal, the grandson of Gaunt's eldest daughter. Edward was now king indeed, with no over-powerful cousin at his elbow to curb his will. He had, moreover, at his disposal plunder almost as valuable as that which he had divided up in 1461—the estates of the great Neville clan and their adherents. A great career seemed open before him; he had proved himself a fine soldier and an unscrupulous diplomatist; he was in the very prime of life, having not yet attained his thirty-first year. He might have devoted himself to foreign politics and have rivalled the exploits of Edward III. or Henry V.—for the state of the continent was all in his favour—or might have set himself to organize an absolute monarchy on the ruins of the parliament and the baronage. For the successive attainders of the Lancastrians and the Nevilles had swept away many of the older noble families, and Edward's house of peers consisted for the main part of new men, his own partisans promoted for good service, who had not the grip on the land that their predecessors had possessed.

But Edward either failed to see his opportunity or refused to

take it. He did not plunge headlong into the wars of Louis XI. and Charles of Burgundy, nor did he attempt to recast the institutions of the realm. He settled down into inglorious ease, varied at long intervals by outbursts of spasmodic tyranny. It would seem that the key to his conduct was that he hated the hard work without which a despotic king cannot hope to assert his personality, and preferred leisure and vicious self-indulgence. In many ways the later years of his reign were marked with all the signs of absolutism. Between 1475 and 1483 he called only one single parliament, and that was summoned not to give him advice, or to raise him money, but purely and solely to attaint his brother Clarence, whom he had resolved to destroy. The duke's fate (Feb. 17, 1478) need provoke no sympathy; he was a detestable intriguer, and had given his brother just offence by a series of deeds of high-handed violence and by perpetual cavilling. But he had committed no act of real treason since his long-pardoned alliance with Warwick, and was not in any way dangerous; so that when the king caused him to be attainted, and then privately murdered in the Tower, there was little justification for the fratricide.

Edward was a thrifty king; he was indeed the only mediaeval monarch of England who succeeded in keeping free of debt and made his revenue suffice for his expenses. But his methods of filling his purse were often unconstitutional and sometimes ignominious. When the resources drawn from confiscations were exhausted, he raised "benevolences"—forced gifts extracted from men of wealth by the unspoken threat of the royal displeasure—instead of applying to parliament for new taxes. But his most profitable source of revenue was drawn from abroad. Having allied himself with his brother-in-law Charles of Burgundy against the king of France, he led an army into Picardy in 1475, and then by the treaty of Picquigny sold peace to Louis XI. for 75,000 gold crowns down, and an annual pension (or tribute as he preferred to call it) of 50,000 crowns more. It was regularly paid up to the last year of his reign. Charles the Bold, whom he had thus deliberately deserted in the middle of their joint campaign, used the strongest language about this mean act of treachery, and with good cause. But the king cared not when his pockets were full. Another device of Edward for filling his exchequer was a very stringent enforcement of justice; small infractions of the laws being made the excuse for exorbitant fines. This was a trick which Henry VII. was to turn to still greater effect. In defence of both it may be pleaded that after the anarchy of the Wars of the Roses a strong hand was needed to restore security for life and property, and that it was better that penalties should be over-heavy rather than that there should be no penalties at all. Another appreciable source of revenue to Edward was his private commercial ventures. He owned many ships, and traded with great profit to himself abroad, because he could promise, as a king, advantages to foreign buyers and sellers with which no mere merchant could compete.

During the last period of Edward's rule England might have been described as a despotism, if only the king had cared to be a despot. But except on rare occasions he allowed his power to be disguised under the old machinery of the mediaeval monarchy, and made no parade of his autocracy. Much was pardoned by the nation to one who gave them comparatively efficient and rather cheap government, and who was personally easy of access, affable and humorous. It is with little justification that he has been called the "founder of the new monarchy," and the spiritual ancestor of the Tudor despotism. Another king in his place might have merited such titles, but Edward was too careless, too unsystematic, too lazy, and too fond of self-indulgence to make a real tyrant. He preferred to be a man of pleasure and leisure, only awaking now and then to perpetrate some act of arbitrary cruelty.

Richard, Duke of Gloucester.—The uneventful latter half of the reign of Edward IV. ended with his death at the age of forty-one on April 9, 1483. He had ruined a splendid constitution by the combination of sloth and evil living. Since Clarence's death he had been gradually falling into the habit of transferring the conduct of great matters of State to his active and hard-working youngest brother, Richard, duke of Gloucester, who had served him well and faithfully ever since he first took the field at Barnet. Gloucester passed as a staid and religious prince, and if there was blood on his hands, the same could be said of every statesman of his time. His sudden plunge into crime and usurpation after his brother's death was wholly unexpected by the nation. Indeed it was his previous reputation for loyalty and moderation which made his scandalous *coup d'état* of 1483 possible. No prince with a sinister reputation would have had the chance of executing the series of crimes which placed him on the throne. But when Richard declared that he was the victim of plots and intrigues, and was striking down his enemies only to defend his own life and honour, he was for some time believed.

At the moment of King Edward's death his elder son by Elizabeth Woodville, Edward, prince of Wales, was twelve; his younger son Richard, duke of York, was nine. It was clear that there would be a long minority, and that the only possible claimants for the regency were the queen and Richard of Gloucester. Elizabeth was personally unpopular, and the rapacity and insolence of her family was well known. Hence when Richard of Gloucester seized on the person of the young king, and imprisoned Lord Rivers and Sir Richard Grey, the queen's brother and son, on the pretence that they were conspiring against him, his action was regarded with equanimity by the people. Nor did the fact that the duke took the title of "protector and defender of the realm" cause any surprise. Suspicions only became rife after Richard had seized and beheaded without any trial, Lord Hastings, the late king's most familiar friend, and had arrested at the same moment the archbishop of York, Morton, bishop of Ely, and Lord Stanley, all persons of unimpeachable loyalty to the house of Edward IV. It was not plausible to accuse such persons of plotting with the queen to overthrow the protector, and public opinion began to turn against Gloucester. Nevertheless he went on recklessly with his design, having already enlisted the support of a party of the greater peers, who were ready to follow him to any length of treason. These confidants, the duke of Buckingham, the lords Howard and Lovel, and a few more, must have known from an early date that he was aiming at the crown, though it is improbable that they suspected that his plan involved the murder of the rightful heirs as well as mere usurpation.

Richard III. Crowned.—On June 16, Richard, using the aged archbishop Bourchier as his tool, got the little duke of York out of his mother's hands, and sent him to join his brother in the Tower. A few days later, having packed London with his own armed retainers and those of Buckingham and his other confidants, he openly put forward his pretensions to the throne. Edward IV., as he asserted, had been privately contracted to Lady Eleanor Talbot before he ever met Queen Elizabeth. His children therefore were bastards, the offspring of a bigamous union. As to the son and daughter of the duke of Clarence, their blood had been corrupted by their father's attainder, and they could not be reckoned as heirs to the crown. He himself, therefore, was the legitimate successor of Edward IV. This preposterous theory was set forth by Buckingham, first to the mayor and corporation of London, and next day to an assembly of the estates of the realm held in St. Paul's. Cowed by the show of armed force, and remembering the fate of Hastings, the two assemblies received the claim with silence which gave consent. Richard, after a hypocritical show of reluctance, allowed himself to be saluted as king, and was crowned on July 6, 1483. Before the coronation ceremony he had issued orders for the execution of the queen's relatives, who had been in prison since the beginning of May. He paid his adherents lavishly for their support, making Lord Howard duke of Norfolk, and giving Buckingham enormous grants of estates and offices.

Murder of the Princes.—Having accomplished his *coup d'état* Richard started for a royal progress through the Midlands, and a few days after this departure sent back secret orders to London for the murder of his two nephews in the Tower. There is no reason to doubt that they were secretly smothered on or about July 15 by his agent Sir James Tyrrell, or that the bones found buried under a staircase in the fortress two hundred years after-

ward belonged to the two unhappy lads. But the business was kept dark at the time, and it was long before any one could assert with certainty that they were dead or alive. Richard never published any statement as to their end, though some easy tale of a fever, a conflagration, or an accident might have served better than the mere silence that he employed. For while many persons believed that the princes still existed there was room for all manner of impostures and false rumours.

Buckingham's Rebellion.—The usurper's reign was from the first a troubled one. Less than three months after his coronation the first insurrection broke out; it was headed—strangely enough—by the duke of Buckingham, who seems to have been shocked by the murder of the princes; he must have been one of the few who had certain information of the crime. He did not take arms in his own cause, though after the house of York the house of Buckingham had the best claim to the throne, as representing Thomas of Woodstock, the youngest son of Edward III. His plan was to unite the causes of York and Lancaster by wedding the Lady Elizabeth, the eldest sister of the murdered princes, to Henry Tudor, earl of Richmond, a young exile who represented the very doubtful claim of the Beauforts to the Lancastrian heritage. Henry was the son of Margaret Beaufort, the daughter of John, first duke of Somerset, and the niece of Edmund, second duke, who fell at St. Albans. All her male kinsmen had been exterminated in the Wars of the Roses.

This promising scheme was to be supported by a rising of those Yorkists who rejected the usurpation of Richard III., and by the landing on the south coast of Henry of Richmond with a body of Lancastrian exiles and foreign mercenaries. But good organization was wanting, and chance fought for the king. A number of scattered risings in the south were put down by Richard's troops, while Buckingham, who had raised his banner in Wales, was prevented from bringing aid by a week of extraordinary rains which made the Severn impassable. Finding that the rest of the plan had miscarried, Buckingham's retainers melted away from him, and he was forced to fly. A few days later he was betrayed, handed over to the king, and beheaded (Nov. 2, 1483). Meanwhile Richmond's little fleet was dispersed by the same storms that scattered Buckingham's army, and he was forced to return to Brittany without having landed in England.

Here King Richard's luck ended. Though he called a parliament early in 1484, and made all manner of gracious promises of good governance, he felt that his position was insecure. The nation was profoundly disgusted with his unscrupulous policy, and the greater part of the leaders of the late insurrection had escaped abroad and were weaving new plots. Early in the spring he lost his only son and heir, Edward, prince of Wales, and the question of the succession to the crown was opened from a new point of view. After some hesitation Richard named his nephew John de la Pole, earl of Lincoln, a son of his sister, as his heir. But he also bethought him of another and a most repulsive plan for strengthening his position. His queen, Anne Neville, the daughter of the kingmaker, was on her death-bed. With indecent haste he began to devise a scheme for marrying his niece Elizabeth, whose brothers he had murdered but a year before. Knowledge of this scheme is said to have shortened the life of the unfortunate Anne, and many did not scruple to say that her husband had made away with her.

Battle of Bosworth.—When the queen was dead, and some rumours of the king's intentions got abroad, the public indignation was so great that Richard's councillors had to warn him to disavow the projected marriage, if he wished to retain a single adherent. He yielded, and made public complaint that he had been slandered—which few believed. Meanwhile the conspirators of 1483 were busy in organizing another plan of invasion. This time it was successfully carried out, and the earl of Richmond landed at Milford Haven with many exiles, both Yorkists and Lancastrians, and 1,000 mercenaries lent him by the princess regent of France. The Welsh joined him in great numbers, not forgetting that by his Tudor descent he was their own kinsman, and when he reached Shrewsbury English adherents also began to flock to his banner, for the whole country was seething with discontent, and Richard III. had but few loyal adherents. When the rivals met at Bosworth Field (Aug. 22, 1485) the king's army was far the larger, but the greater part of it was determined not to fight. When battle was joined some left the field and many joined the pretender. Richard, however, refused to fly, and was slain, fighting to the last, along with the duke of Norfolk and a few other of his more desperate partisans. The slaughter was small, for treason, not the sword, had settled the day. The battered crown which had fallen from Richard's helmet was set on the victor's head by Lord Stanley, the chief of the Yorkist peers who had joined his standard, and his army hailed him by the new title of Henry VII.

Henry VII.—No monarch of England since William the Conqueror, not excluding Stephen and Henry IV., could show such a poor title to the throne as the first of the Tudor kings. His claim to represent the house of Lancaster was of the weakest—when Henry IV. had assented to the legitimating of his brothers the Beauforts, he had attached a clause to the Act, to provide that they were given every right save that of counting in the line of succession to the throne. The true heir to the house of John of Gaunt should have been sought among the descendants of his eldest legitimate daughter, not among those of his base-born sons. The earl of Richmond had been selected by the conspirators as their figure-head mainly because he was known as a young man of ability, and because he was unmarried and could therefore take to wife the princess Elizabeth, and so absorb the Yorkist claim in his own. This had been the essential part of the bargain, and Henry was ready to carry it out, but he insisted that he should first be recognized as king in his own right, lest it might be held that he ruled merely as his destined wife's consort. He was careful to hold his first parliament and get his title acknowledged before he married the princess. When he had done so, he had the triple claim by conquest, by election and by inheritance, safely united. Yet his position was even then insecure; the vicissitudes of the last 30 years had shaken the old prestige of the name of king, and a weaker and less capable man than Henry Tudor might have failed to retain the crown that he had won. There were plenty of possible pretenders in existence; the earl of Lincoln, whom Richard III. had recognized as his heir, was still alive; the two children of the duke of Clarence might be made the tools of conspirators; and there was a widespread doubt as to whether the sons of Edward IV. had actually died in the Tower. The secrecy with which their uncle had carried out their murder was destined to be a sore hindrance to his successor.

Bosworth field is often treated as the last act of the Wars of the Roses. This is an error; they were protracted for 12 years after the accession of Henry VII., and did not really end till the time of Blackheath Field and the siege of Exeter (1497). The position of the first Tudor king is misconceived if his early years are regarded as a time of strong governance and well-established order. On the contrary he was in continual danger, and was striving with all the resources of a ready and untiring mind to rebuild foundations that were absolutely rotten. Phenomena like the Cornish revolt (which recalls Cade's insurrection) and the Yorkshire rising of 1489, which began with the death of the earl of Northumberland, show that at any moment whole counties might take arms in sheer lawlessness, or for some local grievance. Loyalty was such an uncertain thing that the king might call out great levies yet be forced to doubt whether they would fight for him—at Stoke field it seems that a large part of Henry's army misbehaved, much as that of Richard III. had done at Bosworth. The demoralization brought about by the evil years between 1453 and 1483, could not be lived down in a day—any sort of treason was possible to the generation that had seen the career of Warwick and the usurpation of Gloucester. The survivors of that time were capable of taking arms for any cause that offered a chance of unreasonable profit, and no-one's loyalty could be trusted. Did not Sir William Stanley, the best paid of those who betrayed Richard III., afterwards lose his head for a deliberate plot to betray Henry VII.? The various attempts that were made to overturn the new dynasty seem contemptible to the historian of the 20th century. They were not so contemptible at the time, because England and Ireland

were full of adventurers who were ready to back any cause, and who looked on the king of the moment as no more than a successful member of their own class—a base-born Welshman who had been lucky enough to become the figurehead of the movement that had overturned an unpopular usurper. The organizing spirits of the early troubles of the reign of Henry VII. were irreconcilable Yorkists who had suffered by the change of dynasty; but their hopes of success rested less on their own strength than on the not ill-founded notion that England would tire of any ruler who had to raise taxes and reward his partisans. The position bore a curious resemblance to that of the early years of Henry IV., a king who, like Henry VII., had to vindicate a doubtful elective title to the throne by miracles of cunning and activity. The later representative of the house of Lancaster was fortunate, however, in having less formidable enemies than the earlier; the power of the baronage had been shaken by the Wars of the Roses no less than the power of the Crown; so many old estates had passed rapidly from hand to hand, so many old titles were represented by upstarts destitute of local influence, that the feudal danger had become far less. Risings like that of the Percies in 1403 were not the things which the seventh Henry had to fear. He was lucky too in having no adversary of genius of the type of Owen Glendower. Welsh national spirit indeed was enlisted on his own side. Yet leaderless seditions and the plots of obvious imposters sufficed to make his throne tremble, and a ruler less resolute, less wary, and less unscrupulous might have been overthrown.

Lambert Simnel.—The first of the king's troubles was an abortive rising in the north riding of Yorkshire, the only district where Richard III. seems to have enjoyed personal popularity. It was led by Lord Lovel, Richard's chamberlain and admiral; but the insurgents dispersed when Henry marched against them with a large force (1486), and Lovel took refuge in Flanders with Margaret of York, the widow of Charles the Bold of Burgundy, whose dower towns were the refuge of all English exiles, and whose coffers were always open to subsidize plots against her niece's husband. Under the auspices of this rancorous princess the second conspiracy was hatched in the following year (1487). Its leaders were Lovel and John, earl of Lincoln, whom Richard III. had designated as his heir. But the Yorkist banner was to be raised, not in the name of Lincoln, but in that of the boy Edward of Clarence, then a prisoner in the Tower. His absence and captivity might seem a fatal hindrance, but the conspirators had prepared a "double" who was to take his name till he could be released. This was a lad named Lambert Simnel, the son of an Oxford organmaker, who bore a personal resemblance to the young captive. The conspirators seem to have argued that Henry VII. would not proceed to murder the real Edward, but would rather exhibit him to prove the imposition; if he took the more drastic alternative Lincoln could fall back on his own claim to the crown.

In May 1487 Lincoln and Lovel landed in Ireland accompanied by other exiles and 2,000 German mercenaries. The cause of York was popular in the Pale, and the Anglo-Irish barons seem to have conceived the notion that Henry VII. was likely to prove too strong and capable a king to suit their convenience. The invading army was welcomed by almost all the lords, and the spurious Clarence was crowned at Dublin by the name of Edward VI. A few weeks later Lincoln had recruited his army with 4,000 or 5,000 Irish adventurers under Thomas Fitzgerald, son of the earl of Kildare, and had taken ship for England. He landed in Lancashire, and pushed forward, hoping to gather the English Yorkists to his aid. But few had joined him when King Henry brought him to action at Stoke, near Newark, on July 17. Despite the doubtful conduct of part of the royal army, and the fierce resistance of the Germans and Irish, the rebel army was routed. Lincoln and Fitzgerald were slain; Lovel disappeared in the rout; the young imposter Simnel was taken prisoner. Henry treated him with politic contempt, and made him a cook boy in his kitchen. He lived for many years after in the royal household. The Irish lords were pardoned on renewing their oaths of fealty; the king did not wish to entangle himself in costly campaigns beyond St. George's channel till he had made his position in England more stable.

The Yorkist cause was crushed for four years, till it was raised again by Margaret of Burgundy, with an imposture even more preposterous than that of Lambert Simnel. In the intervening space, however, while Henry VII. was comparatively undisturbed by domestic rebellion, he found opportunity for a first tentative experiment at interfering in European politics. He allied himself with Ferdinand and Isabella of Spain and with Maximilian of Austria, who was ruling the Netherlands in behalf of his young son, Philip, the heir of the Burgundian inheritance, for the purpose of preventing France from annexing Brittany, the last great fief of the crown which had not yet been absorbed into the Valois royal domain. This struggle, the only Continental war in which the first of the Tudors risked his fortunes, was not prosecuted with any great energy, and came to a necessary end when Anne, duchess of Brittany, in whose behalf it was being waged, disappointed her allies by marrying Charles VIII. of her own free-will (Dec. 1491). Henry very wisely proceeded to get out of the war on the best terms possible, and, to the disgust of Maximilian, sold peace to the French king for 600,000 crowns, as well as an additional sum representing arrears of the pension which Louis XI. had been bound to pay to Edward IV. This treaty of Etaples was, in short, a repetition of Edward's treaty of Picquigny, equally profitable and less disgraceful, for Maximilian of Austria, whom Henry thus abandoned, had given more cause of offence than had Charles of Burgundy in 1475. Domestic malcontents did not scruple to hint that the king, like his father-in-law before him, had made war on France, not with any hope of renewing the glories of Creçy or Agincourt, still less with any design of helping his allies, but purely to get first grants from his parliament, and then a war indemnity from his enemies. In any case he was wise to make peace. France was now too strong for England, and both Maximilian and Ferdinand of Spain were selfish and shifty allies. Moreover, it was known that the one dominating desire of Charles VIII. was to conquer Italy, and it was clear that his ambitions in that direction were not likely to prove dangerous to England.

Perkin Warbeck.—In the year of the treaty of Etaples the Yorkist conspiracies began once more to thicken, and Henry was fortunate to escape with profit from the French war before his domestic troubles recommenced. Ever since 1483 it had been rumoured that one or both of the sons of Edward IV. had escaped, not having been murdered in the Tower. Of this widespread belief the plotters now took advantage; they held that much more could be accomplished with such a claim than by using that of the unfortunate Edward of Clarence, whose chances were so severely handicapped by his being still the prisoner of Henry VII. The scheme for producing a false Plantagenet was first renewed in Ireland, where Simnel's imposture had been so easily taken up a few years before. The tool selected was one Perkin Warbeck, a handsome youth of 17 or 18, the son of a citizen of Tournai, who had lived for some time in London, where Perkin had actually been born. There is a bare possibility that the young adventurer may have been an illegitimate son of Edward IV.; his likeness to the late king was much noticed. When he declared himself to be Richard of York, he obtained some support in Ireland from the earl of Desmond and other lords; but he did not risk open rebellion till he had visited Flanders, and had been acknowledged as her undoubted nephew by Duchess Margaret. Maximilian of Austria also took up his cause, as a happy means of revenging himself on Henry VII. for the treaty of Etaples. There can be small doubt that both the duchess and the German king (Maximilian had succeeded to his father's crown in 1493) were perfectly well aware that they were aiding a manifest fraud. But they made much of Perkin, who followed the imperial court for two years, while his patron was intriguing with English malcontents. The emissaries from Flanders got many promises of assistance, and a formidable rising might have taken place had not Henry VII. been well served by his spies. But in the winter of 1494–95 the traitors were themselves betrayed, and a large number of arrests were made, including not only Lord Fitzwalter and a number of well-known knights of Yorkist families, but Sir William Stanley, the king's chamberlain, who had been rewarded with enormous gifts for his good service at Bosworth, and was reckoned one of the chief supporters of the

throne. Stanley and several others were beheaded, the rest hanged or imprisoned. The vigorous action on the part of the king seems to have cowed all Warbeck's supporters on English soil. But the pretender nevertheless sailed from Flanders in July 1495 with a following of 2,000 exiles and German mercenaries. He attempted to land at Deal, but his vanguard was destroyed by Kentish levies, and he drew off and made for Ireland. Suspecting that this would be his goal, King Henry had been doing his best to strengthen his hold on the Pale, whither he had sent his capable servant Sir Edward Poynings as lord deputy. Already before Warbeck's arrival Poynings had arrested the earl of Kildare, Simnel's old supporter, cowed some of the Irish by military force, and bought over others by promises of subsidies and pensions. But his best-remembered achievement was that he had induced the Irish parliament to pass the ordinances known as "Poynings' Law," by which it acknowledged that it could pass no legislation which had not been approved by the king and his council, and agreed that all statutes passed by the English parliament should be in force in Ireland. That such terms could be imposed shows the strength of Poynings' arm, and his vigour was equally evident when Warbeck came ashore in Munster in July 1495. Few joined the impostor save the earl of Desmond, and he was repulsed from Waterford, and dared not face the army which the lord deputy put into the field against him. Thereupon, abandoning his Irish schemes, Warbeck sailed to Scotland, whose young king James IV. had just been seduced by the emperor Maximilian into declaring war on England. He promised the Scottish king Berwick and 50,000 crowns in return for the aid of an army. James took the offer, gave him the hand of his kinswoman Catherine Gordon, daughter of the earl of Huntly, and took him for a raid into Northumberland (1490). But a pretender backed by Scottish spears did not appeal to the sympathies of the English borderers. The expedition fell flat; not a man joined the banner of the white rose, and James became aware that he had set forth on a fool's errand. But Warbeck soon found other allies of a most unexpected sort. The heavy taxation granted by the English parliament for the Scottish war had provoked discontent and rioting in the south-western counties. In Cornwall especially the disorders grew to such a pitch that local demagogues called out several thousand men to resist the tax-collectors, and finally raised open rebellion, proposing to march on London and compel the king to dismiss his ministers. These spiritual heirs of Jack Cade were Flammock, a lawyer of Bodmin, and a farrier named Michael Joseph. Whether they had any communication with Warbeck it is impossible to say; there is no good proof of such a connection, but their acts served him well. A Cornish army marched straight on London, picking up some supporters in Devon and Somerset on their way, including a discontented baron, Lord Audley, whom they made their captain.

Battle of Blackheath.—So precarious was the hold of Henry VII. on the throne that he was in great danger from this outbreak of mere local turbulence. The rebels swept over five counties unopposed, and were only stopped and beaten in a hard fight on Blackheath, when they had reached the gates of London. Audley, the farrier and the lawyer were all captured and executed (June 18, 1497). But the crisis was not yet at an end. Warbeck, hearing of the rising, but not of its suppression, had left Scotland, and appeared in Devonshire in August. He rallied the wrecks of the west country rebels, and presently appeared before the gates of Exeter with nearly 8,000 men. But the citizens held out against him, and presently the approach of the royal army was reported. The pretender led off his horde to meet the relieving force, but when he reached Taunton he found that his followers were so dispirited that disaster was certain. Thereupon he absconded by night, and took sanctuary in the abbey of Beaulieu. He offered to confess his imposture if he were promised his life, and the king accepted the terms. First at Taunton and again at Westminster, Perkin publicly recited a long narrative of his real parentage, his frauds and his adventures. He was then consigned to not over-strict confinement in the Tower, and might have fared no worse than Lambert Simnel if he had possessed his soul in patience. But in the next year he corrupted his warders, broke out from his prison, and tried to escape beyond seas. He was captured, but the king again spared his life, though he was placed for the future in a dungeon "where he could neither see moon nor sun." Even this did not tame the impostor's mercurial temperament. In 1499 he again planned an escape, which was to be shared by another prisoner, the unfortunate Edward of Clarence, earl of Warwick, whose cell was in the storey above his own. But there were traitors among the Tower officials whom they suborned to help them, and the king was warned of the plot. He allowed it to proceed to the verge of execution, and then arrested both the false and the true Plantagenet. Evidence of a suspicious character was produced to show that they had planned rebellion as well as mere escape, and both were put to death with some of their accomplices. Warbeck deserved all that he reaped, but the unlucky Clarence's fate estranged many hearts from the king. The simple and weakly young man, who had spent 15 of his 25 years in confinement, had, in all probability, done no more than scheme for an escape from his dungeon. But as the true male heir of the house of Plantagenet he was too dangerous to be allowed to survive.

The Tudor Dynasty.—The turbulent portion of the reign of Henry VII. came to an end with Blackheath field and the siege of Exeter. From that time forward the Tudor dynasty was no longer in serious danger; there were still some abortive plots, but none that had any prospect of winning popular support. The chances of Warbeck and Clarence had vanished long before they went to the scaffold. The Yorkist claim, after Clarence's death, might be supposed to have passed to his cousin Edmund, earl of Suffolk, the younger brother of that John, earl of Lincoln, who had been declared heir to the crown by Richard III., and had fallen at Stoke field. Fully conscious of the danger of his position, Suffolk fled to the Continent, and lived for many years as a pensioner of the emperor Maximilian. Apparently he dabbled in treason; it is at any rate certain that in 1501 King Henry executed some, and imprisoned others, of his relatives and retainers. But his plots, such as they were, seem to have been futile. There was no substratum of popular discontent left in England on which a dangerous insurrection might be built up. It was to be 40 years before another outbreak of turbulence against the Crown was to break forth.

The king's great triumphs were the conclusion of the *Intercursus Magnus* of 1496 and the *Intercursus Malus* (so called by the Flemings, not by the English) of 1506. The former provided for a renewal of the old commercial alliance with the house of Burgundy, on the same terms under which it had existed in the time of Edward IV.; the rupture which had taken place during the years when Maximilian was backing Perkin Warbeck had been equally injurious to both parties. The *Intercursus Malus* on the other hand gave England some privileges which she had not before enjoyed—exemption from local tolls in Antwerp and Holland, and a licence for English merchants to sell cloth retail as well as wholesale—a concession which hit the Netherland small traders and middlemen very hard. Another great commercial advantage secured by Henry VII. for his subjects was an increased share of the trade to the Scandinavian countries. The old treaties of Edward IV. with the Hanseatic League had left the Germans still in control of the northern seas. Nearly all the Baltic goods, and most of those from Denmark and Norway, had been reaching London or Hull in foreign bottoms. Henry allied himself with John of Denmark, who was chafing under the monopoly of the Hansa, and obtained the most ample grants of free trade in his realms. The Germans murmured, but the English shipping in eastern and northern waters continued to multiply. Much the same policy was pursued in the Mediterranean. Southern goods hitherto had come to Southampton or Sandwich invariably in Venetian carracks, which took back in return English wool and metals. Henry concluded a treaty with Florence, by which that republic undertook to receive his ships in its harbours and to allow them to purchase all eastern goods that they might require. From this time forward the Venetian monopoly ceased, and the visits of English merchant vessels to the Mediterranean became frequent and regular.

Nor was it in dealing with old lines of trade alone that Henry Tudor showed himself the watchful guardian of the interests of

his subjects. He must take his share of credit for the encouragement of the exploration of the seas of the Far West. The British traders had already pushed far into the Atlantic before Columbus discovered America; fired by the success of the great navigator they continued their adventures, hoping like him to discover a short "north-west passage" to Cathay and Japan. With a charter from the king giving him leave to set up the English banner on all the lands he might discover, the Bristol Genoese trader John Cabot successfully passed the great sea in 1497, and discovered Newfoundland and its rich fishing stations. Henry rewarded him with a pension of £20 a year, and encouraged him to further exploration, in which he discovered all the American coast-line from Labrador to the mouth of the Delaware—a great heritage for England, but one not destined to be taken up for colonization till more than a century had passed.

Foreign Policy of Henry VII.—Henry's services to English commerce were undoubtedly of far more importance to the nation than all the tortuous details of his foreign policy. His chicanery need not, however, be censured over much, for the princes with whom he had to deal, and notably Ferdinand and Maximilian, were as insincere and selfish as himself. Few diplomatic hagglings have been so long and so sordid as that between England and Spain over the marriage treaty which gave the hand of Catherine of Aragon first to Henry's eldest son Arthur, and then, on his premature death in 1502, to his second son Henry. The English king no doubt imagined that he had secured a good bargain, as he had kept the princess's dowry, and yet never gave Ferdinand any practical assistance in war or peace. It is interesting to find that he had for some time at the end of his reign a second Spanish marriage in view; his wife Elizabeth of York having died in 1503, he seriously proposed himself as a suitor for Joanna of Castile, the elder sister of Catherine, and the widow of the archduke Philip, though she was known to be insane. Apparently he hoped thereby to gain vantage ground for an interference in Spanish politics, which would have been most offensive to Ferdinand. Nothing came of the project, which contrasts strangely with the greater part of Henry's sober and cautious schemes.

On the other hand a third project of marriage alliance which Henry carried out in 1503 was destined to be consummated, and to have momentous, though long-deferred, results. This was the giving of the hand of his daughter Margaret to James IV. of Scotland. Thereby he bought quiet on the Border and alliance with Scotland for no more than some ten years. But—as it chanced—the issue of this alliance was destined to unite the English and the Scottish crowns, when the male line of the Tudors died out, and Henry, quite unintentionally, had his share in bringing about the consummation, by peaceful means, of that end which Edward I. had sought for so long to win by the strong hand.

Character of Henry's Internal Rule.—All the foreign politics of the reign of Henry VII. have small importance compared with his work within the realm. The true monument of his ability was that he left England tamed and orderly, with an obedient people and a full exchequer, though he had taken it over wellnigh in a state of anarchy. The mere suppression of insurrections like those of Simnel and Warbeck was a small part of his task. The harder part was to recreate a spirit of order and subordination among a nation accustomed to long civil strife. His instruments were ministers of ability chosen from the clergy and the gentry—he seems to have been equally averse to trusting the baronage at the one end of the social scale, or mere upstarts at the other, and it is notable that no one during his reign can be called a court favourite. The best-known names among his servants were his great chancellor, Archbishop Morton, Foxe, bishop of Winchester, Sir Reginald Bray, and the lawyers Empson and Dudley. These two last bore the brunt of the unpopularity of the financial policy of the king during the latter half of his reign, when the vice of avarice seems to have grown upon him beyond all reason. But Henry was such a hard-working monarch, and so familiar with all the details of administration, that his ministers cannot be said to have had any independent authority, or to have directed their master's course of action.

The machinery employed by the first of the Tudors for the suppression of domestic disorder is well known. The most important item added by him to the administrative machinery of the realm was the famous Star Chamber, which was licensed by the parliament of 1487. It consisted of a small committee of ministers, privy councillors and judges, which sat to deal with offences that seemed to lie outside the scope of the common law, or more frequently with the misdoings of men who were so powerful that the local courts could not be trusted to execute justice upon them, such as great landowners, sheriffs and other royal officials, or turbulent individuals who were the terror of their native districts. The need for a strong central court directly inspired by the king, which could administer justice without respect of persons, was so great, that the constitutional danger of establishing an autocratic judicial committee, untrammelled by the ordinary rules of law, escaped notice at the time. It was not till much later that the nation came to look upon the Star Chamber as the special engine of royal tyranny and to loathe its name. In 1500 it was for the common profit of the realm that there should exist such a court, which could reduce even the most powerful offender to order.

One of the most notable parts of the king's policy was his long-continued and successful assault on the abuse of "livery and maintenance," which had been at its height during the Wars of the Roses. We have seen the part which it had taken in strengthening the influence of those who were already too powerful, and weakening the ordinary operation of the law. Henry put it down with a strong hand, forbidding all liveries entirely, save for the mere domestic retainers of each magnate. His determination to end the system was well shown by the fact that he heavily fined even the earl of Oxford, the companion of his exile, the victor of Bosworth, and the most notoriously loyal peer in the realm, for an ostentatious violation of the statute. Where Oxford was punished, no less favoured person could hope to escape. By the end of the reign the little hosts of badged adherents which had formed the nucleus for the armies of the Wars of the Roses had ceased to exist.

Personal Rule.—Edward IV., as has been already remarked, had many of the opportunities of the autocrat, if only he had cared to use them; but his sloth and self-indulgence stood in the way. Henry VII., the most laborious and systematic of men, turned them to account. He formed his personal opinion on every problem of administration and intervened himself in every detail. In many respects he was his own prime minister, and nothing was done without his knowledge and consent. A consistent policy may be detected in all his acts—that of gathering all the machinery of government into his own hands. Under the later Plantagenets and the Lancastrian kings the great check on the power of the Crown had been that financial difficulties were continually compelling the sovereign to summon parliaments. The estates had interfered perpetually in all the details of governance, by means of the power of the purse. Edward IV., first among English sovereigns, had been able to dispense with parliaments for periods of many years, because he did not need their grants save at long intervals. Henry was in the same position; by strict economy, by the use of foreign subsidies, by the automatic growth of his revenues during a time of peace and returning prosperity, by confiscation and forfeitures, he built himself up a financial position which rendered it unnecessary for him to make frequent appeals to parliament. Not the least fertile of his expedients was that regular exploitation of the law as a source of revenue, which had already been seen in the time of his father-in-law. This part of Henry's policy is connected with the name of his two extortionate "fiscal judges" Empson and Dudley, who "turned law and justice into rapine" by their minute inquisition into all technical breaches of legality, and the nice fashion in which they adapted the fine to the wealth of the misdemeanant, without any reference to his moral guilt or any regard for extenuating circumstances. The king must take the responsibility for their unjust doings; it was his coffers which mainly profited by their chicane. In his later years he fell into the vice of hoarding

money for its own sake; so necessary was it to his policy that he should be free, as far as possible, from the need for applying to parliament for money, that he became morbidly anxious to have great hoards in readiness for any possible day of financial stress. At his death he is said to have had £1,800,000 in hard cash laid by. Hence it is not strange to find that he was able to dispense with parliaments in a fashion that would have seemed incredible to a 14th-century king. In his whole reign he only asked them five times for grants of taxation, and three of the five requests were made during the first seven years of his reign. In the eyes of many men parliament lost the main reason for its existence when it ceased to be the habitual provider of funds for the ordinary expenses of the realm. Those who had a better conception of its proper functions could see that it had at any rate been stripped of its chief power when the king no longer required its subsidies. There are traces of a want of public interest in its proceedings, very different from the anxiety with which they used to be followed in Plantagenet and Lancastrian times. Legislation, which only incidentally affects him, is very much less exciting to the ordinary citizen than taxation, which aims directly at his pocket. It is at any rate clear that during the latter years of his reign, when the time of impostures and rebellions had ended, Henry was able to dispense with parliaments to a great extent, and incurred no unpopularity by doing so. Indeed he was accepted by the English people as the benefactor who had delivered them from anarchy; and if they murmured at his love of hoarding, and cursed his inquisitors Empson and Dudley, they had no wish to change the Tudor rule, and were far from regarding the times of the "Lancastrian experiment" as a lost golden age. The present king might be unscrupulous and avaricious, but he was cautious, intelligent and economical; no one would have wished to recall the régime of that "crowned saint" Henry VI.

Henry VIII.—Nevertheless when the first of the Tudors died, on April 21, 1509, there were few who regretted him. He was not a monarch to rouse enthusiasm, while much was expected from his brilliant, clever and handsome son Henry VIII., whose magnificent presence and manly vigour recalled the early prime of Edward IV. Some years later England realized that its new king had inherited not only the physical beauty and strength of his grandfather, but also every one of his faults, with the sole exception of his tendency to sloth. Henry VIII. indeed may be said, to sum up his character in brief, to have combined his father's brains with his grandfather's passions. Edward IV. was selfish and cruel, but failed to become a tyrant because he lacked the energy for continuous work. Henry VII. was unscrupulous and untiring, but so cautious and wary that he avoided violent action and dangerous risks. Their descendant had neither Edward's sloth nor Henry's moderation; he was capable of going to almost any lengths in pursuit of the gratification of his ambition, his passions, his resentment or his simple love of self-assertion. Yet, however far he might go on the road to tyranny, Henry had sufficient cunning, versatility and power of cool reflection, to know precisely when he had reached the edge of the impossible. He had his father's faculty for gauging public opinion, and estimating dangers, and though his more venturous temperament led him to press on far beyond the point at which the seventh Henry would have halted, he always stopped short on the hither side of the gulf. It was the most marvellous proof of his ability that he died on his throne after nearly 40 years of autocratic rule, during which he had roused more enmities and done more to change the face of the realm than any of the kings that were before him.

But it was long before the nation could estimate all the features of the magnificent but sinister figure which was to dominate England from 1509 to 1547. At his accession Henry VIII. was only 18 years of age, and, if his character was already formed, it was only the attractive side of it that was yet visible. His personal beauty, his keen intelligence, his scholarship, his love of music and the arts, his kingly ambition, were all obvious enough. His selfishness, his cruelty, his ingratitude, his fierce hatred of criticism and opposition, his sensuality, had yet to be discovered by his subjects. A suspicious observer might have detected something ominous in the first act of his reign—the arrest and attainder of his father's unpopular ministers, Empson and Dudley, whose heads he flung to the people in order to win a moment's applause. Whatever their faults, they had served the house of Tudor well, and it was a grotesque perversion of justice to send them to the scaffold on a charge of high treason. A similar piece of cruelty was the execution, some time later, of the earl of Suffolk, who had been languishing long years in the Tower; he was destroyed not for any new plots, but simply for his Yorkish descent. But in Henry's earlier years such acts were still unusual; it was not till he had grown older, and had learnt how much the nation would endure, that judicial murder became part of his established policy.

Henry's first outburst of self-assertion took the form of reversing his father's thrifty and peaceful policy, by plunging into the midst of the Continental wars from which England had been held back by his cautious parent. The adventure was wholly unnecessary, and also unprofitable. But while France was engaged in the "Holy War" against the pope, Venice, the emperor, and Ferdinand of Spain, Henry renewed the old claims of the Plantagenets, and hoped, if not to win back the position of Edward III., at least to recover the duchy of Aquitaine, or some parts of it. He lent an army to Ferdinand for the invasion of Gascony, and landed himself at Calais with 25,000 men, to beat up the northern border of France. Little good came of his efforts. The Spanish king gave no assistance, and the northern campaign, though it included the brilliant battle of the Spurs (Aug. 16, 1513), accomplished nothing more than the capture of Tournai and Thérouanne. It was soon borne in upon King Henry that France, even when engaged with other enemies, was too strong to be overrun in the old style. Moreover, his allies were giving him no aid, though they had eagerly accepted his great subsidies. With a sudden revulsion of feeling Henry offered peace to France, which King Louis XII. gladly bought, agreeing to renew the old pension or tribute that Henry VII. had received by the treaty of Etaples. Their reconciliation and alliance were sealed by the marriage of the French king to Henry's favourite sister Mary, who was the bridegroom's junior by more than 30 years. Their wedlock and the Anglo-French alliance lasted only till the next year, when Louis died, and Mary secretly espoused an old admirer, Charles Brandon, afterwards duke of Suffolk, King Henry's greatest friend and confidant.

While the French war was still in progress there had been heavy fighting on the Scottish border. James IV., reverting to the traditionary policy of his ancestors, had taken the opportunity of attacking England while her king and his army were over-seas. He suffered a disaster which recalls that of David II. at Neville's Cross—a fight which had taken place under precisely similar political conditions. After taking a few Northumbrian castles, James was brought to action at Flodden field by the earl of Surrey (Sept. 9, 1513). After a desperate fight lasting the greater part of a day, the Scots were outmanoeuvred and surrounded. James IV.—who had refused to quit the field—was slain in the forefront of the battle, with the greater part of his nobles; with him fell also some 10,000 or 12,000 of his men. Scotland, with her military power brought low, and an infant king on the throne, was a negligible quantity in international politics for some years. The queen dowager, Margaret Tudor, aided by a party that favoured peace and alliance with England, was strong enough to balance the faction under the duke of Albany which wished for perpetual war and asked for aid from France.

Thomas Wolsey.—With the peace of 1514 ended the first period of King Henry's reign. He was now no longer a boy, but a man of 23, with his character fully developed; he had gradually got rid of his father's old councillors, and had chosen for himself a minister as ambitious and energetic as himself, the celebrated Thomas Wolsey, whom he had just made archbishop of York, and who obtained the rank of cardinal from the pope in the succeeding year. Wolsey was the last of the great clerical ministers of the middle ages, and by no means the worst. Like so many of his predecessors he had risen from the lower middle classes, through the royal road of the church; he had served Henry VII.'s old councillor Foxe, bishop of Winchester, as secre-

tary, and from his household had passed into that of his master. He had been an admirable servant to both, full of zeal, intelligence and energy, and not too much burdened with scruples. The young king found in him an instrument well fitted to his hand, a man fearless, ingenious, and devoted to the furtherance of the power of the Crown, by which alone he had reached his present position of authority. For 14 years he was his master's chief minister—the person responsible in the nation's eyes for all the more unpopular assertions of the royal prerogative, and for all the heavy taxation and despotic acts which Henry's policy required. It mattered little to Henry that the cardinal was arrogant, tactless, and ostentatious; indeed it suited his purpose that Wolsey should be saddled by public opinion with all the blame that ought to have been laid on his own shoulders. It was convenient that the old nobility should detest the upstart, and that the commons should imagine him to be the person responsible for the demands for money required for the royal wars. As long as his minister served his purposes and could execute his behests Henry gave him a free hand, and supported him against all his enemies. It was believed at the time, and is still sometimes maintained by historians, that Wolsey laid down schemes of policy and persuaded his master to adopt them; but the truth would appear to be that Henry was in no wise dominated by the cardinal, but imposed on him his own wishes, merely leaving matters of detail to be settled by his minister. Things indifferent might be trusted to him, but the main lines of English diplomacy and foreign policy show rather the influence of the king's personal desires of the moment than that of a statesman seeking national ends.

It has often been alleged that Henry, under the guidance of Wolsey, followed a consistent scheme for aggrandizing England, by making her the State which kept the balance of power of Europe in her hands. And it is pointed out that during the years of the cardinal's ascendancy the alliance of England was sought in turn by the great princes of the Continent, and proved the make-weight in the scales. This is but a superficial view of the situation. Henry, if much courted, was much deceived by his contemporaries. They borrowed his money and his armies, but fed him with vain promises and illusory treaties. He and his minister were alternately gulled by France and by the emperor, and the net result of all their activity was bankruptcy and discontent at home and ever-frustrated hopes abroad. It is hard to build up a reputation for statecraft for either Henry or Wolsey on the sum total of English political achievement during their collaboration.

Foreign Policy.—During the first few years of the cardinal's ascendancy the elder race of European sovereigns, the kings with whom Henry VII. had been wont to haggle, disappeared one after the other. Louis of France died in 1515, Ferdinand of Aragon in 1516, the emperor Maximilian—the last survivor of his generation—in 1519. Louis was succeeded by the active, warlike and shifty Francis I.; the heritage of both Ferdinand and Maximilian—his maternal and paternal grandfathers—fell to Charles of Habsburg, who already possessed the Netherlands in his father's right and Castile in that of his mother. The enmity of the house of Valois and the house of Habsburg, which had first appeared in the wars of Charles VIII. and Maximilian, took a far more bitter shape under Francis I. and Charles V., two young princes who were rivals from their youth. Their wars were almost perpetual, their peaces never honestly carried out. Their powers were very equally balanced; if Charles owned broader lands than Francis, they were more scattered and in some cases less loyal. The solid and wealthy realm of France proved able to make head against Spain and the Netherlands, even when they were backed by the emperor's German vassals. Charles was also distracted by many stabs in the back from the Ottoman Turks, who were just beginning their attack on Christendom along the line of the Danube. To each of the combatants it seemed that the English alliance would turn the scale in his own favour. Henry was much courted, and wooed with promises of lands to be won from the other side by his ally of the moment. But neither Charles nor Francis wished him to be a real gainer, and he himself was a most untrustworthy friend, for he was quite ready to turn against his ally if he seemed to be growing too powerful, and threatened to dominate all Europe; the complete success of either party would mean that England would sink once more into a second-rate power. How faithless and insincere was Henry's policy may be gauged from the fact that in 1520, after all the pageantry of the "Field of the Cloth of Gold" and his vows of undying friendship for Francis, he met Charles a few weeks later at Gravelines, and concluded with him a treaty which pledged England to a defensive alliance against the king's "good brother" of France. Such things happened not once nor twice during the years of Wolsey's ministry. It was hardly to be wondered at, therefore, if Henry's allies regularly endeavoured to cheat him out of his share of their joint profits. What use was there in rewarding a friend who might become an enemy to-morrow? The greatest deception of all was in 1522, when Charles V., who had made the extraordinary promise that he would get Wolsey made pope, and lend Henry an army to conquer northern France, failed to redeem his word in both respects. He caused his own old tutor, Adrian of Utrecht, to be crowned with the papal tiara, and left the English to invade Picardy entirely unassisted. But this was only one of many such disappointments.

The result of some 12 years of abortive alliances and ill-kept treaties was that Henry had obtained no single one of the advantages which he had coveted, and that he had lavished untold wealth and many English lives upon phantom schemes which crumbled between his fingers. His subjects had already begun to murmur; the early parliaments of his reign had been passive and complaisant; but by 1523 the Commons had been goaded into resistance. They granted only half the subsidies asked from them, pleading that three summers more of such taxation as the cardinal demanded for his master would leave the realm drained of its last penny, and reduced to fall back on primitive forms of barter, "clothes for victuals and bread for cheese," out of mere want of coin. Fortunately for the king his subjects laid all the blame upon his mouthpiece the cardinal, instead of placing it where it was due. On Wolsey's back also was saddled the most iniquitous of Henry's acts of tyranny against individuals—the judicial murder of the duke of Buckingham, the highest head among the English nobility. For some hasty words, amplified by the doubtful evidence of treacherous retainers, together with a foolish charge of dabbling with astrologers, the heir of the royal line of Thomas of Woodstock had been tried and executed with scandalous haste. His only real crime was that, commenting on the lack of male heirs to the crown—for after many years of wedlock with Catherine of Aragon Henry's sole issue was one sickly daughter—he had been foolish enough to remark that if anything should happen to the king he himself was close in succession to the crown. The cardinal bore the blame, because he and Buckingham had notoriously disliked each other; but the deed had really been of the king's own contriving. He was roused to implacable wrath by anyone who dared to speak on the forbidden topic of the succession question.

In the later years of Wolsey's ascendancy, nevertheless, that same question was the subject of many anxious thoughts. From Henry's own mind it was never long absent; he yearned for a male heir, and he was growing tired of his wife Catherine, who was some years older than himself, had few personal attractions, and was growing somewhat of an invalid. Somewhere about the end of 1526 those who were in the king's intimate confidence began to be aware that he was meditating a divorce—a thing not lightly to be taken in hand, for the queen was the aunt of the emperor Charles V., who would be vastly offended at such a proposal. But Henry's doubts had been marvellously stimulated by the fact that he had become enamoured of another lady—the beautiful, ambitious and cunning Anne Boleyn, a niece of the duke of Norfolk, who had no intention of becoming merely the king's mistress, but aspired to be his consort.

England and the Reformation.—The question of the king's divorce soon became inextricably confused with another problem, whose first beginnings go back to a slightly earlier date. What was to be the attitude of England towards the Reformation? It was now nearly ten years since Martin Luther had posted up his famous theses on the church door at Wittenberg, and since

he had testified to his faith before the diet of Worms. All Germany was now convulsed with the first throes of the revolt against the papacy, and the echoes of the new theological disputes were being heard in England. King Henry himself in 1521 had deigned to write an abusive pamphlet against Luther, for which he had been awarded the magnificent title of *Fidei Defensor* by that cultured sceptic Pope Leo X. About the same time we begin to read of orders issued by the bishops for the discovery and burning of all Lutheran books—a clear sign that they were reaching England in appreciable quantities. Hitherto it had been only the works of Wycliffe that had merited this attention on the part of inquisitors. In the Wycliffite remnant, often persecuted but never exterminated, there already existed in England the nucleus of a Protestant party. All through the reign of Henry VII. and the early years of Henry VIII. the intermittent burning of "heretics," and their far more frequent recantations, had borne witness to the fact that the sect still lingered on. The Wycliffites were a feeble folk, compelled to subterraneous ways, and destitute of learned leaders or powerful supporters. But they survived to see Luther's day, and to merge themselves in one body with the first English travelling scholars and merchants who brought back from the Continent the doctrines of the German Reformation. The origins of a Protestant party, who were not mere Wycliffites, but had been first interested in dogmatic controversy by coming upon the works of Luther, can be traced back to the year 1521 and to the University of Cambridge. There a knot of scholars, some of whom were to perish early at the stake, while others were destined to become the leaders of the English Reformation, came together and encouraged each other to test the received doctrines of contemporary orthodoxy by searching the Scriptures and the works of the Fathers. The sect spread in a few years to London, Oxford and other centres of intellectual life, but for many years its followers were not numerous; like the old Lollardy, Protestantism took root only in certain places and among certain classes—notably the lesser clergy and the merchants of the great towns.

King Henry and those who wished to please him professed as great a hatred and contempt for the new purveyors of German doctrines as for the belated disciples of Wycliffe, But there was another movement, whose origins went back for many centuries, which they were far from discouraging, and were prepared to utilize when it suited their convenience. This was the purely political feeling against the tyranny of the papacy, and the abuses of the national church, which in early ages had given supporters to William the Conqueror and Henry II., which had dictated the statutes of Mortmain and of Praemunire. Little had been heard of the old anti-clerical party in England since the time of Henry IV.; it had apparently been identified in the eyes of the orthodox with that Lollardy with which it had for a time allied itself, and had shared in its discredit. But it had always continued to exist, and in the early years of Henry VIII. had been showing unmistakable signs of vitality. The papacy of the Renaissance was a fair mark for criticism. It was not hard to attack the system under which Rodrigo Borgia wore the tiara, while Girolamo Savonarola went to the stake; or in which Julius II. exploited the name of Christianity to serve his territorial policy in Italy, and Leo X. hawked his indulgences round Europe to raise funds which would enable him to gratify his artistic tastes. At no period had the official hierarchy of the Western Church been more out of touch with common righteousness and piety. Moreover, they were sinning under the eyes of a laity which was far more intelligent and educated, more able to think and judge for itself, less the slave of immemorial tradition, than the old public of the middle ages. It Italy the Renaissance might be purely concerned with things intellectual or artistic, and seem to have little or no touch with things moral. Beyond the Alps it was otherwise; among the Teutonic nations at least the revolt against the scholastic philosophy, the rout of the obscurantists, the eager pursuit of Hellenic culture, had a religious aspect. The same generation which refused to take thrice-translated and thrice-garbled screeds from Aristotle as the sum of human knowledge, and went back to the original Greek, was also studying the Old and New Testaments in their original tongues, and drawing from them conclusions as unfavourable to the intelligence as to the scholarship of the orthodox mediaeval divines. Such a discovery as that which showed that the "False Decretals," on which so much of the power of the papacy rested, were mere 9th-century forgeries struck deep at the roots of the whole traditional relation between church and State.

The first English scholars of the Renaissance, like Erasmus on the Continent, did not see the logical outcome of their own discoveries, nor realize that the campaign against obscurantism would develop into a campaign against Roman orthodoxy. Sir Thomas More, the greatest of them, was actually driven into reaction by the violence of Protestant controversialists, and the fear that the new doctrines would rend the church in twain. He became himself a persecutor, and a writer of abusive pamphlets unworthy of the author of the *Utopia*. But to the younger generation the irreconcilability of modern scholarship and mediaeval formulae of faith became more and more evident. One after another all the cardinal doctrines were challenged by writers who were generally acute, and almost invariably vituperative. For the controveries of the Reformation were conducted by both sides, from kings and prelates down to gutter pamphleteers, in language of the most unseemly violence.

But, as has been already said, the scholars and theologians had less influence in the beginning of the English Reformation than the mere lay politicians, whose anti-clerical tendencies chanced to fit in with King Henry's convenience when he quarrelled with the papacy. It is well to note that the first attacks of parliament on the church date back to two years before Luther published his famous theses. The contention began in 1515 with the fierce assault by the Commons on the old abuse of benefit of clergy, and the immunity of clerical criminals from due punishment for secular crimes—a question as old as the times of Henry II. and Becket. But the discussion spread in later years from this particular point into a general criticism of the church and its relations to the State, embracing local grievances as well as the questions which turned on the dealings of the papacy with the Crown. The old complaints which had been raised against the Church of England in the days of Edward I. or Richard II. had lost none of their force in 1526. The higher clergy were more than ever immersed in affairs of State, "Caesarean" as Wycliffe would have called them. It was only necessary to point to the great cardinal himself, and to ask how far his spiritual duties at York were properly discharged while he was acting as the king's prime minister. The cases of Foxe and Morton were much the same; the former passed for a well-meaning man, yet had been practically absent from his diocese for 20 years. Pluralism, nepotism, simony and all the other ancient abuses were more rampant than ever. The monasteries had ceased to be even the nurseries of literature; their chronicles had run dry, and secular priests or laymen had taken up the pens that the monks had dropped. They were wealthier than ever, yet did little to justify their existence; indeed the spirit of the age was so much set against them that they found it hard to keep up the numbers of their inmates. Truculent pamphleteers like Simon Fish, who wrote *Beggars' Supplication*, were already demanding "that these sturdy boobies should be set abroad into the world, to get wives of their own, and earn their living by the sweat of their brows, according to the commandment of God; so might the king be better obeyed, matrimony be better kept, the gospel better preached, and none should rob the poor of his alms." It must be added that monastic scandals were not rare; though the majority of the houses were decently ordered, yet the unexceptionable testimony of archiepiscopal and episcopal visitations shows that in the years just before the Reformation there was a certain number of them where chastity of life and honesty of administration were equally unknown. But above all things the church was being criticized as an *imperium in imperio*, a privileged body not amenable to ordinary jurisdiction, and subservient to a foreign lord—the pope. And it was true that, much as English churchmen might grumble at papal exactions, they were generally ready as a body to support the pope against the Crown; the traditions of the mediaeval church made it impossible for them to do otherwise. That there would in any case have been a new outbreak of anti-clerical and anti-papal agitation in England, under

the influence of the Protestant impulse started by Luther in Germany, is certain. But two special causes gave its particular colour to the opening of the English Reformation; the one was that the king fell out with the papacy on the question of his divorce. The other was that the nation at this moment was chafing bitterly against a clerical minister, whom it (very unjustly) made responsible for the exorbitant taxation which it was enduring, in consequence of the king's useless and unsuccessful foreign wars. The irony of the situation lay in the facts that Henry was, so far as dogmatic views were concerned, a perfectly orthodox prince; he had a considerable knowledge of the old theological literature, as he had shown in his pamphlet against Luther, and though he was ready to repress clerical immunities and privileges that were inconvenient to the Crown, he had no sympathy whatever with the doctrinal side of the new revolt against the system of the mediaeval church. Moreover, Wolsey, whose fall was to synchronize with the commencement of the reforming movement, was if anything more in sympathy with change than was his master. He was an enlightened patron of the new learning, and was inclined to take vigorous measures in hand for the pruning away of the abuses of the church. It is significant that his great college at Oxford—"Cardinal's college" as he designed to call it, "Christ Church" as it is named to-day—was endowed with the revenues of some score of small monasteries which he had suppressed on the ground that they were useless or ill-conducted. His master turned the lesson to account a few years later; but Henry's wholesale destruction of religious houses was carried out not in the interests of learning, but mainly in those of the royal exchequer.

(C. W. C. O.)

VII. THE REFORMATION AND THE AGE OF ELIZABETH (1528–1603)

Wolsey did not fall through any opposition to reform; nor was he opposed to the idea of a divorce. Indeed, both in France and Spain he was credited with the authorship of the project. But he differed from Henry on the question of Catherine's successor. Wolsey desired a French marriage to consummate the breach upon which he was now bent with the emperor; and war, in fact, was precipitated with Spain in 1528. This is said to have been done without Henry's consent; he certainly wished to avoid war with Charles V., and peace was made after six months of passive hostility. Nor did Henry want a French princess; his affections were fixed for the time on Anne Boleyn, and she was the hope of the anti-clerical party. The crisis was brought to a head by the failure of Wolsey's plan to obtain a divorce. Originally it had been suggested that the ecclesiastical courts in England were competent without recourse to Rome. Wolsey deprecated this procedure, and application was made to Clement VII. Wolsey relied upon his French and Italian allies to exert the necessary powers of persuasion; and in 1528 a French army crossed the Alps, marched through Italy and threatened to drive Charles V. out of Naples. Clement was in a position to listen to Henry's prayer; and Campeggio was commissioned with Wolsey to hear the suit and grant the divorce.

No sooner had Campeggio started than the fortunes of war changed. The French were driven out of Naples, and the Imperialists again dominated Rome; the church, wrote Clement to Campeggio, was completely in the power of Charles V. The cardinal, therefore, must on no account pronounce against Charles's aunt; if he could not persuade Henry and Catherine to agree on a mutual separation, he must simply pass the time and come to no conclusion. Hence it was June 1529 before the court got to work at all, and then its proceedings were only preparatory to an adjournment and revocation of the suit to Rome in August. Clement VII. had, in his own words, made up his mind to live and die an imperialist; the last remnants of the French army in Italy had been routed, and the pope had perforce concluded the treaty of Barcelona, a sort of family compact between himself and Charles, whereby he undertook to protect Charles's aunt, and the emperor to support the Medici dynasty in Florence. This peace was amplified at the treaty of Cambrai (Aug. 1529) into a general European pacification in which England had no voice. So far had it fallen since 1521.

In every direction Wolsey had failed, and his failure involved the triumph of the forces which he had opposed. The fate of the papal system in England was bound up with his personal fortunes. It was he and he alone who had kept parliament at arm's length and the enemies of the church at bay. He had interested the king, and to some extent the nation, in a spirited foreign policy, had diverted their attention from domestic questions, and had staved off that parliamentary attack on the church which had been threatened 15 years before. Now he was doomed, and both Campeggio and Cardinal du Bellay were able to send their Governments accurate outlines of the future policy of Henry VIII. The church was to be robbed of its wealth, its power and its privileges, and the papal jurisdiction was to be abolished. In October Wolsey was deprived of the great seal, and surrendered many of his ecclesiastical preferments, though he was allowed to retain his archbishopric of York which he now visited for the first time. The first lay ministry since Edward the Confessor's time came into office; Sir Thomas More became lord chancellor, and Anne Boleyn's father lord privy seal; the only prominent cleric who remained in office was Stephen Gardiner, who succeeded Wolsey as bishop of Winchester.

The Act of Supremacy.—Parliament met in Nov. 1529 and passed many Acts against clerical exactions, mortuaries, probate dues and pluralities, which evoked a passionate protest from Bishop Fisher: "Now, with the Commons," he cried in the House of Lords, "is nothing but 'Down with the church.'" During 1530 Henry's agents were busy abroad making that appeal on the divorce to the universities which Cranmer had suggested. In 1531 the clergy in convocation, terrified by the charge of *praemunire* brought against them for recognizing Wolsey's legatine authority, paid Henry £118,000 and recognized him as supreme head of the church so far as the law of Christ would allow. The details of this surrender were worked out by king and Commons in 1532; but Gardiner and More secured the rejection of the Lords of the bill in which they were embodied, and it was not till 1533, when More had ceased to be chancellor and Gardiner to be secretary, that a parliamentary statute annihilated the independent legislative authority of the church. An Act was, however, passed in 1532 empowering the king, if he thought fit, to stop the payment of annates to Rome. Henry suspended his consent in order to induce the pope to grant Cranmer his bulls as archbishop of Canterbury where he succeeded Warham late in 1532. The stratagem was successful, and Henry cast off all disguise. The Act of annates was confirmed; another prohibiting appeals to Rome and providing for the appointment of bishops without recourse to the papacy was passed; and Cranmer declared Henry's marriage with Catherine null and void and that with Anne Boleyn, which had taken place about Jan. 25, 1533, valid. Anne was crowned in June, and on Sept. 7 the future Queen Elizabeth was born. At length in 1534 Clement VII. concluded the case at Rome, pronouncing in favour of Catherine's marriage, and drawing up a bull of excommunication against Henry and his abettors. But he did not venture to publish it; public opinion in England, while hostile to the divorce, was not in favour of the clergy or the pope, and the rivalry between Charles V. and Francis I. was too bitter to permit of joint, or even isolated, action against Henry. Charles was only too anxious to avoid the duty of carrying out the pope's commands, and a year later he was once more involved in war with France. Henry was able to deal roughly with such manifestations as Elizabeth Barton's visions, and in the autumn of 1534 to obtain from parliament the Act of Supremacy which transferred to him the juridical, though not the spiritual, powers of the pope. No penalties were attached to this Act, but another passed in the same session made it treason to attempt to deprive the king of any of his titles, of which supreme head of the church was one, being incorporated in the royal style by letters patent of Jan. 1535. Fisher and More were executed on this charge; they had been imprisoned in the previous year for objecting to take the form of oath to the succession as vested in Anne Boleyn's children which the commissioners prescribed. But their lives could only be forfeit on the supposition

that they sought to deprive the king of his royal supremacy. Many of the friars observant of Greenwich and monks of the Charterhouse were involved in a similar fate, but there was no general resistance, and Henry, now inspired or helped by Thomas Cromwell, was able to proceed with the next step in the Reformation, the dissolution of the monasteries.

Dissolution of the Monasteries.—It was Cecil's opinion 25 years later that, but for the dissolution, the cause of the Reformation could not have succeeded. Such a reason could hardly be avowed, and justification had to be sought in the condition of the monasteries themselves. The action of Wolsey and other bishops before 1529, the report of a commission of cardinals appointed by Paul III. in 1535, the subsequent experience of other, even Catholic, countries give collateral support to the conclusions of the visitors appointed by Cromwell, although they were dictated by a desire not to deal out impartial justice, but to find reasons for a policy already adopted in principle. That they exaggerated the evils of monastic life hardly admits of doubt; but even a Henry VIII. and a Thomas Cromwell would not have dared to attack, or succeeded in destroying, the monasteries had they retained their original purity and influence. As it was their doubtful reputation and financial embarrassments enabled Henry to offer them as a gigantic bribe to the upper classes of the laity, and the Reformation parliament met for its last session early in 1536 to give effect to the reports of the visitors and to the king's and their own desires.

But it had barely been dissolved in April when it became necessary to call another. In January the death of Catherine had rejoiced the hearts of Henry and Anne Boleyn, but Anne's happiness was short-lived. Two miscarriages and the failure to produce the requisite male heir linked her in Henry's mind and in misfortune to Catherine; unlike Catherine she was unpopular and not above suspicion. The story of her tragedy is still one of the most horrible and mysterious pages in English history. It is certain that Henry was tired and wanted to get rid of her; but if she were innocent, why were charges brought against her which were not brought against Catherine of Aragon and Anne of Cleves? and why were four other victims sacrificed when one would have been enough? The peers a year before could acquit Lord Dacre; would they have condemned the queen without some show of evidence? and unless there was suspicious evidence, her daughter was inhuman in making no effort subsequently to clear her mother's character. However that may be, Anne was not only condemned and executed, but her marriage was declared invalid and her daughter a bastard. Parliament was required to establish the succession on the new basis of Henry's new queen, Jane Seymour. It also empowered the king to leave the crown by will if he had no legitimate issue; but the illegitimate son, the duke of Richmond, in whose favour this provision is said to have been conceived, died shortly afterwards.

Fortunately for Henry, Queen Jane roused no domestic or foreign animosities; Charles V. and Francis I. were at war; and the pope's and Pole's attempt to profit by the Pilgrimage of Grace came too late to produce any effect except the ruin of Pole's family. The two risings of 1536 in Lincolnshire and Yorkshire were provoked partly by the dissolution of the monasteries, partly by the collection of a subsidy and fears of fresh taxation on births, marriages and burials, and partly by the protestantizing Ten Articles of 1536 and Cromwell's *Injunctions*. They were conservative demonstrations in favour of a restoration of the old order by means of a change of ministry, but not a change of dynasty. The Lincolnshire rising was over before the middle of October; the more serious revolt in Yorkshire under Aske lasted through the winter. Henry's lieutenants were compelled to temporize and make concessions. Aske was invited to come to London and hoodwinked by Henry into believing that the king was really bent on restoration and reform. But an impatient outburst of the insurgents and a foolish attempt to seize Hull and Scarborough gave Henry an excuse for repudiating the concessions made in his name. He could afford to do so because England south of the Trent remained stauncher to him than England north of it did to the Pilgrimage. Aske and other leaders were tried and executed, and summary vengeance was wreaked on the northern counties, especially on the monasteries. The one satisfactory outcome was the establishment of the Council of the North, which gave the shires between the Border and the Trent a stronger and more efficient government than they had ever had before.

The "Six Articles."—Probably the Pilgrimage had some effect in moderating Henry's progress. The monasteries did not benefit and in 1538–39 the greater were involved in the fate which had already overtaken the less. But no further advances were made towards Protestantism after the publication and authorization of the "Great" Bible in English. The Lutheran divines who came to England in 1538 with a project for a theological union were rebuffed; the parliament elected in 1539 was Catholic, and only the reforming bishops in the House of Lords offered any resistance to the Six Articles which reaffirmed the chief points in Catholic doctrine and practice. The alliance between pope, emperor and French king induced Henry to acquiesce in Cromwell's scheme for a political understanding with Cleves and the Schmalkaldic League, which might threaten Charles V.'s position in Germany and the Netherlands, but could not be of much direct advantage to England. Cromwell rashly sought to wed Henry to this policy, proposed Anne of Cleves as a bride for Henry, now once more a widower, and represented the marriage as England's sole protection against a Catholic league. Henry put his neck under the yoke, but soon discovered that there was no necessity; for Charles and Francis were already beginning to quarrel and had no thought of a joint attack on England. The discovery was fatal to Cromwell; after a severe struggle in the council he was abandoned to his enemies, attainted of treason and executed. Anne's marriage was declared null, and Henry found a fifth queen in Catherine Howard, a niece of Norfolk, a protégée of Gardiner, and a friend of the Catholic church.

Nevertheless there was no reversal of what had been done, only a check to the rate of progress. Cranmer remained archbishop and compiled an English Litany, while Catherine Howard soon ceased to be queen; charges of loose conduct, which in her case at any rate were not instigated by the king, were made against her and she was brought to the block; she was succeeded by Catherine Parr, a mild patron of the new learning. The Six Articles were only fitfully put in execution, especially in 1543 and 1546; all the plots against Cranmer failed; and before he died Henry was even considering the advisability of further steps in the religious reformation, apart from mere spoliation like the confiscation of the chantry lands.

But Scotland, Ireland and foreign affairs concerned him most. Something substantial was achieved in Ireland; the papal sovereignty was abolished and Henry received from the Irish parliament the title of king instead of lord of Ireland. The process was begun of converting Irish chieftains into English peers which eventually divorced the Irish people from their natural leaders; and principles of English law and government were spread beyond the Pale. In Scotland Henry was less fortunate. He failed to win over James V. to his anti-papal policy, revived the feudal claim to suzerainty, won the battle of Solway Moss (1542), and then after James's death bribed and threatened the Scots estates into concluding a treaty of marriage between their infant queen and Henry's son. The church in Scotland led by Beaton, and the French party led by James V.'s widow, Mary of Guise, soon reversed this decision, and Hertford's heavy hand was (1544) laid on Edinburgh in revenge. France was at the root of the evil, and Henry was thus induced once more to join Charles V. in war (1543). The joint invasion of 1544 led to the capture of Boulogne, but the emperor made peace in order to deal with the Lutherans and left Henry at war with France. The French attempted to retaliate in 1545, and burnt some villages in the Isle of Wight and on the coast of Sussex. But their expedition was a failure, and peace was made in 1546, by which Henry undertook to restore Boulogne in eight years' time on payment of 800,000 crowns. Scotland was not included in the pacification, and when Henry died (Jan. 28, 1547) he was busy preparing to renew his attempt on Scotland's independence.

Edward VI.—He left a council of 16 to rule during his son's

minority. The balance of parties which had existed since Cromwell's fall had been destroyed in the last months of the reign by the attainder of Norfolk and his son Surrey, and the exclusion of Gardiner and Thirlby from the council of regency. Men of the new learning prevailed, and Hertford (later duke of Somerset), as uncle to Edward VI., was made protector of the realm and governor of the king's person. He soon succeeded in removing the trammels imposed upon his authority, and made himself king in everything but name. He used his arbitrary power to modify the despotic system of the Tudors; all treason laws since Edward III., all heresy laws, all restrictions upon the publication of the Scriptures were removed in the first parliament of the reign, and various securities for liberty were enacted. The administration of the sacrament of the altar in both elements was permitted, the Catholic interpretation of the mass was rendered optional, images were removed, and English was introduced into nearly the whole church service. In the following session (1548–49) the first Act of Uniformity authorized the first Book of Common Prayer. It met with strenuous resistance in Devon and in Cornwall, where rebellions added to the thickening troubles of the protector.

His administration was singularly unsuccessful. In 1547 he won the great but barren victory of Pinkie Cleugh over the Scots, and attempted to push on the marriage and union by a mixture of conciliation and coercion. He made genuine and considerable concessions to Scottish feeling, guaranteeing autonomy and freedom of trade, and suggesting that the two realms should adopt the indifferent style of the empire of Great Britain. But he also seized Haddington in 1548, held by force the greater part of the Lowlands, and, when Mary was transported to France, revived the old feudal claims which he had dropped in 1547. France was, as ever, the backbone of the Scots resistance; men and money poured into Edinburgh to assist Mary of Guise and the French faction. The protector's offer to restore Boulogne could not purchase French acquiescence in the union of England and Scotland; and the bickerings on the borders in France and open fighting in Scotland led the French to declare war on England in Aug. 1549. They were encouraged by dissensions in England. Somerset's own brother, Thomas Seymour, jealous of the protector, intrigued against the Government; he sought to secure the hand of Elizabeth, the favour of Edward VI. and the support of the Suffolk line, secretly married Catherine Parr, and abused his office as lord high admiral to make friends with pirates and other enemies of order. Foes of the family, such as Warwick and Southampton, saw in his factious conduct the means of ruining both the brothers. Seymour was brought to the block, and the weak consent of the protector seriously damaged him in the public eye. His notorious sympathy with the peasantry further alienated the official classes and landed gentry, and his campaign against enclosures brought him into conflict with the strongest forces of the time. The remedial measures which he favoured failed; and the rising of Ket in Norfolk and others less important in nearly all the counties of England, made Somerset's position impossible. Bedford and Herbert suppressed the rebellion in the west, Warwick that in Norfolk (July–Aug. 1549). They then combined with the majority of the council and the discontented Catholics to remove the protector from office and imprison him in the Tower (October).

Establishment of Protestantism.—The Catholics hoped for reaction, the restoration of the mass, and the release of Gardiner and Bonner, who had been imprisoned for resistance to the protector's ecclesiastical policy. But Warwick meant to rely on the Protestant extremists; by Jan. 1550 the Catholics had been expelled from the council, and the pace of the Reformation increased instead of diminishing. Peace was made with France by the surrender of Boulogne and abandonment of the policy of union with Scotland (March 1550); and the approach of war between France and the emperor, coupled with the rising of the princes in Germany, relieved Warwick from foreign apprehensions and gave him a free hand at home. Gardiner, Bonner, Heath, Day and Tunstall were one by one deprived of their sees; a new ordinal simplified the ritual of ordination, and a second Act of Uniformity and Book of Common Prayer (1552) repudiated the Catholic interpretation which had been placed on the first and imposed a stricter conformity to the Protestant faith. All impediments to clerical marriage were removed, altars and organs were taken down, old service books destroyed and painted windows broken; it was even proposed to explain away the kneeling at the sacrament. The liberal measures of the protector were repealed, and new treasons were enacted; Somerset himself, who had been released and restored to the council in 1550, became an obstacle in Warwick's path, and was removed by means of a bogus plot, being executed in Jan. 1552; while Warwick had himself made duke of Northumberland, his friend Dorset duke of Suffolk, and Herbert earl of Pembroke.

But his ambition and violence made him deeply unpopular, and the failing health of Edward VI. opened up a serious prospect for Northumberland. He was only safe so long as he controlled the government, and prevented the administration of justice, and the knowledge that not only power but life was at stake drove him into a desperate plot for the retention of both. He could trade upon Edward's precocious hatred of Mary's religion, he could rely upon French fears of her Spanish inclinations, and the success which had attended his schemes in England deluded him into a belief that he could supplant the Tudor with a Dudley dynasty. His son Guilford Dudley was hastily married to Lady Jane Grey, the eldest granddaughter of Henry VIII.'s younger sister Mary. Henry's two daughters, Mary and Elizabeth, the descendants of his elder sister Margaret, and Lady Jane's mother, the duchess of Suffolk, were all to be passed over, and the succession was to be vested in Lady Jane and her heirs male. Edward was persuaded that he could devise the crown by will, the council and the judges were browbeaten into acquiescence, and three days after Edward's death (July 6, 1553), Lady Jane Grey was proclaimed queen in London. Northumberland had miscalculated the temper of the nation, and failed to kidnap Mary. She gathered her forces in Norfolk and Suffolk, Northumberland rode out from London to oppose her, but defection dogged his steps, and even in London Mary was proclaimed queen behind his back by his fellow-conspirators. Mary entered London amid unparalleled popular rejoicings, and Northumberland was sent to the scaffold.

Queen Mary.—Mary was determined from the first to restore papalism as well as Catholicism, but she had to go slowly. The papacy had few friends in England, and even Charles V., on whom Mary chiefly relied for guidance, was not eager to see the papal jurisdiction restored. He wanted England to be first firmly tied to the Habsburg interests by Mary's marriage with Philip. Nor was it generally anticipated that Mary would do more than restore religion as it had been left by her father. She did not attempt anything further in 1553 than the repeal of Edward VI.'s legislation and the accomplishment of the Spanish marriage. The latter project provoked fierce resistance; various risings were planned for the opening months of 1554, and Wyat's nearly proved successful. Only his arrogance and procrastination and Mary's own courage saved her throne. But the failure of this protest enabled Mary to carry through the Spanish marriage, which was consummated in July; and in the ensuing parliament (Oct.–Jan. 1554–55) all anti-papal legislation was repealed; Pole was received as legate; the realm was reconciled to Rome; and, although the holders of abbey lands were carefully protected against attempts at restitution, the church was empowered to work its will with regard to heresy. The Lollard statutes were revived, and between Feb. 1555 and Nov. 1558 some 300 Protestants were burnt at the stake. They began with John Rogers and Rowland Taylor, and Bishops Ferrar of St. Davids and Hooper of Gloucester. Ridley and Latimer were not burnt until Oct. 1555, and Cranmer not till March 1556. London, Essex, Hertfordshire, East Anglia, Kent and Sussex provided nearly all the victims; only one was burnt north of the Trent, and only one south-west of Wiltshire. But in the Protestant districts neither age nor sex was spared; even the dead were dug up and burnt. The result was to turn the hearts of Mary's people from herself, her church and her creed. Other causes helped to convert their enthusiastic loyalty into bitter hatred. The Spanish marriage was a failure from every point of view. In spite of Mary's repeated delusions,

she bore no child, and both parliament and people resisted every attempt to deprive Elizabeth of her right to the succession. Philip did all he could to conciliate English affections, but they would not have Spanish control at any price. They knew that his blandishments were dictated by ulterior designs, and that the absorption of England in the Habsburg empire was his ultimate aim. As it was, the Spanish connection checked England's aspirations; her adventurers were warned off the Spanish Main, and even trade with the colonies of Philip's ally Portugal was prohibited. They had to content themselves with the Arctic ocean and Muscovy; and they soon found themselves at war in Philip's interests. Philip himself refused to declare war on Scotland on England's behalf, but he induced Mary to declare war on France on his own (1557). The glory of the war fell to the Spaniards at St. Quentin (1557) and Gravelines (1558), but the shame to England by the loss of Calais (Jan. 1558). Ten months later Mary died (Nov. 17), deserted by her husband and broken-hearted at the loss of Calais and her failure to win English hearts back to Rome.

Elizabeth.—The Spanish and Venetian ambassadors in London were shocked at what they regarded as the indecent rejoicings over Elizabeth's accession. The nation, indeed, breathed a new life. Papal control of its ecclesiastical, and Spanish control of its foreign policy ceased, and it had a queen who gloried in being "mere English." There was really no possible rival sovereign, and no possible alternative policy. The English were tugging at the chain and Elizabeth had to follow; her efforts throughout were aimed at checking the pace at which her people wanted to go. She could not have married Philip had she wished to, and she could not have kept her sea-dogs off the Spanish Main. They were willing to take all the risks and relieve her of all responsibility; they filled her coffers with Spanish gold which they plundered as pirates, knowing that they might be hanged if caught; and they fought Elizabeth's enemies in France and in the Netherlands as irregulars, taking their chance of being shot if taken prisoners. While Elizabeth nursed prosperity in peace, her subjects sapped the strength of England's rivals by attacks which were none the less damaging because they escaped the name of war.

It required all Elizabeth's finesse to run with the hare and hunt with the hounds; but she was, as Henry III. of France said, *la plus fine femme du monde,* and she was ably seconded by Cecil who had already proved himself an adept in the art of taking cover. Nevertheless, English policy in their hands was essentially aggressive. It could not be otherwise if England was to emerge from the slough in which Mary had left it. The first step was to assert the principle of England for the English; the queen would have no foreign husband, though she found suitors useful as well as attractive. Spanish counsels were applauded and neglected, and the Spaniards soon departed. Elizabeth was glad of Philip's support at the negotiations for peace at Cateau Cambrésis (1559), but she took care to assert the independence of her diplomacy and of England's interests. At home the church was made once more English. All foreign jurisdiction was repudiated, and under the style "supreme governor" Elizabeth reclaimed nearly all the power which Henry VIII. had exercised as "supreme head." The Act of Uniformity (1559) restored with a few modifications the second prayer-book of Edward VI. The bishops almost unanimously refused to conform, and a clean sweep was made of the episcopal bench. An eminently safe and scholarly archbishop was found in Matthew Parker, who had not made himself notorious by resistance to authority even under Mary. The lower clergy were more amenable; the 200 who alone are said to have been ejected should perhaps be multiplied by five; but even so they were not one in seven, and these seven were clergy who had been promoted in Mary's reign, or who had stood the celibate and other tests of 1553–54. Into the balance must be thrown the hundreds, if not thousands, of zealots who had fled abroad and returned in 1558–59. The net result was that a few years later the lower house of convocation only rejected by one vote a very puritanical petition against vestments and other "popish dregs."

The next step was to expand the principle of England for the English into that of Britain for the British, and Knox's reformation in 1559–60 provided an opportunity for its application. By timely and daring intervention in Scotland Elizabeth procured the expulsion of the French bag and baggage from North Britain, and that French avenue to England was closed for ever. The logic of this plan was not applied to Ireland; there it was to be Ireland for the English for many a generation yet to come; and so Ireland remained Achilles' heel, the vulnerable part of the United Kingdom. The Protestant religion was forced upon the Irish in a foreign tongue and garb and at the point of foreign pikes; and national sentiment supported the ancient faith and the ancient habits in resistance to the Saxon innovations. In other directions the expansion of England, the third stage in the development of Elizabeth's policy, was more successful. The attractions of the Spanish Main converted the seafaring folk of south-west England into hardy Protestants, who could on conscientious as well as other grounds contest a papal allocation of new worlds to Spain and Portugal. Their monopoly was broken up by Hawkins, Drake, Frobisher, Raleigh, and scores of others who recognized no peace beyond the line; and although, as far as actual colonies went, the results of Elizabeth's reign were singularly meagre, the idea had taken root and the ground had been prepared. In every direction English influence penetrated, and Englishmen before 1603 might be found in every quarter of the globe, following Drake's lead into the Pacific, painfully breaking the ice in search of a north-east or a north-west passage, hunting for slaves in the wilds of Africa, journeying in caravans across the steppes of Russia into central Asia, bargaining with the Turks on the shores of the Golden Horn, or with the Greeks in the Levant, laying the foundations of the East India company, or of the colonies of Virginia and Newfoundland.

Mary, Queen of Scots.—This expansion was mainly at the expense of Spain; but at first Spain was regarded as Elizabeth's friend, not France. France had a rival candidate for Elizabeth's throne in Mary Stuart, the wife of the dauphin who soon (1559) became king as Francis II.; and Spanish favour was sought to neutralize this threat. Fortunately for Elizabeth, Francis died in 1560, and the French Government passed into the hands of Catherine de' Medici, who had no cause to love her daughter-in-law and the Guises. France, too, was soon paralysed by the wars of religion which Elizabeth judiciously fomented with anything but religious motives. Mary Stuart returned to Scotland with nothing but her brains and her charms on which to rely in her struggle with her people and her rival. She was well equipped in both respects, but human passions spoilt her chance; her heart turned her head. Elizabeth's head was stronger and she had no heart at all. When Mary married Darnley she had the ball at her feet; the pair had the best claims to the English succession and enjoyed the united affections of the Catholics. But they soon ceased to love one another, and could not control their jealousies. There followed rapidly the murders of Rizzio and Darnley, the Bothwell marriage, Mary's defeat, captivity, and flight into England (1568). It was a difficult problem for Elizabeth to solve; to let Mary go to France was presenting a good deal more than a pawn to her enemies; to restore her by force to her Scottish throne might have been heroic, but it certainly was not politics; to hand her over to her Scottish foes was too mean even for Elizabeth; and to keep her in England was to nurse a spark in a powder-magazine. Mary was detained in the hope that the spark might be carefully isolated.

But there was too much inflammable material about. The duke of Norfolk was a Protestant, but his convictions were weaker than his ambition, and he fell a victim to Mary's unseen charms. The Catholic north of England was to rise under the earls of Westmorland and Northumberland, who objected to Elizabeth's seizure of their mines and jurisdictions as well as to her proscription of their faith; and the pope was to assist with a bull of deposition. Norfolk, however, played the coward; the bull came nearly a year too late, and the rebellion of the earls (1569) was easily crushed. But the conspiracies did not end, and Spain began to take a hand. Elizabeth, partly in revenge for the treatment of Hawkins and Drake at San Juan de Ulloa, seized some Spanish treasure on its way to the Netherlands (Dec. 1569). Alva's opera-

tions were fatally handicapped by this disaster, but Philip was too much involved in the Netherlands to declare war on England. But his friendship for Elizabeth had received a shock, and henceforth his finger may be traced in most of the plots against her, of which the Ridolfi conspiracy was the first. It cost Norfolk his head and Mary more of her scanty liberty. Elizabeth also began to look to France, and in 1572, by the treaty of Blois, France instead of Spain became England's ally, while Philip constituted himself as Mary's patron. The massacre of St. Bartholomew placed a severe strain upon the new alliance, but was not fatal to it. A series of prolonged but hollow marriage negotiations between Elizabeth and first Anjou (afterwards Henry III.) and then Alençon (afterwards duke of Anjou) served to keep up appearances. But the friendship was never warm; Elizabeth's relations with the Huguenots on the one hand and her fear of French designs on the Netherlands on the other prevented much cordiality. But the alliance stood in the way of a Franco-Spanish agreement, limited Elizabeth's sympathy with the French Protestants, and enabled her to give more countenance than she otherwise might have done to the Dutch.

War with Spain.—Gradually Philip grew more hostile under provocation; slowly he came to the conclusion that he could never subdue the Dutch or check English attacks on the Spanish Main without a conquest of England. Simultaneously the counter-Reformation began its attacks; the "Jesuit invasion" took place in 1580, and Campion went to the block. A papal and Spanish attempt upon Ireland in the same year was foiled at Smerwick. But more important was Philip's acquisition of the throne of Portugal with its harbours, its colonies and its marine. This for the first time gave him a real command of the sea, and at least doubled the chances of a successful attack upon England. But Philip's mind moved slowly and only on provocation. It took a year or two to satisfy him that Portugal was really his; not until 1583 was the fleet of the pretender Don Antonio destroyed in the Azores. The victor, Santa Cruz, then suggested an armada against England, but the English Catholics could not be brought into line with a Spanish invasion. The various attempts to square James VI. of Scotland had not been successful, and events in the Netherlands and in France disturbed Philip's calculations. But his purpose was now probably fixed. After the murder of William the Silent (1584) Elizabeth sided more openly with the Dutch; the Spanish ambassador Mendoza was expelled from England for his intrigues with Elizabeth's enemies (1586); and on the discovery of Babington's plot Elizabeth yielded to the demand of her parliament and her ministers for Mary's execution (1587); her death removed the only possible centre for a Catholic rebellion in case of a Spanish attack. It also removed Philip's last doubts; Mary had left him her claims to the English throne, and he might, now that she was out of his path, hope to treat England like Portugal. Drake's "singeing of Philip's beard" in Cadiz harbour in 1587 delayed the expedition for a year, and a storm again postponed it in the early summer of 1588. At length the armada sailed in July under the incompetent duke of Medina Sidonia; its object was to secure command of the narrow seas and facilitate the transport of Parma's army from the Netherlands to England. But Philip after his 20 years' experience in the Netherlands can hardly have hoped to conquer a bigger and richer country with scantier means and forces. He relied in fact upon a domestic explosion, and the armada was only to be the torch. The miscalculation made it a hopeless enterprise from the first. Scarcely an English Catholic would have raised a finger in Philip's favour; and when he could not subdue the two provinces of Holland and Zealand, it is absurd to suppose that he could have simultaneously subdued them and England as well. English armies were not perhaps very efficient, but they were as good as the material with which William of Orange began his task. Philip, however, was never given the opportunity. His armada was severely handled in a week's fighting on its way up the Channel, and was driven off the English ports into the North Sea; there a south-west gale drove it far from its rendezvous, and completed the havoc which the English ships had begun. A miserable remnant alone escaped destruction in its perilous flight round the north and west of Scotland.

The defeat of the armada was the beginning and not the end of the war; and there were moments between 1588 and 1603 when England was more seriously alarmed than in 1588. The Spaniards seized Calais in 1596; at another time they threatened England from Brest, and the "invisible" armada of 1599 created a greater panic than the "invincible" armada of 1588. It was not till the very end of the reign that what was in some ways the most dangerous of Spanish aggressions was foiled at Kinsale. Nor were the English counter-attacks very happy; the attempt on Portugal in 1589 under Drake and Norris proved a complete failure. The raid on Cadiz under Essex and Raleigh in 1596 was attended with better results, but the "Islands" voyage to the Azores in 1597 was a very partial success. Still it was now a war upon more or less equal terms, and there was little more likelihood that it would end with England's than with Spain's loss of national independence. The subjection of the Netherlands was now almost out of the question, and although Elizabeth's help had not enabled the Protestant cause to win in France, Henry IV. built up a national monarchy which would be quite as effectual a bar to the ambitions of Spain.

Elizabeth had in fact safely piloted England through the struggle to assert its national independence in religion and politics and its claim to a share in the new inheritance which had been opened up for the nations of Europe; and the passionate loyalty which had supported her as the embodiment of England's aspirations somewhat cooled in her declining years. She herself grew more cautious and conservative than ever, and was regarded as an obstacle by the hotheads in war and religion. She sided with the "scribes," Burghley and Sir Robert Cecil, against the men of war, Essex and Raleigh; and she abetted Whitgift's rigorous persecution of the Puritans whose discontent with her *via media* was rancorously expressed in the Martin Marprelate tracts. Essex's folly and failure to crush Hugh O'Neill's rebellion (1599), the most serious effort made in the reign to throw off the English yoke in Ireland, involved him in treason and brought him to the block. Parliament was beginning to quarrel with the royal prerogative, particularly when expressed in the grant of monopolies, and even Mountjoy's success in Ireland (1602–03) failed to revive popular enthusiasm for the dying queen. Strange as it may seem, the accession of James I. (March 24, 1603) was hailed by Shakespeare, and minor writers, as heralding a new and gladder age.

(A. F. Po.)

VIII. THE STUARTS, 1603–1714

James I., 1603–1625.—The first Stuart king ascended the throne of England under favourable auspices. In the war with Spain the English nation had asserted its political and religious independence and had laid the foundation of its naval supremacy. Trade was expanding and wealth increasing. By the union of the Crowns an old enemy of England became her partner and a fully insular kingdom was established. The Elizabethan conquest of Ireland made the new king effective master of that country.

James was in his 37th year, a mature and experienced man. He had maintained correspondence with ministers and courtiers of Elizabeth, so that her death found him prepared. For the most part he kept the old servants of the Crown in their places, giving his chief confidence to Sir Robert Cecil, the secretary, whom he successively created Viscount Cranborne and earl of Salisbury. James encountered no serious opposition. A lover of peace, he negotiated a treaty with Spain in 1604. At home ecclesiastical affairs claimed his first attention. Both of the parties which had suffered under Elizabeth looked to him for relief; the Catholics expected much from the son of Mary Stuart; the Puritans expected much from a king of Scots bred in Calvinist orthodoxy. James began by remitting the recusancy fines, but soon found that he could not dispense with that source of revenue. His return to the policy of intolerance revived Catholic discontent, which broke out in the Gunpowder Plot of 1605. In Scotland he had often been incensed by the ministers of the Kirk, who claimed ecclesiastical independence together with the right of admonishing sovereigns. On his journey southwards he received ungraciously the so-called Millenary Petition, in which a thousand ministers,

it was said, asked for certain changes in rites and ceremonies. In a conference at Hampton Court between divines of opposite schools, where the king presided, he declared his abhorrence of Presbytery and refused all concessions save a new and more accurate translation of the Scriptures, fulfilled in the Authorized Version.

James and Parliament.—The king met his first parliament in March 1604. With the advance of prosperity and enlightenment, the classes represented in the House of Commons—the squires and yeomen, the citizens and lawyers—became more self-confident and more desirous of power. But James held in its extreme form the doctrine of Divine right then generally accepted. As the king, and the king alone, derives his power direct from God, he can in the last resort overrule every other authority; parliament holds its privileges merely by his free grace. Against this doctrine the Commons maintained that they held their privileges, like their lands and goods, not of grace but of right, thus implying that the royal prerogative could be limited by law. Contrary to the king's wishes, the Commons pressed for the strict execution of the laws against Catholics and for indulgence to Puritans. James wished the personal union of England and Scotland to be followed by an incorporating union, but the Commons, who disliked the Scots and feared their competition in trade, would only consent to a mutual repeal of hostile laws. The Commons wanted the king to forgo his right of purveyance and his rights of wardship and marriage over minors who were tenants of the Crown in return for a fixed revenue somewhat larger than the product of these rights. The proposed bargain, known as the Great Contract, was repeatedly discussed, but came to nought because James demanded a larger equivalent than the Commons would grant. The Commons were penurious and James, a bad economist, sank into debt. The Commons took alarm at the decision in Bates' case by the court of exchequer in 1606, which laid down, not merely that the king could levy customs duties at his pleasure (impositions, so-called), but also that he had a power of taking measures for the public safety unlimited by law (*see* BATES, JOHN).

James dissolved his first parliament in 1611. Salisbury, whom he made treasurer in 1608 and who did something to relieve his distress, died in 1612. The heir to the crown, Prince Henry, died in the same year. A new parliament in 1614 proved unmanageable, made no grant, enacted no law and was dissolved after a session of two months. James struggled on for seven years without a parliament. Always under the influence of favourites chosen for their youth and good looks, he was fascinated at this time by a certain George Villiers, whom he made successively earl, marquess and duke of Buckingham. In 1615 and the following years a London merchant, Lionel Cranfield, who had been brought into the king's service, effected such reforms and economies that revenue at last balanced expenditure. But then the outbreak of the Thirty Years' War involved James in new difficulties.

Foreign Affairs.—Frederick, Elector Palatine, chief of the German Calvinists, who had married the king's daughter Elizabeth, gave the occasion for that war by accepting the crown of Bohemia. He was promptly expelled from Bohemia by the new emperor, Ferdinand II., and the Catholic princes of Germany, while a Spanish army overran the Palatinate. James had long fancied that he could ensure the peace of Christendom by marrying his son to a daughter of the king of Spain, who was still regarded as the foremost Catholic sovereign. He hoped thus to enlist Spanish mediation on behalf of his son-in-law. The English public, which believed that Spain was the contriver of every Catholic attack upon Protestants, and that a Spanish war would be lucrative, wished to help Frederick by attacking Philip III. Philip had not instigated the war in Germany, but he felt no desire to save a rebel and a heretic, nor did he wish to marry his daughter in England, unless the English king and people were ready to return to the Catholic faith. As it became clear that Frederick could recover the Palatinate only by force of arms, James was driven to meet a third parliament in Jan. 1621. The Commons, after making a small grant in earnest of their goodwill, went on to consider grievances, especially monopolies, which had been multiplied of late. Their enquiries led to the impeachment of Sir Giles Mompesson (the first impeachment since the accession of the Tudors) and the condemnation of Lord Bacon, the chancellor, on charges of judicial corruption. A second session having produced no further grant, James dissolved the parliament and sent one or two members to prison. He fell back on his project of a Spanish marriage. The new king of Spain, Philip IV., proving as dilatory as his father, Prince Charles and Buckingham thought to expedite matters by a visit to Madrid. By reckless concessions they obtained a marriage treaty, but the Infanta was to remain with her brother until it was known whether the promise of toleration to the English Catholics had been fulfilled. Even so, Philip refused to do anything on behalf of Frederick, and Charles and Buckingham returned bitterly resentful and determined to break with Spain. They forced James to call a new parliament in 1624. It was eager for a Spanish war which the king still hoped to avert. It also passed the one important statute of the reign, the act prohibiting monopolies. But it did not work smoothly with the Crown. A negotiation with France for the hand of Henrietta Maria, sister of Louis XIII., led the king and prince secretly to promise a toleration for the English Catholics. Soon afterward James died, on March 27, 1625.

Ireland and America.—His reign was memorable in Irish history. The submission of the earl of Tyrone almost immediately after the death of Elizabeth was followed by the enforcement of the English legal and administrative systems throughout the kingdom. A few years later Tyrone and the earl of Tyrconnel, falling under the suspicion of the Government, fled from Ireland. Their flight being construed as proof of guilt, six of the northern counties were declared forfeit to the Crown. The actual possessors were moved into the less fertile tracts, and the best land was used for the great Ulster plantations, which created a strong English and Scottish colony in the north of Ireland. (*See* PLANTATION.) The reign of James also witnessed the foundation of British rule in North America. The colony of Virginia was finally established in 1607; Plymouth, Mass., the starting point of New England, was founded in 1620.

CHARLES I., 1625–1649

Charles and Parliament.—Charles at his accession was in his 25th year. He had thoroughly imbibed his father's political principles. His chief counsellor was Buckingham, who retained with the son all the influence which he had possessed with the father. While yet prince, Charles had engaged England in war with Spain. He was also at war with the emperor, whom he could attack only by subsidizing his enemies. Charles called a parliament which met in June 1625. Zeal for the Spanish war had cooled when there was no longer the possibility of a Spanish queen. Wishing to enforce a settlement of the dispute about impositions, the Commons withheld the usual grant of customs, tunnage and poundage to a new king for the term of his life. Attached to Puritan theology the Commons saw with alarm the rise of an Anglo-Catholic (or Arminian) school of divines, who insisted on the absolute authority of the Crown because they looked to the Crown for protection.

Charles soon dissolved the parliament. In the autumn an expedition against Cadiz failed and brought obloquy upon Buckingham who, as lord high admiral, was held accountable for the defects of the fleet, although he had not taken command. Charles had to call another parliament in 1626. Led by the eloquent Sir John Eliot, the Commons impeached Buckingham and Charles dissolved the parliament to save his friend. Again he had secured no grant. Since his accession he had levied customs, tunnage, poundage and impositions by his own authority. He resorted to doubtful expedients, especially a forced loan, and punished with imprisonment or otherwise those who refused to contribute. He obtained a decision of the judges in favour of his right to imprison at discretion. Meanwhile, largely through disputes arising out of the marriage treaty, Charles had drifted into war with France. An expedition led by Buckingham to occupy the Isle of Ré, near the Huguenot stronghold of Rochelle, had failed with

heavy loss. He was thus forced to call a third parliament. The Commons adopted a petition of right by which they condemned arbitrary taxation and imprisonment, the enforcement of martial law and the billeting of soldiers as contrary to the law of the land. Charles first gave an evasive answer and then assented in the usual form. In return the Commons made a grant. In the course of the following recess Buckingham was murdered by a fanatic, and one of the ablest leaders of the Commons, Sir Thomas Wentworth, went over to the king's side. When parliament reassembled, the king and the Commons entered on a dispute about the levy of tunnage and poundage by prerogative, and the Commons spent much time in discussing the affairs of the Church. At last the king commanded the House to adjourn. Before it obeyed it passed resolutions declaring all who favoured Arminianism or paid duties not granted by parliament to be enemies of their country. Charles replied with a dissolution and sent nine members to prison. Sir John Eliot died in the Tower.

Personal Government.—The king resolved to summon no more parliaments until he could be sure of their compliance. For the next 11 years he ruled as an absolute monarch. He shaped his own policy, for nobody succeeded to Buckingham's influence. He made peace with Spain in 1629 and with France in 1630 and, although he tried diplomatic means to help his sister and her children, he took no military measures against the emperor. In order to meet necessary expenses he had to go on levying customs, tunnage, poundage and impositions, and to adopt obsolete or questionable expedients for raising revenue. In 1634 he levied shipmoney, although he was not at war, and in 1635 levied it, not merely on the coast towns and counties, but on the whole kingdom. Twice consulted, the judges twice declared that this action was legal; but the judges were liable to be dismissed at the king's pleasure. Even so, when John Hampden (*q.v.*) forced a decision in the court of exchequer chamber, five out of the 12 judges decided in his favour. At the same time the king sought to extirpate Puritanism. A devout Anglo-Catholic, he gave his confidence to William Laud, bishop of St. David's, who became in 1628 bishop of London and in 1633 archbishop of Canterbury. By a metropolitan visitation prolonged over three years, Laud enforced the Anglo-Catholic standard of doctrine and ritual. With the help of the court of high commission he made it impossible for any honest Puritan minister to keep his living. When Puritan indignation burst forth in furious pamphlets, the authors were hunted down and punished without mercy in the Star Chamber.

The Scottish Revolt.—It was in Scotland, however, that the religious revolt began. Scotland was still a feudal country where men cared little about politics. But in Scotland the Reformation had been a popular movement, the Kirk had a democratic organization, and the influence of the ministers over the Lowland population was prodigious. James had restored episcopacy and broken the power of the General Assembly. Charles continued his policy. In 1637 he sent down to Scotland a liturgy closely resembling the Anglican. The first reading in St. Giles' cathedral in Edinburgh caused a riot. Organized resistance followed. A National Covenant binding the subscribers to uphold the king's authority and the purity of the Kirk was signed by multitudes. Charles thought it necessary to allow the meeting of a General Assembly which abolished episcopacy. Then Charles prepared for war. But his army was untrained and spiritless, while the army of the Covenanters was full of enthusiasm and contained many who had gained experience as soldiers of fortune on the Continent. Charles, therefore, consented to negotiate. By the treaty of Berwick everything was referred to a new parliament and General Assembly. But fresh disputes followed. Resolved to continue the war, Charles was driven by want of money to summon the English parliament. Even Wentworth who, as president of the Council of the North and as lord deputy in Ireland, had ruled with great ability and in the most despotic temper (and about this time was created earl of Strafford, *q.v.*), advised this step, trusting to the old national grudge of Englishmen against Scotsmen. When parliament met, the Commons proceeded at once to the redress of grievances. The king insisted that they must first supply his wants, but having heard that the leaders of the Commons were negotiating with the Scots, he hastily dissolved the parliament. The arbitrary measures recommended by Strafford did not avail, however, to fill the Treasury. The Scots invaded England and occupied Northumberland and Durham. Then 12 peers petitioned the king to call a new parliament. He preferred to call a great council of the peers at York. The peers negotiated with the Scots the treaty of Ripon. But the calling of a new parliament could not be avoided.

The Long Parliament.—The parliament met on Nov. 3, 1640. The king was at its mercy, for both the English and the Scottish armies in the north had to be maintained out of the English revenue. The parliament was resolved, first to punish the king's councillors and, secondly, to make personal government impossible. Finch, the lord keeper, and Windebank, the secretary, saved themselves by flight. Led by Pym (*q.v.*) and Hampden, the Commons impeached Strafford and the archbishop. Under a forced construction of the law Strafford was charged with treason, but the evidence was weak, and the impeachment was exchanged for a bill of attainder. The assent of the Lords and the king was extorted by fear of popular violence, and Strafford was executed on May 12, 1641. Acts were passed forbidding all the unparliamentary modes of taxation employed by the king. Other acts suppressed all the extraordinary courts which had been the most effective weapons of the Crown, the Star Chamber, the Council of the North, the Council of Wales and the Court of High Commission. An act was passed to ensure that parliaments should never again be intermitted for more than three years: it was also enacted that the existing parliament should not be dissolved without its own consent. But upon ecclesiastical questions there was no agreement. A bill to abolish episcopacy was brought into the Commons, but went no further. A bill to remove the bishops from parliament passed the Commons, but was lost in the Lords. Many desired indulgence for Puritan scruples about rites and ceremonies, while some would have liked to abolish the Book of Common Prayer. None was prepared to grant unlimited freedom of conscience which was to be a dream for many years to come.

In Sept. 1641 Charles visited Scotland with the vain hope of conciliating all parties in that country. Before his return a rebellion broke out in Ireland. Its causes were national sentiment, the hatred inspired by the policy of plantation and fear for the Catholic religion. Strafford's death, and the disbandment of the army which he had formed, gave the opportunity. Beginning in Ulster, the revolt soon spread over most of Ireland and was marked by much cruelty. To raise armies and appoint commanders was the king's prerogative. But the parliament dared not trust the king with an army. The leaders of the Commons brought in the Grand Remonstrance which recited all the misdeeds of his reign, real or imaginary, and ended with a petition for the appointment of ministers whom parliament could trust. The Remonstrance was carried by a majority of 11 only. From this time the division of parties in parliament was irreconcilable. The king in his reply claimed full freedom to choose his advisers. Somewhat later his personal attempt to arrest five members, Pym, Hampden, Holles, Hazlerigg and Strode, on a charge of treason embittered the conflict. In order, however, to gain time for sending the queen to the Continent, he assented to a bill for the exclusion of the bishops from the House of Lords. When she was gone he proceeded to York, where the northern nobility and gentry flocked round him. There followed an interchange of manifestos ending with the Nineteen Propositions in which the parliament claimed amongst other things that its approbation should be necessary for the appointment of privy councillors, ministers of State and chiefs of the courts of common law. The king refused these demands. Both parties prepared for war and the king raised his standard at Nottingham on Aug. 22, 1642.

The First Civil War.—As the civil war was fought to decide political and ecclesiastical rather than economic issues, men of all classes were found on either side. But a great majority of the peers and gentry were for the king, and a great majority of traders and craftsmen with many yeomen were for the parliament. The portion of England east of a line from the Humber to Southampton Water was on the side of the parliament, while the north, the

west and Wales were mainly for the king. Holding London and nearly all the other ports, the Parliament could levy the customs and was financially the stronger. Its hold on the ports was secure, as the navy declared for the parliament. Neither party had an effective army. The only force known to the law—the militia—was ill-trained except in London and was not liable to serve outside its county, except in case of foreign invasion. Both sides tried to enlist volunteers and both had recourse to impressment. Cavalry still played a large part in battles, and in cavalry the king had an advantage, for the gentry were a warlike class with a long military tradition.

After the first battle at Edgehill and an unsuccessful attempt on London, the king established himself in Oxford, which became his capital for the rest of the war. His friends were so successful that by the autumn of 1643 he was master of three-fourths of the kingdom. The parliament then sought the help of the Scots who had hitherto been neutral, but who felt that the Kirk could not be secure unless Presbyterianism prevailed in England. By the Solemn League and Covenant the Scots undertook to help in the war, while the parliament promised, or seemed to promise, that it would adopt the Presbyterian system. The trial and execution of Archbishop Laud were a result of this alliance. Early in 1644 the Scots invaded England. With the help of a parliamentary army they gained the battle of Marston Moor (July 2), which ended the king's power in the north. His own successes in the south could not counterbalance this disaster, but drove the parliament to make a really effective army. By the Self-denying Ordinance it required all members of either House to resign their commissions, thus getting rid of several incapable leaders. It resolved to raise a new army, the famous New Model, composed of men who should undertake to serve until the end of the war and to go whithersoever they should be required. The command-in-chief was given to Sir Thomas Fairfax; the second in command was Oliver Cromwell. At Naseby, June 14, 1645, Fairfax won a victory which drove the king out of the midlands. He then conquered the southwest, and in the spring of 1646 returned to besiege Oxford. Charles fled from Oxford in disguise and took refuge with the Scottish army. Thus ended the first Civil War.

The Second Civil War.—As conditions of a settlement the parliament demanded the control of the militia, the punishment of the king's chief supporters and the establishment of Presbyterianism. The king refusing these terms, the Scots handed him over to the parliament and returned to their own country. Then a third party interposed. The war being over, the parliament wished to send part of the army to Ireland and disband another part. Before allowing themselves to be thus dispersed, the soldiers wanted payment of their arrears, and the Independants and other sectaries among them wanted to be secure of toleration. Unable to obtain satisfaction, they took the king into their custody and tried to reach an understanding with him. They offered freedom of conscience and a merciful treatment of his friends, but they desired democratic changes which would have further reduced the power of the Crown. Convinced that neither army nor parliament could stand without his support, Charles would not close with either, but negotiated with the Scots a treaty known as the Engagement, by which they were to restore him to power and he was to establish Presbyterianism in England for three years. There followed the second Civil War—a series of scattered and futile insurrections. A Scottish invading army was wellnigh destroyed by Cromwell in the campaign of Preston. Through these events the party among the soldiers which maintained that negotiation with the king was useless and that he should be tried and punished for his part in the civil wars, became supreme. The military chiefs purged the House of Commons. A remnant of 60 or 70 members, the so-called Rump, passed a bill creating a high court of justice to try the king. When the Lords rejected it, they passed it once more with a declaration that the assent of the Lords was needless. Brought before the high court, Charles refused to acknowledge its jurisdiction and, on a second and third appearance, reiterated his refusal. He was nevertheless condemned. On Jan. 30, 1649, he was executed in front of the Banqueting House, Whitehall. (*See* also CHARLES I., GREAT REBELLION, CROMWELL.)

THE COMMONWEALTH—1649–1660

The king's death was followed by the abolition of the monarchy and the House of Lords, and the proclamation of a Commonwealth. Executive power was vested in a council of state. In fact the Commonwealth was based upon the army, for the bulk of the nation held monarchical opinions and resented the rule of the sword, the heavy taxation and the suppression of popular amusements. All parties in Ireland were hostile to the Commonwealth. The Scots, upon hearing of the king's execution, proclaimed his son. No foreign power recognized the Commonwealth. Its upholders were not united. But mutiny in the army was quelled by the prompt action of Fairfax and Cromwell, and against the army the other malcontents were impotent. Cromwell, in his Irish campaign, broke up the royalist combination and conquered half the kingdom. He was then recalled to take the command against the Scots. Charles II. had been allowed to land on condition of subscribing the Covenants, but enjoyed little power. The victory of Dunbar, Sept. 3, 1650, enabled Cromwell to occupy Edinburgh. Charles resolved to invade England, where he hoped to find recruits. Taking the western road, he reached Worcester without meeting opposition, but also without gaining many adherents. Cromwell marched rapidly south, closed upon Worcester with superior forces and annihilated the Scottish army (Sept. 3, 1651). Charles ultimately escaped to France. Before the end of 1652 Scotland and Ireland were thoroughly subdued and were thenceforward ruled as conquered countries. In Ireland confiscation and plantation on a vast scale ensued.

Expulsion of the Parliament and Rule of Cromwell.—The Commonwealth had obtained recognition from France and Spain, but commercial and colonial rivalry had involved it in war with Holland. A schism opened between the army and the parliament. Afraid of the general ill-will, the parliament sought to put off its dissolution as long as possible. Impatient for certain reforms, the army pressed for a dissolution. Finally Cromwell and the officers expelled both parliament and Council of State in April 1653. There no longer existed a semblance of legal power. The Council of Officers sent letters to the congregational Churches, inviting them to nominate representatives. Out of the names thus submitted the Council chose 129 for England, five for Scotland and six for Ireland. Thus was formed the so-called Little Parliament which was really a congress of Puritan notables. Its reforms alarmed the clergy, the lawyers and the owners of property. Cromwell became convinced that the parliament would not answer: a minority made a voluntary resignation and the rest were expelled by the soldiers. (*See* BAREBONES PARLIAMENT.) From this event dates the beginning of a political reaction in England. Those officers who were attached to old institutions drew up the Instrument of Government (*q.v.*), a written constitution aiming at a separation and balance of powers. It set up (1) a lord protector elected for life and wielding executive authority; (2) a council of State nominated in the first instance and holding for life, whose consent was required for important executive acts; (3) a parliament of one chamber representing the three kingdoms and possessing legislative power. Cromwell became protector and called a parliament. When it met, the parliament claimed full power of revising the Instrument. Cromwell maintained that the essentials of the Instrument, such as the division of power between a single person and a parliament, must be regarded as beyond discussion. He thought it necessary to exclude a number of the most obstinate members, and dissolved the parliament at the earliest date possible. These events encouraged Royalist conspiracy. Then Cromwell divided England into districts, setting over each a major-general armed with extraordinary powers. The approach of war with Spain induced him, however, to call another parliament which met in Sept. 1656. Again Cromwell excluded about 100 members, while others stayed away of their own accord. Those who remained desired a further return to English tradition. By the so-called Humble Petition and Advice they offered Cromwell the crown, while they claimed for the House the sole power of deciding on its membership, and established a new House of Lords. Rejecting the title of king, which was distasteful to the army, Cromwell accepted the other provisions. After the prorogation he nominated the new

Lords. When parliament re-assembled, many of his friends had been removed to the upper house, while the excluded members took their seats. Thus the temper of the Commons was mutinous. They refused to acknowledge the powers of the Lords, and Cromwell in anger dissolved the parliament.

In his foreign policy Cromwell had two aims; to help the Protestant cause and to augment English commerce and colonies. Regretting the Dutch war, he nevertheless prosecuted it to a successful conclusion. He negotiated commercial treaties with Denmark, Sweden and Portugal. England had grievances against both France and Spain. Regarding Spain as the bitterest enemy of Protestantism, and angered by the Spanish endeavour to exclude English commerce from any part of the New World, Cromwell decided upon war with Spain, and was thus led to ally himself with France. He conquered Jamaica and Dunkirk at the cost of giving an impetus to French power and ambition. At the height of success he died, worn out by labour and anxiety.

Fall of the Commonwealth.—Cromwell was understood to have nominated his eldest son Richard (*see* CROMWELL, RICHARD) as his successor. Richard called a parliament, which the officers forced him to dissolve, as they desired more independence for the army than the parliament would allow. They recalled the Rump, which condemned government by a single person. But conflict broke out afresh, and the soldiers expelled the Rump. A Royalist reaction spread all over the country, for a Stuart restoration seemed the only escape from the rule of the sword. Monk, who commanded the English army in Scotland, and had hitherto kept aloof from politics, declared for a free parliament and marched southwards. He met with no effective opposition. The officers in England were forced to recall the Rump. The Rump welcomed Monk, but he saw that the nation was weary of them. He sent back to their seats the members expelled in 1648 and the parliament thus restored voted its own dissolution. Monk sent Sir John Grenville to Charles with advice on the offers he should make. From Breda, in Holland, Charles issued a declaration promising, subject to parliamentary sanction, a general amnesty, religious toleration and the payment of arrears to the troops. The new parliament was largely Presbyterian and almost wholly Royalist. A few peers met and resumed their sittings, which were not called in question. Both Houses sent a deputation inviting Charles to return. He made his entry into London on May 29, 1660.

CHARLES II., 1660–1685

The Restoration Settlement.—The king's chief adviser was Edward Hyde, lord chancellor and earl of Clarendon, who had been his father's ablest councillor in the Civil War. The Convention Parliament passed a bill of indemnity excepting only the regicides. It raised funds to pay off the army which was disbanded, although the king was allowed to keep a couple of regiments for his protection, the germ of the later standing army. The lands, whether of the Crown, of the Church, or of private persons, confiscated by the revolutionary government, were restored to their former owners. The royal right of purveyance and the military tenures with the burthensome incidents of wardship and marriage were suppressed in exchange for an hereditary excise settled on the Crown. Nothing was done for religious toleration. Scotland became once more an independent kingdom. All the legislation of Scottish parliaments after 1633 was declared invalid. Ireland returned to its former status. But the enormous confiscation of land under the Commonwealth was for the most part confirmed by the Act of Settlement. Soon the king and Clarendon began to diverge. A Catholic at heart, the king hoped to benefit the Catholics by linking their cause with that of the Puritans, and therefore favoured a policy of toleration. For himself he wanted absolute power. Clarendon and the Royalists wished neither for toleration nor for despotism. The new parliament elected in 1661 passed the Act of Uniformity, which drove all Puritan ministers out of the Church, and laid the foundation of modern dissent. It passed other persecuting statutes, the Corporation Act, the Conventicle Act, the Five Mile Act. Claiming a power to dispense with the law, Charles held out the hope of relief to the persecuted, but the parliament forced him to desist. Clarendon, however, became generally unpopular. The outbreak of a new war with Holland, commercial and colonial like the former, added to his embarrassments. The king deprived him of the Great Seal. A parliamentary impeachment followed. Clarendon fled to France and was condemned in absence to perpetual banishment.

The Cabal and Danby.—The king then gave his confidence to a group of men which became known as the Cabal. The ablest was Antony Ashley Cooper, later lord chancellor and earl of Shaftesbury. They helped Charles to carry out a policy of virtual toleration. After making peace with the Dutch in 1667, he concluded in 1668 with them and with Sweden the Triple Alliance, designed to hinder Louis XIV. from conquering the Spanish Netherlands. But his real aims were far different. In 1670 he concluded with Louis the secret Treaty of Dover for the conquest and partition of Holland and the restoration of Catholicism in England, a stipulation concealed from all but the Catholic members of the Cabal. Pursuant to this treaty, he began the third war with Holland in 1672. About the same time he issued a Declaration of Indulgence, suspending all penal laws in matters of religion. But the French alliance and the Dutch war were unpopular. Most Churchmen detested the Indulgence, and all friends of liberty resented the suspension of statutes by the mere will of the sovereign. The king had to withdraw his declaration and to accept the Test Act imposing the sacramental test upon all officeholders. Soon afterwards he had to make peace with Holland, while the Cabal broke up. Shaftesbury, who had discovered the stipulation relating to catholicism in the Treaty of Dover, became the leader of opposition to the king's policy. For by this time an opposition professing to defend the Protestant religion and the liberties of England, the germ of the later Whig party, had become manifest. The king took for his chief adviser Sir Thomas Osborne, whom he appointed treasurer and created earl of Danby (*see* LEEDS, 1ST DUKE OF). Danby was at once a zealous upholder of royal prerogative and a staunch adherent of the Church. Meantime the public became more and more afraid of Catholic encroachment. The king's brother James, duke of York, the heir to the throne, avowed himself a Catholic and married as his second wife a Catholic princess, Mary of Modena. The strongest Continental ruler, Louis XIV., showed himself an implacable enemy of Protestantism.

The Popish Plot.—These fears were raised almost to frenzy by the alleged discovery of a popish plot to kill the king, to overthrow the Church and to restore the domination of Rome. In the main the plot was an invention of Titus Oates (*q.v.*), although the intrigues of rash Catholics helped to make it more plausible. The opposition led by Shaftesbury, whether they believed in the plot or no, saw their advantage in it and did their utmost to inflame Protestant fanaticism. In consequence, a number of innocent persons suffered as traitors. A parliamentary Test Act was passed. On the ground of certain letters written by the king's command, the Commons impeached Danby of treason. To save Danby the king dissolved the parliament which had lasted 17 years. In the ensuing election the opposition gained many seats. Its leaders brought in a bill to exclude James from the succession. To save his brother's right, Charles offered to accept severe restrictions upon the powers of a Catholic sovereign. He also dismissed his old privy council and formed a new one on a plan devised by Sir William Temple, half servants of the Crown and half influential members of either House (*see* PRIVY COUNCIL, CABINET). As these concessions were fruitless, he dissolved the parliament, but not before it had passed the Habeas Corpus Act. In the next parliament the Exclusion bill was brought in again, passed by the Commons and thrown out by the Lords. Charles let the new privy council drop and dissolved the parliament. It was during this period of intense conflict that the two political parties which had been growing since the Restoration took definite shape, and became known as Whigs and Tories.

The Royalist Reaction.—The opposition had injured their cause by adopting the claim of the duke of Monmouth to be rightful heir to the Crown as a legitimate son of the king. Signs that belief in the plot was waning emboldened the king to summon

a new parliament. It was to meet at Oxford so that his adversaries should not have the support of the Londoners. As they would accept no alternative, but brought in a third Exclusion bill, Charles hardened himself in resistance and dissolved the parliament after it had sat a week. He determined not to call another until he could count on its submission. He published a declaration justifying what he had done, which evoked the enthusiasm of the clergy and gentry. He caused proceedings to be taken against the city of London and other corporate towns for having exceeded their lawful powers. Their charters having been adjudged forfeit into the king's hand, he granted new charters securing his control over their administration and the election of their members. At the same time the persecuting laws against the Nonconformists were sharply enforced. The opposition began to conspire, but all was detected. Two of their chiefs, William Lord Russell and Algernon Sidney, and several persons of less consequence, were executed. At his death (Feb. 6, 1685) Charles was more nearly absolute than any other Stuart king. He owed his success mainly to a close alliance with the Church of England.

JAMES II., 1685–1688

James II. broke this alliance. James was an ardent Catholic who had suffered for his faith. For his church he determined to secure, not merely toleration, but ascendancy. The parliament which he called gave him an unprecedented revenue. Its session was interrupted by Monmouth's rebellion. When it re-assembled, the king, who had increased the army, announced that he would grant commissions regardless of the Test Act, and demanded larger supplies. The Tory gentry, who abhorred a standing army and meant to uphold Anglican ascendancy, showed signs of resistance, whereupon James prorogued the parliament, which never met again. He then tried to attain his end by the exertion of prerogative. To control the Anglican clergy he set up the Court of Ecclesiastical Commission, although the establishment of such courts had been forbidden by statute. By dismissing four judges he obtained from the court of king's bench a decision in favour of his power to dispense with the Test Act. Thenceforwards he bestowed preferment on Catholics out of all proportion to their number. He tried to win the Nonconformists by a Declaration of Indulgence. To ensure the support of a future parliament, he purged the borough corporations of Anglicans and Tories. He forced Catholics into office in the universities. In April 1688 he issued a new Declaration of Indulgence with orders that it should be read from every pulpit on two successive Sundays. Archbishop Sancroft and six bishops drew up a petition asking to be excused. The king having ordered them to be prosecuted for a seditious libel, they were acquitted amid general rejoicing. The birth of a son seemed to ensure the continuance of his policy after his death. But certain circumstances gave plausibility to a rumour spread by his enemies that the child was supposititious.

The Revolution.—Discontent had by this time become general. Seven eminent persons, including Lord Danby, the chief of the Tory Party, and Compton, bishop of London, signed a letter to William, prince of Orange, the king's son-in-law and the recognized head of the Protestant interest in Europe, asking him to come to England with an armed force and to effect the redress of grievances. William, whose wife had been until lately the heiress of the crown, and who desired to enlist England in his combination of powers against Louis XIV., resolved to comply with the request. Partly by skill, partly by good fortune, he overcame all difficulties and disembarked his forces in Torbay without opposition. While he marched towards London, Danby and other disaffected lords raised insurrections in the north. The desertion of a few important men, especially of his own son-in-law, Prince George of Denmark, and of Lord Churchill, his best officer, convinced James that he could not trust his army, but must gain time by negotiating with William and issuing writs for a new Parliament. He determined to fly to France and trust to fortune for returning free from all conditions. A first attempt failed, but William contrived to alarm James so much that he made a second attempt, which succeeded. His wife and infant son had already reached France. Thus he opened William's way to the throne. William assembled the Lords, the members of parliaments of Charles II., and representatives of the common council of the City. They requested him to carry on the administration and to summon a parliament. The convention parliament met on Jan. 22, 1689. The Tories, who had for many years asserted the doctrine of divine right, were divided. Some wished to recall James under promise of amendment, some wished to establish a regency, while others, with Danby at their head, took refuge in the pretence that the king's flight was an abdication so that the crown had devolved on the Lady Mary. The Whigs, who thought the deposition of a bad king a sound precedent, held that the throne was vacant and would have liked to elect William. As a compromise, it was agreed that William and Mary should be joint sovereigns, but that William should have the sole administration. A Declaration of Right, deciding in favour of parliament practically all the constitutional disputes of the century, was tendered with the crown to William and Mary and was accepted by them. The supremacy of parliament was thenceforward assured, but the sovereign continued to be the real head of the executive.

The Revolution in Scotland and Ireland.—On William's arrival in London he summoned a meeting of notable Scotsmen, which asked him to undertake the administration of Scotland and to call a parliament. The parliament decided to offer the crown to William and Mary, together with a Claim of Right in which the most memorable clause was that abolishing episcopacy. In the Highlands, however, James Graham, Viscount Dundee, was able to raise a little army which defeated King William's troops at Killiecrankie. But Dundee's death led to the dispersing of his followers, and the Highlands were pacified with hardly any trouble. In Ireland the earl of Tyrconnel, lord deputy, acting under King James' orders, had filled the army with Catholic officers and everywhere placed Catholics in power. Many Protestants fled to England. Many found refuge in the strongholds of Londonderry and Enniskillen. Tyrconnel invited James to come and take command of the Irish in person. He came and received French assistance, but was defeated by William at the battle of the Boyne, July 1, 1690, and fled back to France. The reconquest of Ireland was completed in 1691 by the battle of Aughrim and the surrender of Limerick. The treaty then made secured to the Irish Catholics that measure of religious liberty which they had enjoyed under Charles II., but its terms were not observed in after years.

WILLIAM III. AND MARY, 1689–1694; WILLIAM III., 1694–1702

In England the Convention turned itself into a parliament in order to avoid the risks of a general election at a time so critical. The Declaration of Right was converted into the Bill of Rights, which gave the succession to Anne in default of issue of William and Mary, and excluded Catholics from the throne. By the Toleration Act all Protestant Nonconformists other than Unitarians obtained freedom of worship. The mutiny of a Scottish regiment gave occasion for the first Mutiny Act, which placed soldiers under a special law and special tribunals. It was enacted only for a period of six months, as parliament wished to keep control of the army. A new parliament in 1690 granted the customs duties to William and Mary, not as heretofore for life, but for a term of four years. It also assigned certain branches of revenue for the expenses of civil government, and others for maintaining the army and navy. The help given to James by Louis made war inevitable. England joined the coalition of which the emperor, Leopold I., the king of Spain and the Dutch republic were principal members. The war lasted eight years. The French were generally successful in battles, but the wealth of England and Holland gave the allies greater power of endurance. War completed William's dependence on parliament and made necessary the national debt. Hitherto, when loans were needed, they had been raised on the credit of the Crown. But William was not secure in his kingdom and the sums needed were beyond all precedent. In 1693, therefore, a loan was raised on the faith of an act of parliament, and this became the type of all subsequent loans. Largely in order to assist the raising of loans, the Bank of England was founded in 1694. The currency was reformed in 1696. A bill limiting the life of a parliament to three years was passed in 1694 and a bill to

reform trials for treason in 1696. The expiry of the last Licensing Act in 1694 left every man free to publish what he would, subject to the risk of prosecution for libel. A noteworthy increase of newspapers and pamphlets ensued.

The Partition Treaties.—The war was not popular, its burthens were heavy and William gave offence by his ungracious manners and Dutch favourites. But the naval victory of La Hogue (1692) ended the fear of invasion and the detection of a plot to assassinate William aroused loyalty. At length Louis became willing to treat. The Peace of Ryswick virtually restored the state of things before the war. Thus was seen the importance of English help to the enemies of Louis. Soon afterwards Louis sounded William about the Spanish succession. Charles II., king of Spain, a childless invalid, was visibly near his end. Spain was almost powerless to defend her enormous dominions. As Louis himself, the emperor Leopold and the little son of the elector of Bavaria all had claims by descent, another European war seemed likely. Therefore William and Louis framed two successive treaties for the peaceable partition of the Spanish empire on the death of King Charles. These treaties became known and exasperated the Spaniards. Finally Charles made a will bequeathing all his dominions to Philip, duke of Anjou, second son of the dauphin. A little later he died. Louis accepted the Spanish crown for his grandson. As no power could then offer effective resistance, Philip took quiet possession of his kingdom.

Meantime William had found it hard to govern England. After the Peace of Ryswick the Tories became powerful. The Commons insisted on reducing the army to a few thousand men, called in question William's grants of forfeited Irish land, and impeached some of the ministers for their share in the partition treaties which were unpopular. When the death of Anne's last child made necessary the Act of Settlement, which gave the succession to the next Protestant heir, the electress Sophia of Hanover, granddaughter of James I., they inserted clauses further restricting the power of the Crown. (*See* SETTLEMENT, ACT OF.)

Thus William could not interpose with effect in European affairs. But Louis, who controlled the actions of Philip, irritated the English by refusing them any commercial privileges in Spanish America, and by putting French garrisons into certain fortresses of the Spanish Netherlands. He thus enabled William to conclude with the emperor and Holland a treaty sometimes termed the Grand Alliance, whereby the parties undertook to procure certain satisfactions for one another. By promising James II., then on his deathbed, that he would recognize his son as king of England, and thus breaking the Treaty of Ryswick, Louis ensured a war. William's health had long been declining and a slight accident brought on a fatal illness. On March 8, 1702, he died.

ANNE, 1702–1714

War of the Spanish Succession.—Anne, his successor, was a Tory and a zealous churchwoman. She had disliked William and did not comprehend his policy. She gave office only to Tories, Lord Godolphin becoming treasurer and virtual head of the Government. There was, however, no break in the conduct of foreign affairs. Anne was dominated by Sarah countess of Marlborough. The countess, a devoted wife, used all her influence to exalt her husband. Marlborough, a lukewarm Tory, adopted without reserve William's foreign policy, which gave full scope for his military and diplomatic genius. Godolphin, who resembled Marlborough in temperament and opinions, approved of that policy. They carried queen and parliament along with them. England, Holland and the emperor were joined by several of the German princes and, somewhat later, by Portugal. Victor Amadeus, duke of Savoy, took part, at first with Louis, but afterwards against him. During the first four years of the war the allies were brilliantly successful. They drove the French out of Germany by the victory of Blenheim (1704), and out of Italy by the victory of Turin (1706). By the victory of Ramillies (1706) they secured almost the whole of the Spanish Netherlands. In Spain they captured Gibraltar and were joined by the Catalans, who hoped to recover lost provincial liberties. Dismayed by so many reverses, Louis at the end of 1706 sued for peace. The allies, who had agreed to recover the whole Spanish inheritance for the archduke Charles, second son of the emperor Leopold, refused the offer. During the next four years they conquered Naples, Sicily, Sardinia and Minorca, but they failed in an invasion of southern France, and in Spain they suffered a ruinous defeat at Almanza. By the victories of Oudenarde (1708) and Malplaquet (1709) they prepared for an invasion of France, but the siege of the border fortresses was a tedious process. Yet the more and more tempting offers made by Louis were obstinately refused.

Parliamentary Union of England and Scotland.—At home the Godolphin ministry achieved the parliamentary union of England with Scotland. The Scots desired to share in English commerce and colonial enterprise, which they could only do by a closer union with England. Yet the Scots cherished their legal independence; above all, they were concerned for the safety of the Kirk. In 1704 the Scottish parliament passed the Act of Security to the effect that upon Anne's death the successor to the throne should not be the same as in England, unless securities were obtained for the religion and liberties of Scotland. The English parliament replied to the Act of Security with an act which declared that Scotsmen should be treated as aliens unless the Scottish succession were settled like the English. This led to the appointment of commissioners of both kingdoms to draft articles of union. They finished their work in July 1706. The number of Scottish representatives, 16 in the Lords and 45 in the Commons, was based partly on population and partly on revenue. Scotland retained its own laws and courts of justice, and was to pay £48,000 in land tax when England paid £2,000,000. Separate acts, incorporated with the Act of Union, ensured the independence of the two Churches. The Union took effect on May 1, 1707. It was highly unpopular in Scotland and could hardly be called popular in England.

Tory and High Church Reaction.—The foreign policy of the Government was repugnant to the Tories, who detested a standing army, heavy taxation and the national debt. Marlborough and Godolphin were thus compelled to seek help from the Whigs, and by degrees admitted so many to office that at the end of 1708 the ministry was Whig rather than Tory. It therefore lost the queen's goodwill; the duchess of Marlborough, too, had lost the queen's favour and the nation at large was growing weary of the war which, in spite of so many victories, seemed endless. A certain high church clergyman, Dr. Henry Sacheverell, having assailed the ministers in virulent sermons, attracted so much notice that they resolved to impeach him. He became a popular hero, the queen attended the proceedings and the Lords did not venture to inflict more than a nominal penalty. The queen then took courage to dismiss Godolphin, and gave office to Robert Harley and Henry St. John, who in former years had served under Godolphin but had been dismissed. They decided upon a general election, which produced a strong Tory majority. Then they resolved to end the war. They began a separate and secret negotiation with Louis, which became public in the course of 1711. At the end of that year, having collected evidence which cast suspicion of corrupt practices upon Marlborough, they felt able to dismiss him and give the command-in-chief to a Jacobite, the duke of Ormond, who had orders to remain inactive. A congress was opened at Utrecht early in 1712, but Louis became more and more unyielding, so that the definitive treaties were not signed until April 1713. (*See* UTRECHT, TREATY OF.) By the treaty England kept Gibraltar and Minorca, and acquired from France Nova Scotia, Hudson bay and Newfoundland. She also obtained trading rights in Spanish America, especially a monopoly of the increasingly valuable slave trade.

At home the ministers tried to secure permanent ascendency for Tories and Churchmen. In 1711 they passed an act requiring a qualification in landed property for members of parliament. A bill to punish the occasional conformity by which dissenters ambitious of office sought to evade the Test Act had been passed by the Commons in 1703, and again in 1704, and both times had been thrown out by the Lords. It was revived and passed into law in 1711. In 1714 the Schism Act took from dissenters the right of educating their own children. But the ministry was weakened by

the rivalry, at last rising to enmity, of its two chiefs. Harley, who in 1711 was created earl of Oxford and Mortimer, took alarm at the violence of his followers and wished to moderate reaction. St. John, who in 1712 was created Viscount Bolingbroke, was ready to go all lengths and intrigued with the Pretender so as to have an alternative if he could not make terms with the elector of Hanover. He induced Anne to dismiss Oxford and to make the duke of Shrewsbury treasurer. Almost immediately afterwards Anne died, Aug. 1, 1714. (F. C. M.)

IX. THE HANOVERIAN KINGS, 1714–1789

The period during 1714–89 in British history has an essential and internal unity alike in politics, thought, and economic and social development, marked off from the 17th century which really ended in 1714, and the period of revolution and world-wide war which commenced with the fall of the Bastille on July 14, 1789. It began with one bloodless British revolution, the accession of George I., which consummated the "Revolution of 1688" and it closed with the opening of a European revolution that left Great Britain intact, but convulsed the world in which the British State stood unshaken. The consolidation of the parliamentary State, *i.e.*, a commonwealth governed by a limited and constitutional monarchy by and with an executive responsible to a parliament of two chambers, and with a judiciary independent of the executive and the legislature, is the main feature of this broad and unified period, called the 18th century, which correctly speaking closed in 1789. When George I. succeeded to Anne, in virtue of the statutory definition of the succession laid down in the Act of Settlement (1701), government by the Crown in and through parliament was an experiment that still had to make good. The French Revolution of 1789 found parliamentary government in Great Britain established in principle, and proved efficient and acceptable in practice. The period of the Hanoverian kings, therefore, if it had accomplished nothing else, had laid an unshakeable foundation for the developments of the 19th century. This achievement was mainly the work of the Whig supremacy of the first 60 years of the 18th century. This supremacy rested on and expressed the aims of a virtual alliance between a majority of the aristocracy, with an overwhelming majority in the House of Lords, and a masterly control of the representation in the House of Commons, the trading classes and the nonconformists. It was not until the middle of the reign of George III. that the country gentry and the Church of England definitely accepted the principles of the Whig system, and a new combination of the social forces of the community became possible. The result was a new Tory Party which had shed the principles of Jacobitism, of a divine right monarchy and of an executive not dependent on the legislature. The rise of the New Tories dissolved the Old Whigs and for 30 years Whiggism repeated the old formulae while it sought for a new faith and new convictions under the hammer strokes of the American and French Revolutions. The downfall of Bolingbroke in 1714 really ended the Toryism of the 17th century, and the watershed of Whiggism is crossed in the careers of Burke, the younger Pitt and Charles James Fox. Subordinate to this dominating political movement are important moulding forces and movements—John Wesley and Methodism (*qq.v.*), the "Agricultural Revolution" (*q.v.*), which transformed the technique of agriculture (*see* AGRICULTURE; ENCLOSURES), the Industrial Revolution (*q.v.*) which transformed the parliamentary State into the industrial "workshop of the world," which dates from 1770, and the steady and continuous development of the Empire (*see* BRITISH EMPIRE), marked by the great disruption of 1783. The Deist and Methodist movements belong more strictly to the history of thought and of the Church of England; agriculture and industry make chapters by themselves in national development; but the play of the purely political forces can only be fully understood if they are correlated to the internal political development and the "Expansion of England." Great Britain by 1789 was politically, socially and economically ripe for an era of fundamental reform. The French Revolution and the titanic struggle with Napoleon delayed the Reform movement (*q.v.*) for 30 years and very nearly transformed it into a revolution.

THE AGE OF WALPOLE, 1714–1742

The First Phase: 1714–21.—The peaceful accession of George I., which to Tories such as Swift and Atterbury seemed a "miracle," was due to the political incapacity of Bolingbroke, the fine organization of the Whigs who were ready when a divided Tory Party was not, and to the common-sense of the majority of Englishmen who were prepared to let the Elector of Hanover come and have a fair trial, but were not prepared to invite the Roman Catholic son of James II. to start a civil war as the justification of a hereditary, but not a statutory, title to the throne. The Whigs realized that this German-speaking king, ignorant of England and English mentality, would only stay at Windsor if his government were made acceptable. The new king knew that without the Whigs he was a king without a kingdom, and the Whigs knew that without George I. they had a kingdom without a king. They concentrated on essentials. Time and statesmanship could solve the problem. Meanwhile let the king and court be German, and the government English and for England. There was a double practical problem—internal, to keep order and reconcile the nation to a "foreign" sovereign and court (with an awkward appendage in Hanover)—external, to control foreign policy so as to keep England out of war. The ministry of Stanhope (1714–21) was a masterly achievement of both ends. The Jacobite Rebellion of 1715 was a miserable fiasco. France refused to stir; "James III. and VIII." arrived too late and had no gift of leadership; and at Preston (place of ill-omen for Stuart adventures) the rebellion was quenched. The Riot Act of 1715 is the one permanent survival of this mismanaged miscarriage of Jacobite sentiment. The Septennial Act followed (1716), and by a daring assertion of parliamentary supremacy repealed the Triennial Act, postponed a general election, and made such elections necessary only every seven years. It lasted as the law of the land until 1911. In foreign policy Stanhope deserves fame for the Triple Alliance (with Holland and the France of the regent Orleans), for the crushing of Alberoni's schemes, for the Treaty of Passarowitz which ended the war in the East (1718), for the conversion of the Triple into a Quadruple alliance (1718) by bringing in the Emperor, and for the series of treaties (1721) which ended the war that had raged in the north of Europe since 1698.

The Second Phase: The Ministry of Walpole.—In 1717 there was a sharp schism in the Whig Party; Townshend, Walpole and Pulteney left the ministry and Walpole accentuated the division by defeating the Peerage Bill in the House of Commons. This measure which limited the royal prerogative to create peers, would have made the only avenue to the House of Lords "through the winding-sheet of a decrepit lord or the grave of an extinct noble family" and removed the constitutional means of overcoming the opposition of the Lords to a decision of the Commons and the constituencies. The crash of the "South Sea Bubble" (*q.v.*), due to the reckless finance of the ministry and an orgy of speculation in the nation (1720) discredited the Government. Walpole, who had rejoined the ministry as chancellor of the exchequer in 1720, was, by the death of Stanhope, the leading political figure. Promoted to be first lord of the Treasury, with Townshend as secretary of State, he founded the famous administration which rightly bears his name and which lasted for 20 years, a longer continuous period than that of any ministry before or since.

Sir Robert Walpole was the last and the greatest of the true Revolution Whigs; he stood for a "system" both in home and foreign policy; the 20 years, 1721–42, are the history and justification of that system; and his fall was the fall of that system. At home his main object was to complete the reconciliation of Great Britain to the new dynasty, and by wise finance, avoidance of unnecessary controversies—particularly on religion—and by the maintenance of order and prosperity, prove the efficiency of parliamentary government on principles laid down in the Revolution settlement of 1689. Walpole was intensely English, and a Whig to the core. By 1742 he had made the House of Commons the real centre of political gravity and the cabinet (*q.v.*) an effective organ for linking executive and legislature together. He grasped that parliamentary government was party government; he led the Whigs as a party leader; he was the first and one of the

greatest of British prime ministers (though he never claimed the title) and one of the three or four memorable finance ministers in two centuries. His foreign policy (directed until 1730 by Townshend) was based on the necessity of peace; he refused to intervene in the wars which shook Europe; he maintained the alliance with France which he used to solve the complicated problems that from 1721 onwards are only intelligible by detailed study. Alike in 1725, 1729, 1731 and finally in 1738, Great Britain was instrumental in bringing about elaborate treaty settlements which prevented or ended devastating wars on the Continent.

Walpole's tenure of power was not seriously shaken either by the quarrel with and retirement of Townshend (1730), the accession of George II., whose gifted queen, Caroline of Anspach, was Walpole's stoutest ally until her death in 1737, or by the failure to carry his Excise bill in 1733 against the ignorant fanaticism of the country. But in 1739, popular clamour voiced by the elder Pitt, the Whig dissidents and the Tory Party, forced him into war with Spain—"the war of Jenkins's ear." This colonial and commercial quarrel, which Walpole had really settled satisfactorily by negotiation, became merged in the War of the Austrian Succession begun by Frederick the Great in 1740. The war with Spain was mismanaged, for Walpole was no war minister and his cabinet was hopelessly divided: the alliance with France was worn out. The "system" at home and abroad in fact had collapsed. Defeated in the House of Commons, Walpole resigned. His health was broken; he had done his work; he had been the main force in creating a new England and a new age, which he did not understand and which did not understand him. He left no successor of a like calibre or with the same remarkable combination of gifts. But he had stamped his personality and political principles on two generations.

THE AGE OF CHATHAM, 1742-1775

The 33 years that followed Walpole's fall are dominated by the genius and the defects of William Pitt the elder, first earl of Chatham. They commence with the struggle of "the great Commoner" to secure office and power against the established Whig families, the sunshine and splendour of the great ministry of Pitt from 1757-61, the accession of a young king, George III., who with the new Tory Party first divided the Whigs and then destroyed the Whig supremacy, and they concluded with the civil war in the British Commonwealth, commonly called the "War of American Independence" against which Chatham led the opposition, and which ended with the disruption of the British empire. In these 30 years the elder Pitt proved himself to be head and shoulders above all his contemporaries, yet the most intractable of colleagues and in all the arts of party organization, essential for parliamentary government, defiantly ignorant, and, for his own leadership, tragically deficient.

The ministry of Henry Pelham, 1743-54, maintained Whig solidarity and a coalition of Whig forces for 11 years, but its conduct of the British share in the War of the Austrian Succession, brought it no credit either on land or on sea. Great Britain won Cape Breton in 1744 and lost Madras, and was defeated at Fontenoy (1744) and Raucoux (1746). The Treaty of Aix-la-Chapelle of 1748 was, in reality, a truce which settled neither the British claims on Spain which had caused the war in 1739, nor the issues raised between Prussia and the House of Austria. The war and the peace only made clear that the alliance with France had passed into open antagonism in every quarter of the globe. In 1745 had occurred the dramatic episode of the second Jacobite rebellion under the leadership of Prince Charles Edward, "the young Pretender." Victorious at Prestonpans, he marched to Derby, retreated, and won a second victory at Falkirk. At Culloden (April 16, 1746), Jacobitism was finally extinguished by the duke of Cumberland. The Hanoverian monarchy was never again in Great Britain seriously challenged. Highland Scotland was remodelled by a series of administrative measures and the union with England entered on a new and happier chapter for both countries.

Henry Pelham's death (1754) broke up the Whig coalition which the duke of Newcastle failed to re-solder. While Great Britain drifted into war with France (1756) for which she was quite unprepared, the politicians wrangled, combined and recombined. Finally William Pitt, who had first obtained office under Henry Pelham "borrowed Newcastle's majority" in the House of Commons and formed a coalition (1757) with Newcastle and Fox, in which Pitt was the supreme figure with the confidence of the nation. The next four years justified Pitt's belief in his own powers, and the trust that his countrymen placed in him.

The Seven Years' War, 1756-63.—The Seven Years' War was a combination of two separate and deeply founded rivalries—a maritime and colonial struggle on the seas, in North America and the Indian peninsula between Great Britain and France, and a purely continental struggle between the House of Austria and Prussia under Frederick the Great. It was prefaced by "The Diplomatic Revolution," more accurately described as a reversal of the diplomatic system on which the policy of the European States had hitherto been based. In order to crush Prussia the House of Austria abandoned the alliance with Great Britain and obtained an alliance with France, combined with an alliance with Russia. Prussia, isolated, found an alliance with an isolated Great Britain. When the war broke out Great Britain and Prussia were confronted with a coalition of France, Russia, the House of Austria and the Germanic States that supported the Habsburg empire. The fate of Prussia was thus linked up with the fate of the British empire. The war, as so often, opened disastrously for Great Britain. The British had lost Ft. Duquesne (1754), and Braddock's expedition to recover it (1755) ended in the annihilation of the troops; operations against Ft. William Henry and Louisburg, and against Rochefort were failures, and Minorca, for failing to relieve which Admiral Byng was court-martialled and shot, was lost (1757). Pitt had, however, now established his supremacy in the Government and rapidly showed his genius for conducting a war. Confidence, competence and victory dispelled disillusionment, incompetence and defeat. Pitt grasped and enforced two principles—the power vested in the command of the sea, and the value of focussing a superiority of force on a strategic centre instead of dissipating it on varied and unconnected efforts. Ft. Duquesne was recovered and Louisburg recaptured; the British fleet blockaded the French coast. "The year of victory" (1759) followed. Guadeloupe and Ft. Niagara were captured; Quebec fell after Wolfe's victory on the Heights of Abraham; British troops materially aided in the decisive defeat of the French at Minden; and the French fleet was crushed in Lagos bay and off Quiberon. In India Clive had avenged the outrage of "The Black Hole of Calcutta" by the victory of Plassey (1757) which made the East India Company master of the three rich provinces of Bengal, Orissa and Behar. Pitt was determined to fight the war to a decisive finish. In 1760 the conquest of Canada was completed by the capture of Montreal; in India a victory at Wandewash led up to the capture of Pondicherry; Dominica in the West Indies was taken, and Belle Isle, commanding the French coast, stormed and captured. France, to avert defeat, had but one card left to play—to bring in Spain (as agreed by the Third Family Compact of the Bourbon dynasties in Paris, Madrid and Naples). Pitt's ultimatum to Spain, to anticipate the blow, was rejected by the cabinet and he resigned (Oct. 5, 1761). Three months later Spain declared war; Great Britain had lost three months, her invaluable war minister, and the alliance with Frederick the Great, alienated by the withdrawal of his subsidy. Lord Bute who had replaced Pitt and Newcastle carried on Pitt's war measures. Martinique, Granada, St. Lucia, St. Vincent, Havana (in Cuba) and Manila in the Philippines were captured by the expeditions that Pitt had planned. Bute, however, meant to have peace at any price, with or without Britain's allies. The Peace of Paris (Feb. 10, 1763) brought to Great Britain, Canada, Nova Scotia, Cape Breton, a group of West India islands and an assured position in India; but Bute's clumsy and reckless diplomacy threw away without compensation many valuable acquisitions, and if the independence of Prussia was maintained, Frederick owed it, as he claimed, not to his "treacherous" ally, but to his own genius and the luck that in the supreme crisis, changed Russia from a foe to a friend. The terms of the treaty, denounced by Pitt's unanswerable criticism,

BY COURTESY OF THE NATIONAL PORTRAIT GALLERY

ENGLISH STATESMEN

1. John Hampden (1595–1643)
2. Sir Robert Walpole, earl of Orford (1676–1745)
3. William Pitt, 1st earl of Chatham (1708–78)
4. Edmund Burke (1729–97)
5. Charles James Fox (1749–1806)
6. William Pitt the younger (1759–1806)
7. George Canning (1770–1827)
8. Sir Robert Peel (1770–1827)
9. Viscount Palmerston (1784–1865)
10. Benjamin Disraeli, earl of Beaconsfield (1804–81)
11. William Ewart Gladstone (1809–98)
12. Joseph Chamberlain (1836–1914)

were only forced through parliament by the remorseless corruption of Henry Fox. The victorious end of the war and the parliamentary rout of the Whig coalition were precisely the prelude to his reign desired by the young king, George III., who in 1760, had succeeded his grandfather on the throne.

George III. and the "New Monarchy."—It was the fate of this young prince to rule nominally for 60 (actually for 50) of the most momentous years in British history, 32 of which were absorbed in war (apart from wars in the over-seas dependencies of Great Britain)—a period which saw the Industrial Revolution subverting the history and settled order of social life begun and consummated, the civil war and disruption of the empire in North America, the Pacific brought into the orbit of European policy by the explorations of Capt. Cook, the French Revolution, and the titanic struggle with Napoleonic France, the grant of Irish autonomy (1782) followed by revolution and civil war in Ireland, the destruction of the Whig system and the reconstruction of parliamentary government. The reign closed in 1820 with the prelude to what, but for the Reform act of 1832, would have been civil war and revolution in Great Britain. That the monarchy not only survived, but was a force through these momentous 60 years, was a tribute, not to the intellectual gifts or political insight of the king (for these were mediocre and surprisingly limited in range and vision) but to solid qualities of character. The first two Georges were German princes reigning in a British kingdom which they neither understood nor assimilated. George III. was, by training and temperament, English, and he exhibited both in youth, middle and old age, the virtues and defects of middle-class English insularity. The only logic which influenced him was the logic of fact; and it was the fact, not the logic, that compelled a reluctant acquiescence in conclusions though not in a new point of view. The ambitions of the new and young king inaugurated "a new monarchy." He was determined to make the Crown, not merely as an institution but as a person, the decisive power in policy and government. This involved the destruction of the Whigs and the Whig system. But even had George III. been simply a replica of George II., a remodelling of the system and a re-grouping of the parties and social forces in Great Britain would have followed the Peace of Paris in 1763.

The two great strongholds of Toryism—the country clergy and the country squire, the manor and the parish church, on which English life from the Reformation to the French Revolution was solidly built—had shed their Jacobitism and their political theory of a king ruling *divino iure*, and were ready to assert their right against a handful of territorial magnates (with the Nonconformists and commercial middle class) to make the policy and conduct the government of their country. Pitt's career and achievements had been a corrosive and dissolvent acid of Whiggism. A Whig of the Whigs in the fundamentals of his creed he had forced the Whig magnates to accept his leadership, while he had voiced the patriotism and aspirations of the manor and the rectory. The Whigs had ceased to be a party led by able statesmen; they had degenerated into a group of clans ranged round a dozen chieftains as quarrelsome, vindictive and jealous in their rivalries as Campbells, Frasers, Macleods or Macdonalds in the heyday of Highland Scotland. That parliament in 1763 did not represent the constituencies and that the constituencies did not represent the nation is the one sovereign and tragic fact in British history between 1760 and 1792; and this fact wrecked alike the Whigs, the later career of Pitt the elder, and the system of George III. which crashed in 1783.

Personal Monarchy.—The dreary kaleidoscope of ministries—Bute, Grenville, Bedford, Rockingham, Pitt, who became earl of Chatham, and finally North (which lasted during 1770–82)—was due to the refusal of the king to work with the successive groups and the refusal of the groups to work with the king. The king's determination to make parliament a submissive organ of the royal will was responsible for the gross mismanagement of the struggles which converted in the person of John Wilkes (*q.v.*) a libertine demagogue into the triumphant champion of constitutional law and liberty. Parliamentary privilege, the law of libel, general warrants, the rights of the electors in the county of Middlesex and the publication of debates provided material for permanent and beneficial definition. Burke's *Thoughts on the Causes of the Present Discontents* (1770), re-stating the principles of cabinet and party government, with Adam Smith's *Wealth of Nations* (1776) redeem the period by their foundation of a philosophy of national policy on the transient issues of an empty day. The acid test of statesmanship came from the American colonies and the action of the home government.

The American Colonies, 1760–75.—The 13 colonies on the eastern coast of North America had, down to the accession of George III., been governed on an imperial system which allowed them a large measure of internal autonomy, but subjected them to a code of mercantile economics, defined in the Navigation Acts and other statutes of the imperial legislature at Westminster, which implied that the colonies were an integral part of an undivided British empire to be governed as a whole alike for defence, commerce and foreign relations. Grenville's Stamp Act (1765) imposing internal taxation by an imperial statute illustrated this system, because it required a colonial contribution to imperial defence from which the colonies directly benefited. The colonial opposition to this and subsequent measures of legislation and coercion, culminating in the Declaration of Independence (July 4, 1776) challenged the whole system. Three cardinal results since 1660 had really destroyed its basis. As the *Wealth of Nations* proved, the economic mercantilism of "the old colonial system" was obsolete in its principles and no longer true to the facts either of colonial or British trade. Thirteen weak and struggling "plantations" had become, unconsciously, a nation of three millions of prosperous English-speaking men and women with an inherited right to self-government in a vast country 3,000 miles from Westminster, ignorant of their needs and their capacity. The conquest of Canada and the removal of the French danger pared the need of imperial protection to a minimum. In the light of present knowledge two conclusions on the embittered controversy between 1763 and 1776 are certain. The policy of the home government, ignorant, prejudiced and blind to the facts, precipitated a crisis in 1775. But that crisis would have arisen even if there had been no George III. or Lord North, unless Great Britain had been prepared to anticipate the challenge by a drastic reconstruction of her whole system of economic policy and of imperial administration and defence. The American War of Independence which developed from the Penal Acts of 1773 into the first bloodshed at Lexington (April) and Bunker's Hill (June 1775) was a civil war of two radically different societies in America and Great Britain, speaking the same language, sprung from the same racial stocks and with a common heritage of law, institutions and religion. Chatham was the one statesman who could have resolved the deadlock; but Chatham's criticism of the king's policy made him a "trumpet of sedition"; he had destroyed the party without which he could not make or maintain a ministry and by 1775 he was a physical and mental wreck. His death in 1778 ended an epoch.

THE DISRUPTION OF THE EMPIRE; AND REFORM

The War, 1775–83.—The war that began at Lexington developed into a war of Great Britain against half the world—the Bourbon Powers of France and Spain, Holland, and "the armed neutrality of the North" formed by the Scandinavian States, Russia and Prussia, in defence of the rights of neutrals. But for the legislation of 1782–83, which freed Ireland from the fetters imposed in 1719 on her legislative and economic autonomy, a second civil war against united Protestants and Catholics might have been added. The incompetence of Lord North's ministry to avert the struggle in the North American colonies and to anticipate or prevent the intervention in 1778 of France in the struggle, was exhibited in the conduct of the war itself. The army was quite inadequate for the tasks imposed upon it; and the navy had been allowed to fall far below the strength required to assure the command of the sea. It was the loss of the command of the sea which was responsible for Cornwallis' surrender at Yorktown (1781), and which for two years placed Great Britain and the empire in the gravest peril it had so far faced. Lord North's

ministry stands convicted of unpardonable and preventable blunders, which rightly shattered the system of personal government embodying the principles of George III. At the commencement of the struggle a majority in Great Britain supported the ministry against the powerful, eloquent and determined opposition of a large minority voiced by Chatham and Burke, and above all Charles Fox. The disasters, the corruption, the lack of unity in policy and direction slowly turned the minority into a majority which by a vote of the House of Commons ended the ministry of Lord North (March 1782). The American catastrophe thus saved the system of responsible parliamentary government working through a cabinet, representing a committee of the party which had and could retain a majority in the House of Commons; it administered the *coup de grâce* to the delusive ideal of a "Patriot King," ruling as well as reigning through a legislature dominated by "The King's Friends" and through departmental chiefs dependent both for power and policy on the Sovereign who was his own prime minister. Had North's ministry known its business it could have crushed the armed resistance of British subjects in America before France had either the power or the will to intervene. Despite Washington's heroic efforts the American "rebels" realized that without France they must be beaten in the end, and Burgoyne's disaster at Saratoga (1777) was more persuasive at Paris than Franklin's diplomacy. With French intervention in 1778 Great Britain was at bay with the crisis which ministerial lethargy and blindness had created. Fortunately, Great Britain had great men in her hour of need whose splendour and obstinacy redeemed the government's blunders. India was saved by Warren Hastings; Canada by Carleton; Gibraltar by Elliott; the command of the sea by Rodney. But Cornwallis' surrender at Yorktown convinced even the king that the war in North America must be abandoned. A separate treaty (1783) with the American colonies granted the independence proclaimed in 1776. The 13 North American colonies passed out of domestic British history. The United States of America (a new republic in the new world) were born. The tragedy of their birth, both for the mother from whom they sprang and for the child thus ushered into the political firmament, was the black and angry memories of the issues raised and of the struggle itself which were to poison for a century and a half the relations of the two great branches of the English-speaking race.

With her other enemies Great Britain also made a disadvantageous peace. St. Lucia and Tobago, Senegal and Goree, Pondicherry and the French establishments in Bengal went back to France; Florida and Minorca to Spain. Fox, who negotiated the peace with Vergennes, obtained as counter-concessions some West India islands for Great Britain. France might indeed be content. Her navy had shown itself remarkably capable, and in the disruption of the British empire the world decided that she had inflicted a mortal wound on her secular antagonist.

Peace, Retrenchment and Reform, 1783–89.—The world was wholly wrong. The recuperation of Great Britain in the nine years that intervened between the independence of the United States and the wars of the French Revolution surprised Europe and can safely be attributed to the restoration of a healthy parliamentary and party system of government, to the wise and liberal policy of the younger Pitt, and to the growing intellectual and economic forces which make the first chapter of the Industrial Revolution. The general effect, more difficult to measure, of Wesley and the Wesleyan movement from 1740 onwards on the whole tone of the national life, must certainly be reckoned amongst the most powerful of the regenerative elements. These nine years in fact were a remarkable period of powerful minds and personalities, of fertilizing ideas and constructive effort in every sphere of the nation's activities.

A reconstructed Whig party under Lord Rockingham took the place of North's effete and discredited ministry. Burke's fine measure of economic reform, apart from the restoration of the cabinet system, was a notable achievement. On Rockingham's death Fox made the capital blunder of his life when he combined with North in the coalition Government, rightly resented by the nation and hateful to the king, whose unconstitutional acts in securing the defeat of the "India Bills" in the House of Lords and in dismissing the ministers, were condoned as an arbitrary retribution on a cynical disregard of the principles of a regenerated public life. The young Pitt's courage in accepting office was rewarded by a sweeping victory at the general election; and if the king had satisfied his vengeance on the Whigs and "the deserter" North, Pitt had made himself indispensable to the Crown. The nation, like the House of Commons, welcomed the youthful prime minister not as "a chip of the old block," but as "the old block itself."

Pitt completed the work of the Rockingham Whigs in noiselessly securing that the prime minister should be the head of the cabinet, that the cabinet should be a cabinet, not a group of departmental executive chiefs, and that it must depend on the confidence of the House of Commons. He reorganized the government of India successfully, though on less drastic lines than Fox's ill-fated measure; he reconstituted national finance and credit, and by the establishment of the Consolidated Fund laid the basis of the modern system; his economic treaty with France (1786), and the reduction and simplification of an antiquated code of contradictory tariffs proved his grasp of the principles of Adam Smith; the Canada Act of 1791 and the commencement of the colony of New South Wales in Australia opened a new chapter in the evolution of the British empire; a sane and peaceful foreign policy restored the shattered prestige of Great Britain in Europe. Pitt suffered three serious defeats. His proposals for placing the economic and financial relations of Great Britain and Ireland on sound lines were rejected in Ireland and dropped in England; his moderate schemes of parliamentary reform, urgently needed, were defeated by the ministerial party and abandoned by the prime minister; in 1791 his ultimatum to Russia had to be withdrawn; and his failure to support Warren Hastings, and his personal attitude towards the charges which led to his impeachment, that started in 1788, was a regrettable error of judgment, when Hastings's services both to India and Great Britain are impartially measured. It is no less unquestionable that if his powerful influence had been used as freely as his eloquence for the abolition of the slave trade, it would not have been deferred until 1807.

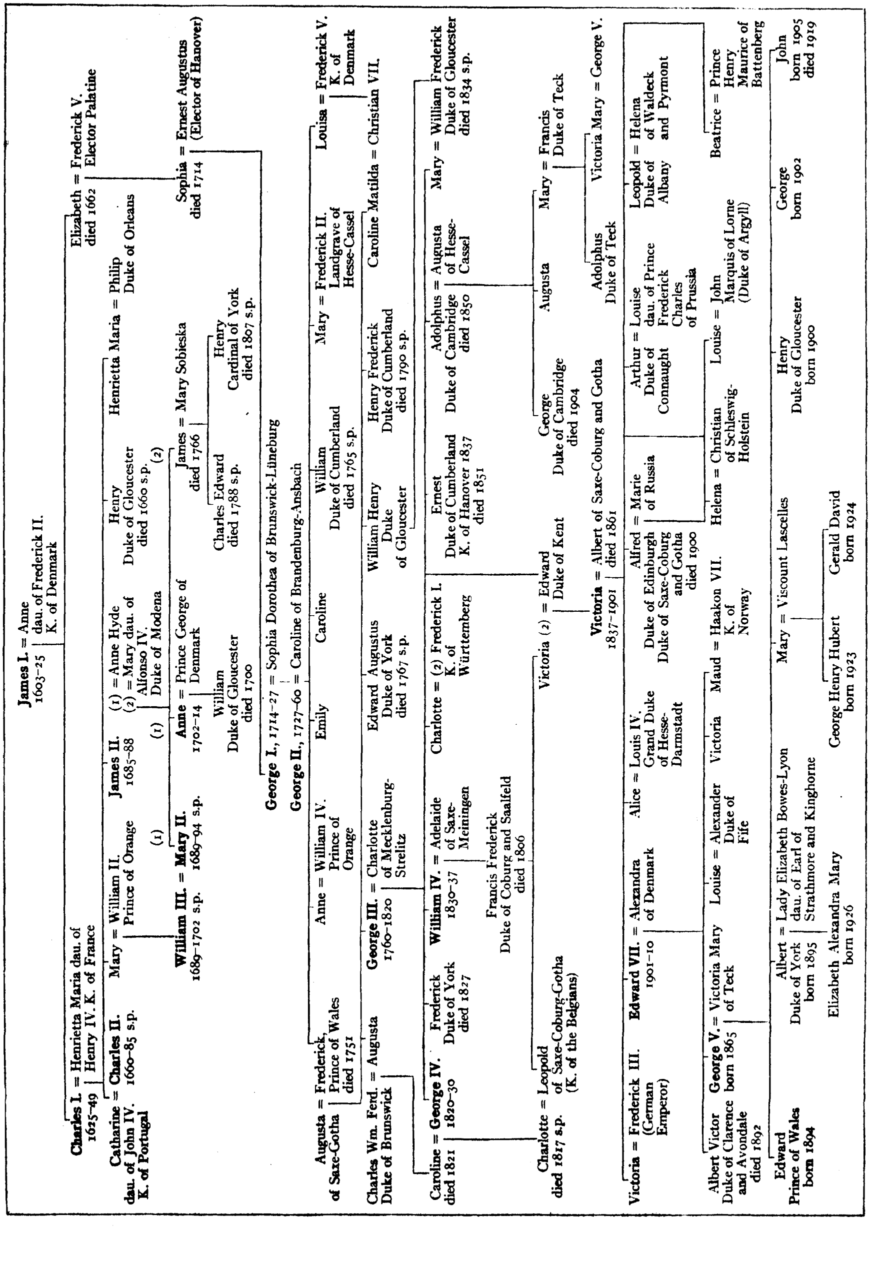
By 1789 the country was yearly becoming more ready for large and continuous instalments of political, economic and social reconstruction, and the organized demand for reform was creating an educated public opinion within and without parliament which would have proved irresistible before the century closed. It was across this Great Britain marked by such minds and characters as Howard, Hannah More, Wilberforce and Simeon, Bentham, Paine, Godwin and Cartwright, Arkwright, Cavendish, Black, Herschel, Crompton and John Hunter, the young Wordsworth and the young Coleridge, Crabbe, Cowper and Burns, that first the sunshine and then the deepening shadows of the French Revolution fell. Although Great Britain did not at first recognize it, the 18th century had really closed three years before; in Goethe's phrase, the Cannon of Valmy (1792) proclaimed the opening of a new age and a new world.

(C. G. Ro.)

X. THE REVOLUTIONARY PERIOD, 1789–1832

Under the seeming immobility of the Georgian era potent forces were working for change. By 1789 the Industrial Revolution (*q.v.*) was beginning to drive weavers and spinsters from the cottage to the factory, and to deplete the eastern and southern districts in favour of the north and west where water-power and coal were abundant. The new townships, dependent on nature's forces and man's inventions, cared little for tradition and began to chafe at control by a parliament representing imperfectly even the old agricultural England. The ever growing commercial class also became politically clamant. Above all, there now came from France a clarion call for freedom and equality which awakened echoes even in the semi-somnolent England of George III. Yet the French and English movements for reform, though alike aiming at the freedom of man from outworn laws, were destined to clash, with results infinitely disastrous. To outline the chief causes and consequences of this collision is here the guiding purpose.

GENEALOGY OF THE HOUSES OF STUART, HANOVER AND WINDSOR



First, to avoid hostility was far from easy at the end of a century punctuated by five desperate wars in which France figured as "the natural enemy." After she finally tore in half the British empire, national animosities were so keen that quick advance implied assault. Secondly, the attitude of the two peoples towards monarchy was curiously divergent. Early in 1789 the loyal acclaim of the French, on Louis XVI.'s summoning the States General for the reform of abuses, seemed to promise a longer duration for the house of Bourbon than the house of Hanover, when contrasted with the factious wranglings at Westminster occasioned by the lunacy of George and the intrigues of the prince of Wales for unrestricted power as regent. The prudence of Pitt and the opportune recovery of George soon ended the crisis, to the joy of all except the prince and his Whig supporters; but while the English monarchy took firmer hold of the people, Louis XVI., lacking foresight and finding no sure guide, saw the loyal States General soon metamorphosed into an almost hostile National Assembly; and, the end of the year 1789 found him, his unpopular queen, the court and the assembly virtually prisoners in Paris. In the next years English and French politics diverged ever more widely. While George III. and Pitt in 1790 successfully rebutted the claims of Spain to exclude England from Nootka sound and the northern Pacific, France, in spite of noble efforts at national renovation, fell a prey to disorder, discredit and bankruptcy. After the death of Mirabeau and Louis's futile attempt to escape to Germany, her discords became incurable. Suspicion and class hatred bred a fanatical republicanism hostile to all thrones and leading to war with Austria (April, 1792).

Meanwhile Fox's indiscreet praise, and Burke's eloquent denunciations, of the French Revolution split up the Opposition and sent up a solid Tory majority in the general election of 1790. During the debates on the Canada Act of 1791 Burke abjured Fox; and by degrees the New Whigs under Fox and Sheridan separated from the Old Whigs, led by the duke of Portland, Burke and Windham, who now opposed all change. Pitt, aided by his cousin Lord Grenville at the Foreign Office, pursued a peaceful policy, and in 1792 lessened the armed forces and taxation, but now scouted all proposals for reform. The overthrow of the French monarchy and the September massacres at Paris increased the tension; but the cabinet, while not recognizing the French Republic, treated with it unofficially. Nevertheless a series of aggressive decrees passed at Paris, in Nov.–Dec., 1792 (culminating in two which threatened Britain's Dutch allies) portended a rupture, which would have occurred even if the republic had not on Jan. 21, 1793, executed Louis XVI. On the consequent expulsion of Chauvelin, the French "ambassador," the French convention (assembly) unanimously declared war on Great Britain and Holland (Feb. 1, 1793). The leading Jacobins (*q.v.*) vainly hoped to overrun Holland, seize her riches and her fleet, and rouse the English republicans to overturn the throne.

THE FRENCH WAR

The First Phase.—In the ensuing war the following phases may be noted. First, France had leagued against her Austria, Prussia, Sardinia and Naples, then Great Britain and Holland, and, later, Spain, Portugal, the Holy Roman empire, and (nominally) Russia. But her whole-hearted vigour and their discords and intrigues (turning chiefly on the partitions of Poland) finally discomfited their ill-concerted operations, until in 1794 the French *levée en masse* drove them back on all fronts, the British retiring on Holland. Meanwhile the British navy, hastily manned, had showed up poorly, but in 1794 under Lord Howe gained a notable success over slightly larger numbers on the "Glorious First of June." Lord Hood with the Mediterranean fleet, though driven from Toulon at the close of 1793, yet in 1794, with the help of Captain Nelson, captured three French strongholds in Corsica. After Hood's recall by Earl Spencer, the Mediterranean campaign of 1795 dragged on ineffectively, while in the following winter the French drove back into Hanover the duke of York's army, and forced the Dutch Republic to accept a French alliance.

The Second Phase.—The defection of Prussia and Spain soon following, the war entered on a second phase (Aug., 1795–Oct., 1797). England and Austria struggled ever more unsuccessfully against the French arms, directed by Carnot, the "organizer of victory," and thrust home by its executant, Bonaparte. The French invasion of Italy was favoured by Hotham's ineffective handling of our Mediterranean fleet, which, owing to the hostility of the Spaniards, abandoned Corsica and that sea at the end of 1796. Accordingly, in 1797, Bonaparte compelled first Naples then Austria to make peace. Thereafter Great Britain, with slight help from Portugal, bore the brunt of the war. Republicanism in the large towns, and annoyance at the inefficient handling of the campaigns (especially the diffuse and costly operations in the West Indies), had by this time aroused wide-spread discontent. The New Whigs urged parliamentary reform, which was loudly demanded by great mass meetings and Radical clubs. Pitt and his mechanical majority, reinforced by the Old Whigs, thereupon passed repressive measures, and prosecuted, often unsuccessfully, Tooke, Hardy and other Radicals. Thus the war rent asunder the party of reform, whose pacifist and Francophile left wing was now dubbed unpatriotic. Yet the intensity of the crisis in 1797 helped to stay national disintegration. First, in February the drain of the war compelled the Bank of England to stop cash payments and placed credit on a paper basis for some 20 years. Then, in succession the seamen of the Channel and Nore fleets mutinied for higher pay, the latter blockading the Thames until sheer rascality brought about successful retaliation, but not before consols had sunk to 48½. Next, Pitt's untimely overtures for peace with France met with a condign rebuff from the new extremist and aggressive Directory thrust into power by Bonaparte (September).

The Third Phase.—Insult, added to peril, now stiffened Pitt's attitude and that of the nation at large. In the third phase (Oct. 1797–Oct. 1801) all but the wilfully blind saw that the French no longer warred for the liberty of mankind but for their own colonial and commercial domination. Bonaparte's new oriental policy speedily led to the spoliation of the central Swiss cantons and of Rome, the seizure of Malta and the capture of Egypt. The triumph of Nelson at the Nile (Aug. 1, 1798), the capture of Minorca (1798) and Malta (1800) checked his designs and assured the safety of the overland route to the East. Indeed, so far back as 1795, the occupation of Cape Town and the Dutch settlements in Ceylon (due to the foresight of Henry Dundas) had placed the maritime keys of the Orient in British hands. Bonaparte's dream of eastern conquests came to him three years too late, and he was supremely lucky to escape from Egypt to France just in time to be greeted as "conqueror of the East." That illusory title and the far more valid hope of attaining glory and order under his rule enabled him to expel the Directory and make himself first consul (Nov. 1799). Pitt, however, refused to treat seriously a New Year offer of peace; for he hoped to breathe life into the second coalition of England, Austria, Russia and Naples; but Austro-Russian discords and the blows of Bonaparte and Moreau soon sapped its vitality, and it collapsed in the winter of 1800–1.

Meanwhile the Irish malcontents had acted as cat's paws for the French directory, which early in 1798 had fomented a rising with the futile hope of detaining the British fleet in home waters; but the Irish rebellion broke out in May and was sharply repressed before even a small French force arrived. In 1799–1800, however, the presence of a great Franco-Spanish fleet at Brest encouraged the malcontents, but also strengthened the arguments of Pitt, Grenville, Castlereagh and Cornwallis in favour of a parliamentary union, which resulted in 1800 by the use of methods of influencing votes far from uncommon in the Irish parliament. The union was a war measure, concentrating power in one central authority as was then happening in France in the hands of the first consul. (*See* IRELAND: *History*.) The sequel was curious. Pitt and most of his colleagues resolved to link with the union a measure for catholic emancipation which indeed the viceroy, Cornwallis, secretly promised to some leading Irish catholics. The king, however, on hearing of this project, declaimed against it so violently that Pitt and a majority of the cabinet resigned.

Another fit of royal lunacy supervened, and during the tardy recovery Pitt weakly promised not to bring up the question again in that reign. He also felt bound informally to help the next prime minister, Henry Addington, whose weakness disgusted most Pittites. Consequently the national party, formerly cemented by Bonaparte's aggressiveness, now went to pieces. Nevertheless, the war ended not unfavourably. The armed neutrality of the league of the Baltic Powers, trumped up against England by Bonaparte and his new friend the Tsar Paul, was shattered by Nelson's victory at Copenhagen and the assassination of the tsar. The expulsion of the French from Egypt further conducing to a general stalemate, negotiations for peace led to the signing of the Preliminaries of London on Oct. 1, 1801.

The resulting Treaty of Amiens (March, 1802) was unsatisfactory; for England, though supreme at sea, restored all the conquered enemy colonies, retaining only Trinidad from Spain and the Dutch posts in Ceylon. Yet France kept nearly all her continental conquests along with virtual control over the cordon of republics on the east. England evacuated Minorca, Egypt and the Cape, and reinstated the Knights of St. John at Malta on terms which proved unworkable. The situation became unbearable when Bonaparte intervened in the affairs of Holland, Switzerland and Italy, annexed Elba, and showed his resolve to conquer Egypt and regain the Ionian isles. Addington thereupon demanded the retention of Malta for ten years, and the rupture occurred in May, 1803. His manifest unfitness for so uphill a struggle led to the return of Pitt to power in May, 1804, when Napoleon became emperor of the French.

The Fourth Phase.—Owing to the retrocession of the French colonies England's position was less favourable than in 1801, but she defied Napoleon's efforts at invasion, tried to organize an efficient army, improved the militia and volunteers, and swept the seas by fleets which Earl St. Vincent had improved and Lord Barham now perfected. Napoleon's overbearing treatment of neutrals and annexation of Genoa having enraged the emperors of Austria and Russia, Pitt was able to form the third coalition against France. It was stricken to death by those Napoleonic masterpieces, Ulm and Austerlitz; but the coalition strategy, though faultily diffuse, achieved one great success; Pitt and the Tsar Alexander having sent forces to rescue south Italy, Napoleon ordered to the Mediterranean the Franco-Spanish fleet refitting at Cadiz. The result was Trafalgar, which averted French domination in that sea and enabled Britain to hold both Sicily and Malta, *barrière infranchissable* as Napoleon termed it, against his eastern designs. Thus Pitt and Nelson by their last efforts assured ultimate victory; for Napoleon, while conquering in turn Austria, Prussia and Russia, lost command of the sea and never realized the eastern plans dearest to his heart.

After Pitt's death a "broad bottom" ministry, nicknamed "of all the Talents," diverted British efforts to the Dardanelles, Rosetta and Monte Video with infelicitous results. Successful in abolishing the slave trade in British vessels, it failed to come to terms with Napoleon in 1806, and his "insincerity" in these negotiations probably hastened the end of Fox. In March, 1807, when Portland and Canning took up the reins, the nation supported them even in so reprehensible an act as their seizure of the neutral Danish fleet by way of retort to Napoleon's open bid for world supremacy at Tilsit (July–Aug., 1807).

The Fifth Phase.—Napoleon's secret bargain at Tilsit with Alexander for the partition of Turkey led him on into the Spanish adventure of 1808, which turned the Iberian peoples into bitter enemies and furnished England at last with a sure continental fulcrum for her army. The Anglo-Portuguese-Spanish efforts in the campaigns of 1808–13, backed by the prudent and untiring genius of Wellington, brought salvation to the three peoples and the hope of deliverance to Europe. The British navy not only carried without fail to the Iron Duke the needed supplies and reinforcements, but also threatened the French coasts and wore down the commerce and finances of Napoleon's empire. His immense expansion of that organism in order to bar out British goods from the Continent never fully achieved that purpose; for after Trafalgar the sea power won the Cape of Good Hope and most of the French and Dutch colonies, thus giving British trade a virtual monopoly of all tropical produce. Thereafter, the manufactured products were smuggled into his dominions through vantage points such as Anholt, Heligoland, the Channel Islands, the Iberian ports, Sicily and the Ionian islands. Thus his continental system, devised for the ruin of British trade, was ever being punctured, though hermetical sealing was essential for success. Great Britain's resources were seriously strained in 1810–11; and her Orders in Council brought about the lamentable war with the United States (1812–14); but the yet severer pressure of Napoleon's fiscal decrees led at that time to his rupture with Russia and the tragedy of the Moscow campaign. Thus his methods led to campaigns brilliant though barren; hers, to conquests of new lands fraught with infinite promise. The contrast explains the future shrinkage of the French people and the expansion of the British people.

1813–15.—It is impossible to describe here the closing phases of this mighty struggle; but, as the movements of great peoples register the verdict of history, we may note that, whereas in 1803–05 Great Britain was isolated, in 1813–15 the other Great Powers espoused her cause against Napoleon and assured his overthrow. To this result Wellington had materially contributed by his six peninsular campaigns even more than at Waterloo, for in them (to quote Napier) he won 19 pitched battles, made or sustained ten sieges, took four great fortresses, twice expelled the French from Portugal, and killed, wounded, and took prisoners 200,000 enemies. With uncertain help from Britain's difficult Spanish and Portuguese allies, he baffled the best of the French marshals at the head of veteran armies, and finally drove them over the Pyrenees, beating them at Orthez and Toulouse.

In his appeal to the prince regent[1] Napoleon termed the British "the most powerful, the most consistent and the most generous of his enemies"; and in the negotiations leading to the Peace of Paris, Castlereagh and Wellington sought successfully, with help from Alexander I., to prevent the partition of France by the Germanic Powers. Consequently she was restricted to her old boundaries in Europe, but recovered all of the British naval conquests except St. Lucia, Tobago, Mauritius and the Seychelles. Of her Dutch conquests England restored Java and other East India isles, but retained the Cape, Demerara and Curaçao, paying to the new kingdom of the United Netherlands as indemnity a sum not exceeding £5,000,000. In Europe the strategic points, Malta, the Ionian isles and Heligoland were also retained. Thus, while the heart of the British empire was protected by the allocation of the Flemish and Belgic lands to the now friendly Dutch, its outlying portions were safeguarded by naval bases, the importance of which had appeared in hostile designs and actions. (*See* also EUROPE: *History;* PENINSULAR WAR; NAPOLEONIC CAMPAIGNS; WATERLOO CAMPAIGN; NAPOLEON; GEORGE III.)

The economic features of the war are remarkable. Thanks to the factory system and Pitt's sound finance the revenue of the United Kingdom rose from £18,900,630 in 1792 to £33,069,775 in 1800 and £71,900,005 in 1815. Textile and hardware manufactures showed almost uninterrupted increases, as also the tonnage of ships clearing outwards. The population of England and Wales grew from about 8,760,000 in 1790 to 8,892,536 in 1801 (first census) and 10,164,256 in 1811. Yet improved agriculture and stock-breeding (largely due to Arthur Young, Bakewell and others) met these growing needs except after bad harvests. Thus the national vitality, shielded by the navy, defied Napoleon's efforts at commercial strangulation, carried on a costly war and met the financial demands of exigent allies.

THE REFORM MOVEMENT

Social Conditions.—War, however successful, leaves behind a rank seed-bed of discontent; for its rewards and penalties are in general brutally unjust. Discharges of sailors and soldiers (some 4,000 were helped out to Grahamstown in 1819–20) and the collapse of war industries and prices worked havoc with a social system already tottering to a great change, and now bowed down under unheard-of burdens. The war had raised the National

[1]Issued off Rochefort in July 1815.

Debt to £861,000,000 entailing the annual charge of £32,645,000. High taxes, bankruptcies and falling wages caused widespread discontent, which was accentuated by the repressive legislation of the Liverpool cabinet and the unpopularity of the prince regent. In fact Britain, which had deposed the imperial heir of the French revolution, now had to grapple with the outcome of her own industrial revolution. For during these twenty-one years of war the wonder-working inventions of Arkwright, Watt, Trevithick and Stephenson were multiplying steam-factories and laying out the first primitive railways—a change which drew population towards the coal fields. There these new amorphous groups, at the mercy of masters as hard as themselves, formed political gobbets indigestible by the old Georgian England. The discontent of the working classes during the war having largely ranged them with the Jacobins, the Pitt ministry in 1799 had suppressed all combinations of wage-earners. Trade unions being illegal, dissatisfaction with low wages and bad housing conditions took a threatening turn, as was seen in the Luddite Riots (*see* LUDDITES) of 1810–1811 and many outbreaks after the peace.

The schism between the new industrial England and the old agricultural England now yawned deep. For in 1815 farmers who during five years had waxed fat on wheat at an average of 100 shillings the quarter, had to face a drop to 63 shillings. The parliament of landlords, seeking to "save the farmer," imposed the Corn Law of 1815 excluding foreign corn until home grown corn reached the average of 80 shillings the quarter. The income tax of two shillings in the £ also gave place in 1816 to duties on very many articles which raised prices out of all proportion. Wages ruling low, there were numerous riots, the worst being the affair called Peterloo (*q.v.*) on the outskirts of Manchester (1819), when, at a meeting on behalf of parliamentary reform, the magistrates, in a fit of nervousness, let the Cheshire yeomanry charge, a dozen persons being killed and hundreds injured in the stampede. Rick burning in the country and machine breaking in the factories being rife, the Liverpool ministry, with Wellington and lords Sidmouth and Castlereagh as leading spirits, passed the repressive "Six Acts" (1819), which incited the extreme Radicals to the futile Cato street plot for the murder of ministers (1820). Knowledge now came under the official ban. The work of Bell and Lancaster in the new National schools and British schools being deemed dangerous, education was discouraged, and pamphlets and newspapers were subjected to a tax of fourpence a copy. The result was to favour the growth of the "unstamped press," secretly printed and circulated by Hetherington, Lovett and other working-men Radicals. And while the base of the social structure heaved with discontent the scandals of George IV.'s life and in 1820–21 his vulgar feud with Queen Caroline threatened to blow off the apex. Revolution, however, was averted both by the good sense of the mass of the people and by the slow but steady improvement of industrial conditions. Despite the financial vagaries of Vansittart, chancellor of the exchequer down to 1823, the Liverpool administration (1812–27) paid off much war-debt, reduced its rate of interest, resumed cash payments at banks in 1821–23, and was then able to remit some £3,500,000 in taxation. Huskisson, as president of the Board of Trade, reformed the navigation laws, lessened the duties on silks and sought to give effect to free trade principles. Nevertheless, Liverpool and his colleagues still opposed parliamentary reform, though the changing conditions of English life rendered the old system increasingly anomalous, and aroused general discontent, stridently voiced by the ablest of English pamphleteers, William Cobbett, and by several agitators.

Canning.—On a higher plane was British foreign policy, ably conducted by Castlereagh. He, the cementer of the European alliance against Napoleon, now steadily and in the main successfully opposed the monarchical reaction symbolized in the Holy Alliance (*q.v.*) and manipulated by Metternich. Thus throughout the period of the Congresses (1818–22) Britain exercised a moderating influence detested by the autocrats. After his suicide (1822), his rival and successor, Canning, imparted an even more progressive trend to foreign policy. Acute friction with France ensued in 1823 owing to her invasion of Spain on behalf of the Spanish autocrat Ferdinand VII., and her designs on Spanish America, then freeing itself from the mother-land. By way of counterpoise Canning proposed joint action with the United States. Unfortunately, President Monroe declined it, but issued the message, termed the Monroe Doctrine (*q.v.*), warning off the Continental Powers from the New World. Canning also recognized the independence of the Spanish American colonies on Dec. 31, 1824; and both they and the reactionary monarchs recognized in Britain's naval supremacy the decisive factor in the situation. Their rage was vented less on Monroe than on Canning; and he declared with no less justice than pride: "I called the New World into existence to redress the balance of the Old." In the sequel he was able to counteract reaction both in Iberian affairs and by assuring the independence of Brazil, before he turned to grapple with the "eternal" Eastern question (*q.v.*).

The Greeks, then almost beaten in their heroic struggle for independence, owe far more to Canning than they have generally realized. Though not claiming for them independence, which then seemed hopeless, he cautiously prepared the way for it, first, in 1823, by recognizing them as belligerents, next by sending to Constantinople as ambassador Stratford Canning with pro-Greek instructions, also by framing a close agreement with the new tsar, Nicholas I. After Canning became prime minister (April, 1827) this masterly orientation in British policy led to the Treaty of London (July 6, 1827) between Britain, Russia and France for imposing an armistice on Turks and Greeks with the ulterior aim of establishing Greek autonomy under the Sultan's suzerainty; failing which the three powers would interpose to prevent further hostilities. Before this last (secret) clause took effect Canning died (Aug. 8); but his last diplomatic action led to the joint pacific blockade of the Morea, which involved the Battle of Navarino (*q.v.*). More than any one man, Canning freed Greece.

Less progressive in home than in foreign affairs, Canning blocked the way to reform except in regard to Catholic emancipation, which, as a pupil of Pitt, he sought to further. Finally, Wellington as prime minister (1828–30) had reluctantly to concede this measure as needed to pacify Ireland, then roused to passion by O'Connell's indignant oratory. Despite the king's opposition and the no-popery cry, the bill passed both houses in March–April, 1829. Justice had been tardily done to Nonconformists in 1828 by the abolition of the Test and Corporation Acts (*see* TEST ACTS) on the motion of Lord John Russell.

Parliamentary Reform.—Meanwhile the disfranchisement of three of the most rotten boroughs, Grampound, Penryn and East Retford, showed that parliamentary reform could not long be staved off. That question had passed through the following phases—in 1780–84 constitutional growth, 1785–90 apathy, 1790–98 Gallophile effervescence, 1799–1815 apathy, 1815–29 revival under the impulse of material distress and the diatribes of Cobbett, etc. The quick shifting of population to the new industrial towns furnished an even more cogent argument against the old haphazard plan whereby many villages returned two members apiece and Cornwall sent up 44 members as against 45 from the whole of Scotland. The caprices of the old franchise being equally fantastic, Lord John Russell easily proved the need for a system which would be intelligible and national. Fortunately, the opportune death of George IV. now brought to the throne William IV.; and against the homely "sailor king" it was hard to get up a revolution. The general election of September, under the impulse of the democratic July revolution at Paris, sent up a majority favourable to Reform. Wellington, declaring in favour of the old system as the best that the wit of man could devise, was beaten; and the second Earl Grey formed a ministry, which, after two rejections by the House of Lords and fierce rioting by way of protest, carried its third Bill through that house on June 4, 1832.

That measure disfranchised 56 nomination boroughs, and halved the members from 30 more. In all 143 seats were left free for distribution and of these 65 were allotted to counties in England and Wales, which were to send 150 members, elected by the 40-shilling freeholders along with £10 copyholders and £50 leaseholders. Forty-three towns now became parliamentary boroughs, having a uniform £10 household suffrage in place of the old

chaotic franchises. Scotland now gained her due place in parliament. The power of the squires was lessened, for shop-keepers in the towns, and in the counties, landlords and farmers, now formed the majority of voters. The result disgusted not only the old Tories but also the Radical working-men, who complained that Grey and Russell had cheated them of power. Hence the Chartist movement of the near future.

Viewing the period as a whole, we see that the divergence and subsequent clash of the reform movements of England and France worked infinite harm on both peoples. Apathy, bred of contentment, hypnotized English reformers in 1785–89; just grievances, national excitability and a long series of political blunders worked up those of France to fury, with its sequel the Terror and war with England. That internecine conflict led France to an empire, England to reaction. Fear of the red spectre haunted the minds of Pitt's followers even up to 1827. Fox and his disciples saw more clearly that reform would strengthen the constitution; but their anti-national tirades during the war long clogged their efforts. Finally the slow but mighty uplift of the industrial revolution removed the war-incubus; and, by a curious stroke of irony, the Paris revolution of 1830 came to clinch the finale at Westminster. When the dust of conflict cleared, the Reform Bill of 1832 was seen to be truly conservative, and might indeed claim a lineal descent from Pitt's reforming efforts in 1783–85. (*See* also Reform Movement and the various biographical articles.) (J. H. Ro.)

XI. THE VICTORIAN AGE, 1832–1901

When the great Reform bill had sailed safely into port, leaving the storms of popular riot and constitutional crisis behind it, a new epoch had begun. That epoch may be said to end with the conquest of the Dutch Republics in South Africa, the death of Queen Victoria, and the end of the century, three events that came almost together. We call the age Victorian, for the Queen's reign covered all but five years of it. It was an age remarkably free, in England, from sudden revolutions and violent catastrophes such as France, Germany, Italy, and the United States experienced. None the less, in Britain quite as much as in those other countries, it was an age of unprecedentedly rapid change and development. The population of England and Wales rose from 14,000,000 to over 32,000,000, and wealth increased faster than population. Overseas trade was multiplied sixfold. The number of paupers in receipt of relief was reduced by one-third; the number of criminals in prison was halved. Railways were a novelty and an experiment in 1832; in 1901 the novelty was the motor-car. In 1832 the tonnage of vessels served by steam was less than 100,000 tons; in 1901 it was 13,700,000 tons, more than four times the total mercantile tonnage of the country at the earlier date. In 1832 electricity had no commercial uses; in 1901 electric light, telegraphy, and traction were all taken for granted.

The great Reform Bill had extended the electorate, but even so there were less than a million voters in the whole country; it was a middle-class electorate. By 1901 the control of the government belonged to the wage-earning males. In 1832 only about a quarter of the children of England and Wales received any school education; in 1901 education was compulsory and free of charge. In 1832 there was a four-penny tax on newspapers. The taxed and legal newspapers catered only for an educated and prosperous class, and the untaxed and illegal papers led a precarious and generally disreputable existence. By 1901 the half-penny *Daily Mail* had a circulation of a million copies. In 1832 trade unions had only been legalized eight years before, and their membership was probably well under 100,000. In 1901 there were close on two million trade unionists, and the Labour members had sat in the House of Commons.

If we turn to Britain overseas we find that, in 1832, Canada consisted of two small colonies, soon to be in rebellion against the government provided for them; Australia was still used as a place for convict settlements; New Zealand was not yet British territory; Cape Colony was rent by the Anglo-Dutch rivalries which resulted soon after in the Great Trek, the exodus of the discontented Dutch to found new communities north of the Orange and the Vaal rivers. By 1901 that quarrel had reached its climax in the South African War, and troops from the other three "colonies," by that time self-governing dominions, were voluntarily assisting the mother-country in the South African War. The British population in the dominions, a mere handful in 1832, was by 1901 nearly equal to the population of England and Wales at the earlier date.

THE WHIGS AND THE CHARTISTS, 1832–41

During the agitations attending the passage of the Reform bill some had feared and others had hoped that the character of the House of Commons would be henceforth radically different. These hopes and fears proved groundless. The new House and its successors for the next forty or fifty years were much like the Houses of the years immediately before the Reform. Country gentlemen predominated, and the proportion of self-made business men and lawyers increased but slowly. Cabinets, especially Whig cabinets, continued to be recruited mainly from the old aristocratic families. The new voters proved, as Bagehot remarked 35 years later, to be "deferential"; they preferred to be represented by their "betters."

The Whigs secured a big majority in the first election on the new franchise, and Lord Grey's cabinet kept in office. Its first important measure was the Abolition of Slavery (1833), an Act which completed the good work begun by the Abolition of the Slave Trade Act in 1807. These measures are the first notable example in our history of the power of a great voluntary organization, the Anti-Slavery Society, working to stir public opinion and thus to secure parliamentary action. It is also remarkable as the work of the great evangelical religious movement, whose origins can be traced back to the preaching of Wesley and Whitefield. The slave-owners received £20,000,000 in compensation, but the change inevitably produced grave complications in South Africa and the West Indies. (*See* Wilberforce, William; British Empire.)

The principal measure of 1834 was inspired not by philanthropy but economy, namely the Poor Law Amendment Act, which brought to an end the reckless distribution of outdoor relief which had grown up in the previous forty years. The aim of the new Act was to abolish outdoor relief entirely. It inflicted great misery on the poorest folk, and no government depending on a democratic franchise would have dared to introduce it; none the less, it terminated an intolerable misuse of ratepayers' money.

In the same year Lord Melbourne, who had succeeded Grey as Prime Minister, being in difficulties with his cabinet, secured his own dismissal by King William IV. Peel took office, and dissolved parliament; but the election gave the Whigs another, though reduced, majority, and Melbourne returned to office. The episode had enabled Peel in his "Tamworth manifesto" to proclaim that his party, henceforth not Tory but Conservative, frankly accepted the Reform bill as final, and proposed to enact its logical consequence, namely, a reform of the system by which town councils were elected. Henceforth these were to be elected by the whole body of the ratepayers. This measure was actually carried by the Whigs on their return to office (1835). But it is remarkable that country areas remained under the government of nominated magistrates for another half-century.

Queen Victoria.—The year 1837 saw the accession of Victoria, and Melbourne is best remembered to-day as the wise and kindly old statesman who gave the young queen her political education. That education was to be continued by Prince Albert of Saxe-Coburg, who became the queen's husband in 1840. In 1839 Victoria's devotion to Melbourne occasioned a somewhat ludicrous political crisis. Melbourne resigned office, having practically lost his majority in the Commons, and the queen sent for Peel, who, however, declared that he could not form a government unless the queen would consent to dismiss some of the Whig ladies of her household and receive Tory ladies in their places. The queen refused, and Melbourne consented to resume the office he had laid down. After her marriage the queen attached less importance to these ladies, and no further "Bedchamber questions" arose.

Two important innovations marked the year 1839. One was

the establishment of the penny postal service, a corollary of the railway system now rapidly developing. In this matter England led the world. In the matter of elementary education, on the other hand, she took, in the words of a great French historian, "the lowest place among Protestant countries." Since the early years of the century organizations affiliated to the Church of England and the nonconformist churches had been establishing elementary schools in increasing numbers. In 1838 the Government made an annual grant of £20,000 to these organizations. In 1839 the grant was increased to £30,000, and a committee and inspectors appointed to supervise the expenditure of the grant. Here was the beginning of what has grown into the Board of Education.

Chartism and the Anti-Corn Law League.—Industrial enthusiasts, such as Ure, in his *Philosophy of Manufactures* (1835), gloried in the strict discipline enforced by factory conditions, but the factory workers themselves took a different view. The new Poor Law was another exhibition of "discipline" and was equally unpopular. The masses whose formidable enthusiasm had helped to carry a middle-class Reform bill, were already beginning to ask themselves "what next?" In 1834 Robert Owen (*q.v.*), once the "model employer" of New Lanark and afterwards the evangelist of other doctrines, co-operative, socialist and secularist, organized a Grand National Consolidated Trades Union which should secure the establishment of some vaguely defined socialistic system by means of a General Strike. A merciless government prosecution of seven Dorchester labourers pricked the bubble of Owenism, but Chartism (*q.v.*) stepped into its place. The "People's Charter," published in May 1838, demanded manhood suffrage, vote by ballot, payment of members, abolition of the property qualification for members, equal constituencies, and annual parliaments. But the movement behind this programme lacked capable leaders, and such leaders as it had were hopelessly divided in method. Did the Chartists intend simply to present a petition to parliament, or to overawe parliament, or to deny the legitimacy of parliament, as a non-democratic assembly? As so often happens with such movements, the extremists were the most vocal section, and in consequence both trade unionists and radical politicians drifted out of the movement. Mild riots at Birmingham and Newport ended the Chartism of the 'thirties. Chartism was the typical working-class movement of the day, and its ineffectiveness illustrates the fact that the working-classes had not discovered either a satisfactory programme or an effective method of mobilising their power. A different destiny awaited the Anti-Corn Law League, founded in conscious rivalry with Chartism, by Radical M.Ps. and Lancashire manufacturers in 1836. The League sought to persuade the working man that his principle grievance was neither his exclusion from political life nor his inclusion in the factory system but the dearness of his food, due to Corn Laws made by landlords for the benefit of landlords.

But it would be a mistake to regard political agitation as the most characteristic feature of early Victorian England. If we had to select one such feature we should select the domination of all classes and all Protestant churches by evangelical piety. What we loosely call "Victorianism" is in fact the triumph of the evangelical movement.

The Fall of the Whigs.—Melbourne's government, like so many other British governments, was continuously embarrassed by Irish problems—Irish tithe, Irish Poor Law, and Irish local government. Canada and Jamaica were also the subjects of stormy debates. The Canadian rebellions of 1837 (*See* CANADA: *History*) led to the mission of Lord Durham (*q.v.*), whose famous Report led to the establishment of Canadian self-government, a system extended in due course to all the other "White" colonies. In Jamaica, on the other hand, where the population is predominantly "Black," the Government sought to terminate the system by which a handful of British planters governed the island. They failed, and this system lasted until 1865. But the chief weakness of the Whigs was that they lacked a bold and competent financier. Baring's Budgets of 1838–41 were all unsuccessful measures, and the last of these Budgets involved the fall of the Government. The election of 1841 gave the Conservatives a safe majority, and Sir Robert Peel became prime minister.

The Melbourne government had on the whole a poor record, but non-political England was hard at work. Railways, steamships, factories went ahead. The ten years under review mark an important epoch in the history of banking. Joint Stock Banks had been legalized in 1826, and in 1833 were allowed to establish themselves in London, where the Bank of England had hitherto enjoyed a monopoly. The next few years saw the establishment of the Westminster, Union, and London and County Banks. It was proved that a bank could prosper even though it could not issue bank-notes; for this then much valued privilege was restricted to the Bank of England and to "provincial" banks with no branch within sixty miles of London.

Literature.—This period saw the appearance of the last novel of Scott and the first novels of Dickens. Wordsworth was growing old and had long passed his prime, but Tennyson's early poems were beginning to attract attention, and Macready, the actor, enabled Browning to hold the stage (for a few days only) with his historical drama of *Strafford.* Macaulay's essays were eagerly read in the quarterly issues of the *Edinburgh Review,* and Carlyle's *French Revolution* not only showed that the French Revolution was neither as black nor as white as enemies and friends had painted it, but also indicated what happened to governments which disregarded the aspirations of their voteless masses. Lyell's *Principles of Geology* opened up new views of the history of the animal creation, and prepared the way for the violent Victorian controversies between religion and science.

FREE TRADE, 1841–52

Peel.—Peel's first duty was to secure a revenue equal to the expenses of the government, a task in which the Whigs had lamentably failed. His famous Budget of 1842, introduced by the prime minister himself, established an income-tax of sevenpence in the pound. Pitt's income-tax had been explicitly a war measure, and had been dropped in 1815. Peel's was put forward as an emergency measure, but it has proved a permanency. This budget and those of 1845 and 1846, all three of which either abolished or drastically reduced hundreds of import and export duties, mark the substantial establishment of free trade, and of our modern system of taxation. They coincided with the turn of the tide of national prosperity. The "hungry forties" were the early forties, a time of distress quite as bad as any of the years immediately after Waterloo. Now at last the tide of mid-Victorian prosperity set in. In 1844 Peel was able to reduce the interest on nearly a third of the national debt from 3½ to 3¼ per cent., and in 1845 his Bank Charter Act reformed the functions of the Bank of England.

Repeal of the Corn Laws.—Ireland was, as usual, a cause of embarrassment. Peel showed sympathy by increasing the government grant to the Irish Roman Catholic College of Maynooth, but this was a small matter compared with the appalling famine of 1845, occasioned by the failure of the potato crop, the staple food of an already impoverished and overpopulated island. (The population of Ireland was 8,000,000, twice what it was in 1926). In the same year rain destroyed the English harvest. Ireland was starving and England could not feed her. Cobden, the lucid advocate of the Anti-Corn Law League in the House of Commons, had already converted Peel to the policy of applying his free trade system to corn, but his electoral promises pledged him to maintain the Corn Law. He had intended to announce his conversion at the next election but Ireland forced his hand. He resigned. The Whigs, led by Lord John Russell, failed to avail themselves of the opportunity to form a "repeal" government, and Peel resumed office and carried the measure (1846). But the triumph of his policy was the ruin of his party. Landlords predominated on the benches behind him, and they had never wholly trusted Peel, himself the son of a manufacturer and a "Conservative" (whatever that might mean) rather than a genuine "Tory." They found leaders in Lord Stanley (subsequently Derby), Lord George Bentinck, and Disraeli, who attacked Peel night after night with the wittiest invective ever heard in the House of Commons. The rebels and the Whigs combined to defeat Peel on the very night on which his "repeal" measure was reluctantly piloted by the Duke of Welling-

ton through a reluctant House of Lords. Henceforth the rebel Tories were the Tory Party, and the faithful became known as the Peelites, a distinguished but diminishing "third party," of whom one was Gladstone. (*See* CORN LAWS.)

Factory Acts.—The Russell Government (1846–52) was undistinguished in domestic policy and unsuccessful in its well-meant efforts to alleviate distress in Ireland, where eviction of bankrupt tenants and emigration to America assumed gigantic proportions. Two important measures mark these years. The repeal of the Navigation acts (1849) administered a further dose of free trade (for the Acts restricted British commerce to British ships), and ended a system as old as the Commonwealth, and in principle older. The other important measure, the Factory Act of 1847, owed nothing to the favour of the government, but crowned the labours of a lonely, austere philanthropist, Ashley (subsequently Lord Shaftesbury), who, so far as he was a party man at all, was a high Tory. Ashley's first Factory Act (1833) had failed from lack of factory inspectors. His Mines Act of 1842 had prohibited the underground labour of women of all ages and of boys under ten. The act of 1847 prohibited factory labour for women and for lads under 18 for more than ten hours a day. In practice factory convenience generally extended the same privilege to men. These reforms were carried in the teeth of the intellectual convictions of the politicians of both parties; for all orthodox politicians at that date favoured "freedom," *laissez-faire*, non-interference, in all departments of industry. But there were landlords who were glad to get their revenge on the manufacturers who had secured the abolition of the Corn law; and there were also the appalling facts about child-life revealed by the official enquiries preceding these acts. Ashley, in securing government commissions of enquiry, forced the facts into the daylight, and the facts were eloquent. The age of statistics was beginning.

Palmerston.—Palmerston, the Whig foreign minister, enlivened politics, embarrassed his colleagues, and gradually established his position as the most popular statesman since Pitt. In the Grey-Melbourne governments he had powerfully assisted the liberation of Belgium from union with Holland and the extrication of Turkey from the clutches of Mehemet Ali, the ambitious Khedive of Egypt. He now quarrelled (on good grounds) with Louis Philippe, thus hastening the downfall of that insecure monarch, and sent a naval squadron to Athens to support the (mainly fraudulent) claims of a British Jew named Don Pacifico. The occasion was trivial, but Palmerston's triumphant vindication of a policy of supporting British subjects against foreign oppression in every quarter of the globe was a sign of the times. The bellicosity of the Crimean War was approaching. "Old Pam's" policy was his own, and took little account of the wishes either of his colleagues or of the queen, now the ardent pupil of her husband, who was himself a specialist in foreign affairs. Palmerston made a false, because unpopular, move when he congratulated Prince Napoleon on his *coup d'état* at the end of 1851, and was dismissed, but he scored his "tit for tat," as he called it, by securing Russell's defeat in the next year. The brief Government of Lord Derby (1852) which followed was made notable by two facts. It brought Disraeli into high office, and led to the explicit abandonment of protection by the nominally protectionist party. It was defeated on Disraeli's Budget and succeeded by a coalition of Whigs and Peelites under the Peelite Lord Aberdeen.

Prosperity and Co-operation.—The eleven years 1841–52 witnessed an important transformation in the world of labour. They opened with the "hungry forties" and ended with two years each of which was described by the *Times* as "of unexampled prosperity." It was in response to this change of conditions that working-class leaders abandoned projects aimed at revolutionary change, and sought to organize working-class prosperity within the "capitalist system"—capitalism itself making reluctant advances towards humaner methods through the Factory Acts. The final explosion and fiasco of Chartism in the Kennington Common meeting of 1848 was sensational but unimportant. The more important events are less conspicuous. In 1846 the Rochdale Pioneers established a co-operative consumers' society, which proved its right to its self-chosen title of Equitable Pioneers. Its novelty was that instead of attempting the impossible task of selling at cost price, it sold at market price and returned profits to its customers in "dividend," this being often left to accumulate as share capital. Co-operative production was more hazardous and less successful. The same year, 1846, saw the establishment of the Registry of Friendly Societies, and the Permanent Building Society to enable the thrifty to buy their own houses.

When Owen's unseaworthy Grand National Consolidated Trades Union suffered shipwreck in 1834, many small local "craft" unions were formed from among its disappointed members, and these subsequently found strength in amalgamation. The model of such was the Amalgamated Society of Engineers (1851), providing for strikes, unemployment, sickness, and superannuation. It fought and lost, with much public sympathy and assistance, a notable three months' strike in 1852.

Newman and Arnold.—Peel's conversion to free trade in corn created scarcely more excitement than John Henry Newman's conversion to Roman Catholicism in the previous year. The celebrity of this event is not so much evidence of the greatness of Newman as of the fact that the Early Victorian was essentially a theological age. The Oxford Movement, in which Newman had been a leader, seemed to have ended, but it was in fact entering a wider world as the Anglo-Catholic movement. Among its by-products was a renewed interest in and respect for the Middle Ages, which also found expression in Carlyle's *Past and Present* (1842). The first volume of Ruskin's *Modern Painters* appeared in the following year, and Victorian Gothic in all its strange varieties was soon to adapt itself to churches, hospitals and railway stations. Another churchman as notable as Newman was Thomas Arnold, the great headmaster of Rugby, who died in 1842. Henceforth the public schools were to be transformed into centres of earnest endeavour and manly decorum, and the growth of railways was to multiply many times over the public which made use of them. One of Arnold's pupils, Thomas Hughes, author of *Tom Brown's Schooldays*, was, with F. D. Maurice and Charles Kingsley, a leader of the little group of churchmen who, with bold defiance of popular prejudice, called themselves "Christian Socialists" (1848). The church, they held, had other work to do besides defining doctrines and saving souls at home, and converting the heathen abroad; it had to apply gospel standards to industrial organization and substitute co-operation for competition, and though these idealists failed, a bond was established between church and labour.

The Great Exhibition.—But "prosperity" rather than "problem" was the note sounded by the Great Exhibition of 1851, housed, in Hyde Park, in the Crystal Palace afterwards transferred to Sydenham. The event illustrated the fact that the Prince Consort, while fighting a losing battle for the control of purely political issues, was discovering a new career for royalty as the representative of the nation in matters which the parties agree to place above and beyond controversy. Free traders were inclined to regard the new prosperity as a product of free trade. Free trade played a part, but a greater part was played by the now essentially completed system of main-line railways. Hitherto old-world transport had stifled the output of steam production: steam transport enabled steam production to go full-steam ahead. That the demand of the consumer might some day prove unequal to absorbing the supply of the producer was not foreseen; and excusably, for it was a problem of the 20th century.

THE PALMERSTONIAN AGE, 1852-65

When Lord Palmerston, grudgingly supported by his colleagues, had won his strange personal triumph in the Don Pacifico debate of 1850, the Palmerstonian age had begun. Its hero was already 65 and could look back on an official career which began in 1809; but fifteen years of life remained to him, during which he dominated politics and gave a character all his own to our history. It was a curious interlude in the Victorian Age, a time of steady prosperity and domestic quietude, when John Bull took his ease, and enjoyed (or criticized) the adventures of a statesman who, whatever his faults, was proud of his country and determined that she should play a great and worthy part in the affairs of the

world. That is not, of course, the whole story of these fifteen years, but it is the main story. The first two years of it have been included in the previous section.

Aberdeen's coalition (Whig and Peelite) government had Gladstone as its chancellor of the exchequer, and the first of his long series of Budgets (1853) carried on Peel's financial policy. The income-tax was extended and more import duties abolished; the tax on spirits was increased and that on tea reduced. This promoted temperance, and another virtue reputed even nearer to godliness was promoted by the abolition of the tax on soap. But Gladstone budgeted for peace while his colleagues were "drifting" (to use Aberdeen's subsequent admission) into war.

The Crimean War.—The Crimean War (1854–56 *q.v.*) had both general and special causes. The general cause was the aggressive power of Russian despotism. Its south-eastern extension threatened Afghanistan, and its championship of Christian peoples in the Turkish Empire was considered a mere cloak to cover its lust for Constantinople; it was a bugbear to imperialists and an abomination to Liberals. Of the special causes, the chief was Lord Stratford de Redcliffe, British ambassador at Constantinople, who so manipulated controversies between Russia and Turkey as to provoke a Russo-Turkish war and to bring Great Britain into it on the Turkish side. Napoleon III., since 1852 emperor of the French, brought his reluctant country into the war in alliance with Great Britain. Aberdeen's government failed to control Lord Stratford, and Palmerston (imperfectly muzzled at the Home Office) had no desire that they should do so. The war proved, like other wars before and since, that bravery is much commoner than brains. It was the first war to be fully described in the daily press, and the revelations of Russell in the *Times* not only sent Florence Nightingale (*q.v.*) to Scutari, but also brought down the Aberdeen government; so Palmerston became prime minister (Jan. 1855). The British troops had greatly distinguished themselves at the Alma, Balaklava, and Inkerman in the autumn preceding the Crimean winter, but the capture of Sevastopol in Sept. 1855 was mainly the work of the French, whose forces by that time greatly outnumbered our own. The Treaty of Paris, which concluded the war, opened the Black Sea (*q.v.*) to the commerce of the world and closed it to vessels of war, forbidding the establishment of arsenals on its shores. For 15 years Russia accepted the neutralization of the Black Sea. In 1871, when France was at the feet of Bismarck, Gladstone's government was compelled to surrender the principal Crimean trophy, and Sevastopol rose again from its ruins.

In 1857 Palmerston allowed the British minister in China to involve Great Britain in a war over a petty dispute, and he was defeated on a vote of censure in the House of Commons, but he at once appealed to the constituencies and won the general election on this issue. Canton had already been bombarded; subsequently Lord Elgin occupied Pekin. But these events were quite overshadowed by the Mutiny of the Indian Sepoy regiments. Throughout the summer and autumn of 1857 all attention was concentrated upon the siege of Delhi, the tragedy of Cawnpore, and the defence and relief of Lucknow; and new names were added to the long roll of the heroes of the British army. (*See* INDIAN MUTINY.)

The Orsini Plot and Palmerston's Last Government.—In 1858 an Italian named Orsini attempted to assassinate Napoleon with bombs made in Birmingham. The French government despatched a rude remonstrance, and when Palmerston made the retort courteous of a bill increasing the penalties for conspiracy, the "patriotism" of which he had hitherto been the mouthpiece turned against him. He was defeated and succeeded by Derby, with Disraeli as leader in the Commons. The Derby government admitted Jews to parliament, terminated the existence of the East India Company, and incurred defeat over an attempt to extend the parliamentary franchise.

The general election of 1859 restored Palmerston to power, which he retained till his death, strengthened by the inclusion in his cabinet of the Peelite leaders, whose separate organization now came to an end. Gladstone returned to the Treasury and resumed the tale of his Budgets. A commercial treaty with France (1860), negotiated by Cobden, seemed to many the beginning of the conversion of the continental nations to free trade, and Gladstone's name, afterwards annexed by a bag, was temporarily attached to the cheap clarets made available by the treaty. Another item of 1860, the repeal of the paper duties, had an important constitutional consequence. The Lords rejected the bill in which it was embodied, and henceforth all the Budget measures of the year were included in a single Finance Bill. As the Lords could not, by custom, amend financial bills, they could henceforth interfere with taxation only by rejecting the whole of the revenue measures of the year, a course on which they did not venture till 1909.

The years of Palmerston's last government (1859–65) saw the union of modern Italy, the American civil war, and the Danish war with which Bismarck opened his momentous career as the maker of Prussianized Imperial Germany. To the Italian cause the government gave "moral support" which had a distinct though easily exaggerated value; but it is impossible to admire their part in the American and Danish crises. A peremptory despatch about the affair of the *Trent* (when an American naval officer improperly arrested the "Southern" envoys in a British ship) might have led to an unforgivable war had not the Prince Consort altered the document—the last public action of an admirable and unappreciated foreigner. As for the Danes, the British Government encouraged them to fight believing that Prussia would thereby be induced not to fight; but bluff was wasted on Bismarck, and Denmark paid the penalty.

It was a relatively quiet period in the world of labour, but among the miners and the builders trade unionism made a marked advance. In 1863 Alexander Macdonald succeeded in assembling, at Leeds, the first really representative Miners' Conference, and an organization to assist the building trade workers in the lockout of 1859 was a first foreshadowing of the national Trade Union Congress. During these years also a group of trade union secretaries resident in London became an informal clearinghouse for labour policies, and a means of establishing contact with friendly journalists and politicians: the group is commonly known as "the Junta." At about the same time Ruskin, who had secured the attention of a large public by his books on art and architecture, began to denounce in impassioned lectures the immorality of orthodox capitalist economics.

In 1859 the publication of Darwin's *Origin of Species* brought to a head the long pending controversy between "faith" and "science." Bishop Wilberforce disposed of the book as "atheistical" in the *Quarterly Review*, and was unwise enough to encounter Huxley in debate at the annual meeting of the British Association. Strong controversies arose within the church itself over *Essays and Reviews* (1860), a volume by several clerical hands, and Bishop Colenso's rationalistic examination of the Pentateuch (1862). The year of *The Origin of Species* (1859) also saw the publication of the first big novels by George Eliot and George Meredith. Almost all the poetry of Matthew Arnold belongs to the "Palmerstonian age," and its last year witnessed the publication of *Atalanta in Calydon*. Its author, Swinburne, was closely associated with the Pre-Raphaelite group of painters, whose theories and practice, whatever their merits, were about to stimulate a more vivid interest in the problems of pictorial art.

GLADSTONE AND DISRAELI, 1865-80

The Second Reform Bill.—Lord Russell became prime minister on the death of Palmerston, but it was plain that Gladstone would succeed to the leadership of the Whig-Liberal party in the near future, and that Lord Derby would similarly pass on the leadership of the Tory-Conservatives to Disraeli. The main motive of the politics of 1865–68 is the manoeuvring of Gladstone and Disraeli, in a House of Commons elected to support Lord Palmerston, for the succession to Palmerston's position as ruler of England. The principal by-product of these manoeuvres was the Second Reform Bill (1867) which doubled the electorate and gave the vote to the artisans in the borough constituencies, thus enfranchising the bulk of the factory workers but not the miners and agricultural labourers. Chartism had expired amid ridicule in 1848, but very soon after that date leading members of both

parties had begun to speculate upon an extension of the franchise, and various abortive bills had been introduced. Palmerston's indifference or dislike had postponed the issue, and his death immediately brought it within the range of practical politics. Russell and Gladstone introduced a moderate and colourless measure in 1866, which suffered serious amendment at the hands of the Conservatives and anti-Reform Liberals (nicknamed "Adullamites"), whereupon Russell's government resigned. Derby took office, and in 1867, after parting with three anti-Reform colleagues (one of them the future Lord Salisbury) carried an alternative Reform Bill, establishing "Household suffrage" in the boroughs, and lowering the franchise more guardedly in the county constituencies. The bill had been drastically amended in a democratic direction by Liberal proposals which Disraeli accepted and made his own, for both parties were bidding for the support of the new electorate. Lord Derby claimed that he had "educated his party," and "dished the Whigs." But the election had to be postponed till the new registers were ready, at the end of 1868. That year was marked by the activities of the Fenians, the new Irish physical force party, and Gladstone cleverly announced a policy of disestablishing the Irish Protestant Church. English electors hoped that this concession would abate the Irish nuisance, and Gladstone secured a majority of about a hundred. Of the next twelve years Gladstone had the first six.

Gladstone.—Gladstone's first Irish measure, the disestablishment and partial disendowment of the Irish Church, involved a conflict with the House of Lords, the most serious since the first Reform bill. The Lords accepted disestablishment but prepared to fight for the preservation of a larger fraction of the endowment. Gladstone, who never lost all his early Conservatism, worked hard and successfully for a compromise, actively supported by the queen. The next year (1870) witnessed the passing of an Irish Land Act designed to protect the tenant from "undue and unjust" eviction. It was ineffective, and its importance lay not in settling a very difficult problem but in indicating that the problem had got to be solved. In 1873 an unsuccessful attempt was made to provide an Irish University so constituted that British taxpayers would be willing to support it and Irish Catholic bishops to accept it. Ireland was not conciliated by any of these measures and "coercion" (*i.e.*, suspension of some of the normal privileges of British freedom) proved as inevitable under Gladstone's government as under nearly all other governments of the 19th century.

The principal legislative achievement of Gladstone's first government was the great Education Act of 1870. Its author, W. E. Forster, was a son-in-law of Dr. Arnold of Rugby and brother-in-law of the poet and essayist Matthew Arnold, whose long and unobtrusive career as a school inspector rendered valuable service to state-aided education. The government grant to "voluntary" schools (*i.e.*, schools established by the Church of England and other bodies) had steadily grown since its inception in 1833, and in 1870 about half the children of the country received some sort of elementary education. The Act of 1870 did not supersede this system, but filled in the gaps in it by erecting schools offering non-sectarian "simple Bible teaching," paid for out of local rates, and controlled by locally elected School Boards, which were empowered to make education compulsory in their localities. We may add here that elementary education was made compulsory throughout the country in 1880, and the small fees charged in many schools were abolished in 1891.

Among other measures of the 1868–74 government, Oxford and Cambridge degrees were thrown open to Dissenters, the civil service was thrown open to competitive examination, the army was reorganized by Cardwell and the system of purchasing commissions abolished, and the ballot was introduced for parliamentary elections. It may be doubted if this last measure was of much value in England; the time when it was needed had gone by, for voters had no longer cause to fear penalties at the hands of their employers. In Ireland, however, its effect was important and unforeseen. By releasing the Irish voter from the inquisition of his landlord it called into existence the Irish Nationalist party.

In the sphere of foreign policy Gladstone had been unable to prevent or to influence the course of the momentous Franco-German War (*q.v.*), though he secured from both parties an undertaking to respect the neutrality of Belgium. His concession to Russia of her right to rebuild Sevastopol as a naval base was a retreat, and retreats, even from untenable positions selected by one's predecessors, are never popular. Equally unpopular, though eminently wise, was his treatment of the *Alabama* question. The *Alabama* had been a privateer of the rebel Southern States of U.S.A., equipped in the Mersey, and allowed to leave British waters by the negligence of Palmerston's government. American demands for compensation were somewhat insulting in tone, and the controversy had long dragged. Gladstone got the matter referred to an international tribunal and paid the damages awarded. It was an important precedent for the use of arbitration in international disputes. (*See* "ALABAMA" ARBITRATION.)

Disraeli.—A cascade of political reforms is apt to terminate "gratitude for favours to come" and to offend those whom the reforms either irritate or disappoint. Disraeli expressed the sentiments of many when he accused his rivals of "plundering and blundering" and apostrophised the Treasury bench as a "range of exhausted volcanoes." His party secured a sound majority in the election of 1874. The new prime minister (soon to go to the House of Lords as earl of Beaconsfield) had described his policy as "the maintenance of our institutions, the preservation of our empire, and the improvement of the condition of the people." The third of these promises took shape in an Artisans' Dwellings Act, an important new departure in that it called in local public authorities to remedy the defects of unscrupulous private enterprise in housing. There was also an important Trade Union act, to be dealt with below. But for the greater part of its existence the energies of the government were monopolised by a series of foreign and imperial ventures.

The first and most formidable of these was the Balkan crisis of 1875-78. This was the first general nationalist rising of the Balkan peoples against Turkish rule. Russia, whose championship of distressed Balkan peoples was never very clearly distinguishable from imperialist ambition, went to war with Turkey (1877) and her armies advanced up to the defences of Constantinople. Gladstone supported the Balkan peoples on Liberal and moral grounds and looked forward to the expulsion of the Turk "bag and baggage" from the provinces he had misruled. Beaconsfield championed the Turkish Empire as a first line of defence of the British Empire in India. War between Great Britain and Russia was narrowly avoided, but a risky policy was carried with remarkable skill to a triumphant conclusion, and the questions at issue were settled by a European Congress at Berlin (1878), from which the prime minister returned with compliments from Bismarck and "peace with honour." (*See* BERLIN, CONGRESS AND TREATY OF.)

Beaconsfield's first and most popular imperial venture was the purchase (1875) of a majority of the shares in the Suez Canal Company from the bankrupt Khedive of Egypt. The Khedive's bankruptcy also involved other and less welcome entanglements. His creditors were mainly British and French, and in 1879 the two governments established a "Dual Control" over Egyptian finance. Khedive Ismail proved restive and was deposed, making way for the docile Tewfik. Meanwhile trouble had already come to a head on the Indian frontier. Russia had been intriguing in Afghanistan, and the Viceroy, Lord Lytton (son of the popular novelist), insisted that the Amir should accept a permanent British resident at Kabul. He refused and an Afghan campaign established a resident, whose murder entailed a second Afghan campaign. In South Africa the Transvaal, declared independent in 1852, was re-annexed by a stroke of the pen in 1877, partly with a view to a future South African Federation and partly to facilitate the suppression of the barbarous and aggressive Zulus. The Zulu war of 1879 achieved the latter objective, not without a tragic and avoidable military disaster at Isandlwhana.

Gladstone had nominally retired from politics in 1874, but "Beaconsfieldism," with its reckless disregard (as he held) of the rights of Bulgarians, Afghans and Zulus, called him back to the fray in the mood of a crusader. His "Midlothian campaign" of oratory in the last weeks of 1879 created a profound impression,

and the election of 1880 gave the Liberals a decisive victory. Disraeli died in 1881. It was an amazing career which had carried the Jewish novelist and dandy, reluctantly accepted as a leader by the "gentlemen of England" in their rebellion against Peel, to the premiership of one of the strongest of British ministries. Gladstone was to live longer and, in a sense, to fare worse. Among the aspects of Beaconsfield's government his relations with the queen must not be forgotten. Courtesies more than oriental pleased even while they amused, and Victoria emerged at last from the long and unpopular seclusion in which she had venerated the memory of Albert. The way was prepared for the sentimental enthusiasms of the Jubilee period.

Industrial Legislation.—The middle part of the period covered by this section was a very important one in the history of Labour Legislation. A case in the courts in 1867 decided that trade unions were "illegal" associations and therefore were unable to sue their officials even though (as in the case at issue) their officials embezzled their funds. It so happened that various criminal assaults on "blacklegs" had recently concentrated unfavourable attention on the Unions, and a Royal Commission had been appointed to investigate them. It now became necessary to divert this Commission from its original purpose, and to secure from it a report recommending the "legalising" of unions. The Labour case was ably conducted by Thomas Hughes, Frederic Harrison and Applegarth, a trade union secretary, and a favourable Report secured. The Trade Union Congress was established (1868) to press for legislation on these lines. Gladstone's government enacted a bill (1871) which carried out the recommendations of the Commission but at the same time made all the usual forms of picketing illegal. A new agitation had now to be undertaken and carried on into the general election (1874), when 15 "working-men candidates" stood and two were elected. The new electors of the Second Reform Bill, who had supported Gladstone in 1868, turned over in large numbers to the Conservatives, and Disraeli responded with the Act of 1875 which legalized "peaceful picketing," and was reckoned as the charter of trade union liberties down to the end of the century. In the same year an Employers and Workmen Act abolished imprisonment of workmen for breach of contract and thus placed employees on the same legal footing as their employers.

Another notable agitation of these years, supported by trade unions all over the country, was that led by Samuel Plimsoll to restrain the dangerous overloading of merchant ships. The "Plimsoll line" was enacted by the Merchant Shipping Act of 1876, another measure of the Conservatives. None the less the working-men M.Ps. henceforth conducted themselves as members of the Liberal party—"Lib-Labs" as they came to be called by Labour politicians of a later generation who stood for socialism and the independence of labour.

The most notable extension of trade unionism in these years was the Agricultural Labourers' Union of Joseph Arch. But this and other unions that catered for the worse-paid trades were severely curtailed by the period of acute trade depression that began in the middle 'seventies and lasted till 1888. The causes of this depression, fixed like a great gulf between mid-Victorian and late-Victorian prosperity, were many. America and Germany were beginning to copy our industrial methods and to dispense with our exports. British capital began to flow abroad more freely than before. The substitution of steel for iron, by lengthening the life of rails and other goods, diminished the rate of renewals, and a series of inventions in the metal trade processes involved the scrapping of costly plants and the substitution of Spanish and other foreign iron ores for the inferior products of British mines.

THE OLD PARTIES AND THE NEW DEMOCRACY, 1880–95

When we review these 15 years of English History, the salient points that catch the eye are on the one hand Irish obstruction, Gordon at Khartoum, the first Home Rule Bill and the split in the Liberal party, the Parnell Commission and Divorce, the partitioning of Africa, the second Home Rule bill and the retirement of "the Grand Old Man"; and on the other hand, distress and unemployment, the rise of socialism, the Dock Strike, the "new unionism," the Independent Labour Party. The notable fact is that these two sets of events seem to be entirely unrelated to one another. Parliamentary politics were not concerned with the English people, and the English people impinged but slightly on parliamentary politics. Of course a detailed survey would note many exceptions to this sweeping generalisation, but the impression it conveys is in the main correct, even though a Reform Bill of 1884 proclaimed a fully democratised male electorate. How is this to be explained? Partly by the characters of the leading statesmen. Gladstone, the Liberal leader, was a survivor from a past generation; his return to politics had been provoked by the wrongs of foreign peoples, and his interest throughout his last phase was absorbed by the wrongs of the Irish. On the Conservative side, Disraeli, who ever since he wrote *Sybil* in the 'forties had realized that the problem of "the two nations" was the dominating problem of England, was succeeded by Lord Salisbury, a man of massive intelligence and little imagination, whose main interest was foreign policy. Two statesmen there were, of great energy and ability, who might in combination have diverted English politics to English problems,—Joseph Chamberlain and Lord Randolph Churchill. But Chamberlain called himself a Liberal and Churchill called himself a Conservative. Moreover, Chamberlain left the Liberals in 1886 and did not join the Conservatives till 1895, and Churchill quarrelled with his party and reduced himself to impotence in 1886. Thus the situation was unpropitious on the parliamentary side. At the same time the English people must share the blame, if blame it be. They had not yet learnt to formulate their aspirations in a practicable shape, nor to use the parliamentary machine which the second and third Reform bills had placed at their mercy.

The Policy of Extrication.—Gladstone, reluctantly accepted as prime minister by the queen, took office (1880) with a mission to undo the evil wrought by Beaconsfield in Afghanistan, South Africa, and Egypt. In Afghanistan the problem of extrication, as it may be called, was satisfactorily solved. British claims were abandoned and the new Amir became a good friend of British India. In South Africa the Transvaal Boers were given back their independence, under British "suzerainty," but only after the hesitations of the home government and the impatience of the British commander in Natal had provoked hostilities and incurred the minute, unnecessary, and humiliating defeat of Majuba (1881). The Egyptian problem was much more complicated, and extrication impossible. Egypt was a European, not merely a British, problem, and Gladstone's government, enmeshed in a tangle of obligations, found themselves reluctantly enacting a policy they unfeignedly regretted. In 1881 an Egyptian revolt under Arabi attempted to overthrow the Dual Control. France urged joint intervention, secured it, and then withdrew from it. Wolseley defeated Arabi at Tel-el-Kebir (the last battle where British soldiers fought in red coats), and the way was opened for Lord Cromer's 24 years' rule (1883–1907) which did more for the material welfare of Egypt than all the Pharaohs and Ptolemies of past ages. But while Egypt under Arabi was revolting against the Dual Control, the Sudan under the Mahdi was revolting, much more successfully, against the tyranny of Egypt. An Egyptian army was utterly destroyed at El Obeid in 1883. Gladstone's government determined that the Sudan must be abandoned, and sent out General Gordon to report on the situation and to extricate the Egyptian garrisons at Khartoum and elsewhere. Gordon was besieged in Khartoum (1884), and the relief expedition failed to arrive in time to save him. Gladstone was denounced as the "murderer of Gordon"; Gladstone's supporters, on the other hand, held that Gordon, by disregarding his instructions, had created the situation that led to his death. (*See* SOUTH AFRICA, UNION OF; TRANSVAAL; SOUTH AFRICAN WAR; EGYPT; SUDAN.)

Meanwhile Ireland had been occupying all too much attention. Parnell, who hated England as only an Irishman has a right to hate her, used his Nationalist party in the House of Commons to obstruct business by endless and irrelevant oratory: hence the strict rules of "closure" which since that date have governed debate. At the same time he secured control of the Land League,

a kind of "trade union" of Irish tenant farmers, and thus manipulated the forces of agrarian disorder and boycott in Ireland. A Land Act (1881) gave the tenants their "three Fs" (fair rent, fixity of tenure, and free sale), but Parnell was determined to use his organization to force Home Rule. His arrest and imprisonment only made matters worse. In 1882 the Irish Secretary (Lord Frederick Cavendish) and the permanent undersecretary were murdered in Phoenix Park.

Domestic Legislation.—The record of the government was by no means barren of domestic legislation. A popular Ground Game act enabled all occupiers of land (and not only landlords) to shoot hares and rabbits. Chamberlain's first Employers Liability act made employers liable, within certain limits (since abolished), for accidents to their work-people. The Married Women's Property act gave a wife the same rights of acquiring, holding, and bequeathing property as a widow or spinster, *i.e.*, she was no longer at the financial mercy of her husband. The third Reform bill (1885) roughly doubled the electorate, abolished the age-long distinction between the county and borough franchises, and gave to the wage-earner outside the boroughs the vote enjoyed since 1867 by his fellow within them. Mention should also be made of the Bradlaugh controversy. The atheist M.P., Charles Bradlaugh, demanded the right to "affirm" his loyalty without a religious oath. Gladstone supported, and therefore not only bigots but also Conservatives opposed, his demand, and the inevitable (though long delayed) upshot of the controversy was the extension to atheists of the rights already extended to Roman Catholics (1829) and Jews (1858).

The First Home Rule Bill.—Gladstone's government was defeated on a clause of its Budget and resigned in June 1885, and the "Caretakers" (Salisbury) government took office till the new registers were ready for a general election. The election when it came (Dec. 1885) gave the liberals a majority of 80 over the conservatives, thanks in part, no doubt, to Chamberlain's "unauthorized" (*i.e.*, non-Gladstonian) programme of reforms, including the famous "three acres and a cow" to catch the new rural voter. More significant was the Irish result, where Parnell had secured every seat but one outside Ulster. Gladstone now declared for Home Rule; the conservatives resigned, and Gladstone introduced his first Home Rule bill (1886); but 93 "Liberal Unionists," among whom was Chamberlain, united with the conservatives in defeating the measure. Gladstone appealed to the country and was decisively defeated.

Lord Salisbury.—Lord Salisbury's (1886–92) government was, by comparison with what went before, a time of political tranquillity. Ireland was restive, but the Nationalist party was crippled by the growing eccentricity of Parnell, culminating in his divorce case and the consequent divisions among his colleagues. In 1888 the modern County Councils were established and took over most of the work hitherto discharged by nominated magistrates; among the "counties" not the least important was a new one, the County of London. In the sphere of foreign policy an immensely important transaction, the partitioning of tropical Africa among the Great Powers, was carried through with less friction than might have been expected (*see* AFRICA: *History*). The navy was thoroughly overhauled and the "two-power standard" explicitly established—the two powers whose combined navies were envisaged being France and Russia, for Germany as yet had no navy of importance.

The election of 1892 enabled Gladstone to return to office at the unprecedented age of 82, but his majority depended upon the Irish Nationalist vote, and the House of Lords, in rejecting his second Home Rule bill (1893), could claim that they had the support of the majority of the members elected for British constituencies. Gladstone retired in 1894, and the one-year Prime Ministership of Lord Rosebery is notable for Harcourt's Budget, which revised and increased the "Death Duties," applying to them the principle of "graduation," since applied also to the income-tax. Perhaps it is also notable for the fact that Lord Rosebery won the Derby. The election of 1895 restored the Conservatives to power.

Unemployment and Socialism.—The industrial depression which began in the 'seventies continued until 1888, and London became uncomfortably familiar with processions of the unemployed; *e.g.*, the Trafalgar Square disturbance of Jan. 1886, when august windows were broken in Pall Mall. Meanwhile a new proletariat with the habit of reading was growing up. Victorian politics had failed to solve the problems of poverty, and the socialism of Karl Marx seemed to offer an alluringly drastic remedy. Hyndman founded the Social Democratic Federation which adopted a programme of doctrinaire socialism (1883), and William Morris, aspiring to restore true craftsmanship and to rescue the workman from the tyranny of the machine, lent his powerful aid to the socialist movement. How appalling the facts of poverty were was demonstrated by Charles Booth, who undertook at his own expense a statistical survey of London and found 30% of the population to be living below "the poverty line." His conclusions were brought home to a wider public by the publications of General Booth, the founder of the Salvation Army.

Trade Unionism had also become more and more "aristocratic" (*i.e.*, limited to skilled craft unions) since the 'seventies, for the simple reason that the depression practically extinguished the unions of the worse-paid types of worker. The Trade Union Congress was scarcely more in touch with real poverty than the House of Commons. But there was a minority of trade unionists dissatisfied with this position, among them the engineer, John Burns, and these found their opportunity in the great Dock Strike of 1889. Led by Tillett, Burns, and Mann, practically the whole of the Thames riverside labour came out on strike for "the docker's tanner." Widespread sympathy was expressed, large subscriptions were raised, and the aged Cardinal Manning played a spectacular part in securing the dockers' victory. The result was a great extension of trade unionism among the unskilled and hitherto unorganized workers. Both trade unionism and socialism were powerfully affected. Trade unionism became democratic, and the main stream of socialistic energy was diverted from revolutionary idealism into the practical work of organizing and fighting the industrial battle on industrial and political lines.

A Labour party independent of liberals and conservatives was the natural conclusion of the tendencies just indicated. In 1887 Keir Hardie, a Scottish miner and socialist, had urged the Trades Union Congress to found such a party, but in vain. Undiscouraged, he founded it himself and was elected for West Ham in 1892. This was the origin of the "Independent Labour Party." All its candidates were defeated in 1895, but (to complete the story here) the Trade Union Congress was being slowly stirred to action. In 1899 a joint committee of the T.U.C., the I.L.P., and two socialist societies was established under the title of the Labour Representation Committee. This was in fact the foundation of the Labour party, and its first secretary was Ramsay MacDonald.

Victorian industrial history reads like a prologue to the 20th century, whereas the culture of the Victorian upper classes has already become something remote and, as we say, "Victorian." In the sphere of letters the last 20 years of the century mark the long evening of the Victorian age. One by one the great lights were extinguished—Carlyle, George Eliot, Rossetti, Darwin, Matthew Arnold, Browning, Tennyson, Newman, Morris, Ruskin. No stars of equal magnitude seemed left in the sky. Of these great Victorians only William Morris was in his prime during the 'eighties. Himself a craftsman in many trades, he taught that not only churches but houses, not only pictures but wallpapers, books and furniture, pots and pans should be works of art. His influence has been immense, but he came too late to redeem the age he lived in. Fashions change, but it is hard to believe that a generation will ever arise that will admire Victorian domestic architecture. The art of building touched its nadir just at the time when building was more in demand than ever before, owing to the unprecedented growth of population.

IMPERIALISM, 1895-1901

The Last Phase.—The climax of the Victorian age was also the climax of the imperialist movement; and this coincidence

was appropriate, for a sturdy optimism had been the keynote of the age, and in imperialism optimism attained its grandest dimensions. At the beginning of the reign "the colonies" had been little esteemed; they were insignificant, and many expected that with growth they would demand independence. A variety of causes falsified this forecast. The Durham Report indicated lines of development which reconciled local independence with imperial union; the growth of steam transport both favoured emigration and kept the emigrants in closer touch with the mother country; the decline of European and the growth of colonial markets suggested the importance of inter-imperial trade; and the growth of mighty armaments on the continent suggested the value of imperial union and expansion as a source of power. Disraeli saw which celebrated the close of the pomps and splendours of the Tory party. His imperial ventures were not auspicious but the fiascos of Gladstone's anti-imperialism helped the movement forward. And now a political leader for the cause was found in the ex-Liberal Chamberlain who, joining Salisbury's cabinet in 1895, selected for himself the hitherto little-esteemed office of colonial secretary. Another name, however, symbolizes late Victorian imperialism more convincingly than that of any politician—the name of Rudyard Kipling. His first volume of Indian tales had been published in the year of the first Jubilee, and he attained the stature of a national spokesman with his *Recessional*, which celebrated the close of the pomps and splendours of the second Jubilee (1897), a hymn which, with all its genuine humility, expresses the pride of a "chosen people," privileged above other nations to bear "the white man's burdens." The Jubilees themselves, it need hardly be said, were, and could not help being, immense advertisements of the greatness of the British Empire.

The Sudan and South Africa.—In 1896 the steady growth of Egyptian economic prosperity made possible the announcement of an Anglo-Egyptian expedition to reconquer the Sudan. Gordon would be avenged and an immense new tropical province opened to the benefits of British administration; and after 15 years of Mahdism the province was certainly in need of it. Sir Herbert Kitchener took command and astonished the world by the efficiency and economy of his achievement. The battle of the Atbara was fought in April 1898 and the crowning victory of Omdurman (the Khalifa's capital, hard by the ruins of Khartoum) in July. In this battle 11,000 Dervishes were killed at the cost of 48 lives to the victorious army, and the total expenses of the campaign would have paid for about *eight hours* of the British effort in the later stages of the Great War. Yet these events had a rather ugly sequel. Within a week of the occupation of Omdurman it was announced that a French explorer, Major Marchand, had hoisted his flag at Fashoda, 500 miles further up the Nile. The French flag was lowered, but not without a severe straining of diplomatic relations between London and Paris. Britain had been, it appeared, "on the verge of war." The "splendid isolation" of late Victorian Britain was less secure than in retrospect one is apt to imagine. A brief history like the present has omitted all the abortive war-alarms of the last 20 years of the century, but they would make a considerable list. The enemy was always France or Russia; Germany had not yet crossed Britain's path.

On New Year's Day 1896 an astonished public read that a force of mounted police under Dr. Jameson had raided the Transvaal Republic. Its failure was immediate, but "the Raid" was a symptom of the growing tension created by the antagonistic policies of Cecil Rhodes, prime minister of the Cape, Rand gold-magnate, and creator of Rhodesia, and Paul Kruger, President of the Dutch Republic of the Transvaal. About ten years earlier, one of the greatest gold fields of the world had been opened up in the very middle of the Transvaal. The gold-mining population (Uitlanders) had many just grievances against the treatment they received; in particular they were excluded from any share in the government of the Republic. Most of them were British, and in March 1899 they addressed a petition to Queen Victoria. Chamberlain took up their cause. Milner, the British High Commissioner of South Africa, failed to extract any concessions from Kruger, and the upshot was war (Oct. 1899). The early stages of the war proved that the Boers were better prepared than the British, and the three defeats of "Black Week" (Dec. 1899) ushered in a winter less terrible but quite as humiliating as the Crimean winter 44 years before. Three British forces were besieged on British territory in Kimberley, Ladysmith, and Mafeking. With the coming of spring, numbers began to tell, and the clouds lifted; the beleaguered garrisons were successively relieved, and in June Lord Roberts entered Pretoria. It seemed that the war would end before the century. It did not do so, however, and guerilla tactics prolonged an irritating game of military hide-and-seek well on into 1902. The end of the century was to be marked not by the end of the war but by the death of the Queen. Victoria died, after a brief illness, on Jan. 22, 1901, in her eighty-second year. (*See* SOUTH AFRICA, UNION OF; SOUTH AFRICAN WAR; TRANSVAAL.)

The Queen.—This is not the place to attempt an estimate in detail of Victoria's character. The best way of measuring her achievement is to study the position occupied in public esteem by her immediate predecessors. The Crown as it came to her was associated with political ineptitude and moral degradation. She wore it for over 60 years and left it the unique symbol of national honour. Her political opinions were often shrewdly formed and always strongly held, but it is easy to exaggerate the queen's intellectual gifts and to attribute to her a far-seeing statesmanship to which she has no claim. Queen Victoria's achievement was her character. If rigid devotion to duty and unflagging industry are to be respected, then Victoria is entitled to respect. She was worthy to preside over a great nation in one of the greatest epochs of its history. In some ways her plainness of speech and of thought, her simple piety, her regal and maternal dignity make her more typical of her age than any of the brilliant men whom we call "eminent Victorians," and homage is paid both to the queen and to her subjects in the suggestion that Victoria was, of all her generation, the most Victorian. (*See* also VICTORIA, and the various biographical articles.) (D. C. So.)

XII. THE TWENTIETH CENTURY

Across British history since 1901 the World War draws a heavy line; it is impossible to see the period otherwise than in the three divisions—before the war, the war-period and after the war. During the years 1901–14 certain forces, the result of a long period of peace and prosperity, which had already broken the crust of exclusive social traditions and of literary and artistic convention, began to affect national affairs and political life. The period is marked by a restless, uneasy re-alignment of class and party, so searching and at times so violent, that in the last years before the war the very frame of representative government, as the 19th century had known it, seemed on the verge of breaking to pieces under the strain. The war, with its concentration of the national mind, restored balance and stability to the nation, though the world was shaking. After the war, many as the difficulties were, at least there was no appearance of the strange plunge towards an incalculable gulf, which was gravely affecting men's minds during 1909–14.

FROM 1901 TO THE OUTBREAK OF WAR

The period opens, however, with very little indication of a new stirring of national life. The death of Queen Victoria (Jan. 22, 1901), the end of that long reign, coincident as it had been with the rise of a new England in a new Europe, and the accession to the throne of a genial man of the world with wide interests and a zest for life, might suggest the passing of a dead-weight of tradition. But in social and artistic matters the tradition had for some time been weakening; and in national affairs, once the excitement of these events was over, the old seemed to be depressingly present, and the cry for the new depressingly unanswered.

The recovery of the British armies in South Africa during 1900 had not ended the war. The Conservative Government, renewing its mandate by the "khaki election" of 1900, had not renewed its strength. Burdened with the blame for the disasters of the early months of the Boer War, and then for the tedious weariness of a long struggle with the elusive mobile commandos of the Boers, the Government appeared to be a rather lackadaisical survival of

19th century Conservatism. And the Opposition appeared to be an equally ineffective survival; there were Liberals who applied to the war the old Cobdenite-Gladstonian tradition, and condemned it as a deplorable piece of provocative imperialism; there were others who, with Lord Rosebery, felt that a Liberalism thus setting itself against the national pride had no future before it.

In such circumstances politics became little more than a mass of inchoate animosities and recriminations. The session was barren. An education bill designed to meet the awkward situation produced by the Cockerton judgment, which had imperilled the whole provision of higher education at the public expense, was hotly criticized, and eventually replaced by a temporary measure permitting education authorities to "carry on" for a year. W. St. J. F. Brodrick (*see* MIDLETON, VISCOUNT) produced a scheme of military reorganization, with a system of army corps and decentralized commands; but as his corps were admittedly to a great extent "skeleton" formations, he was bidden to learn some more practical lesson from British failures in South Africa, and pay attention to the better education and war training of officers and men. In the latter part of the year the Liberals who were attacking the conduct of the war found a new theme. Lord Kitchener, who was now in command in South Africa (Lord Roberts having returned in January to be the last great public man to be received by Queen Victoria and to take from her hands the Order of the Garter) was meeting guerilla warfare with a new strategy of cordons of troops operating from lines of blockhouses to clear whole districts, emptying, and on occasion burning, the farms to which the Boers retired, hiding their arms. Concentration camps, for the reception of women and children removed from the cleared districts, had inevitably the flaws of an emergency provision; and reports of ill-health, loss of infant life, and insanitary conditions gave material for Liberal agitation, bitterly resented by those who could, quite justifiably, represent the camps as an almost quixotic piece of humaneness in warfare, rendered partly ineffective by the Boers' own insanitary habits. The whole subject bringing to such a definite point the irreconcilable difference of opinion between those who felt the war must be finished, and those who merely demanded that it should be stopped, exacerbated people's minds. Rioting broke up a peace-meeting in Birmingham in December, and forced Lloyd George to escape for his life.

The Liberal Revival.—Within a few months the whole scene was changed. By March 1902 the Boer leaders were known to have opened communications with Lord Kitchener. Peace was signed in May at Vereeniging, on terms generous enough to the Boers in the matters of amnesty and repatriation, with a grant of three millions for re-establishing devastated farms, but also conclusive as to the unity of South Africa under the British Government. Nothing remained to cloud the anticipations of the coronation, which was not only the first for 64 years, but the first great imperial coronation. When last a sovereign of the United Kingdom had been crowned, the colonies had been poor, thinly populated, distant—barely a reality at all to the people at home—and India a chartered company's territory in somewhat indeterminate relations with the Crown. Now the colonies were great and prosperous countries, made much more real and vital to the nation by the explicit imperialism of the Conservatives. Moreover, the king was emperor of India. At the moment of its long-delayed success in South Africa the nation was thoroughly in the mood to savour the meaning of the gay and varied contingents of troops from every quarter of the empire, camped in and around London. Then in the height of the excitement, with princes and potentates arriving from all over the world, King Edward suddenly fell ill, and the ceremony had to be postponed until his recovery from an operation for appendicitis. The coronation finally took place, with undiminished splendour, on Aug. 9.

So far, the nation had been paying little attention to events which suddenly promoted a much more healthy state of party opposition in the Commons. For some time past it had been felt that the school boards of the 1870 act, though they had worked well in towns, were on the whole too parochial in personnel and policy to envisage education in the large and generous way that was becoming increasingly necessary. A new bill abolished them, and placed education in the hands of statutory committees of the borough and county councils. For the moment the significance of the fact that Church of England schools were brought into the reorganization *pari passu* with the undenominational board schools escaped notice; then the old Liberal nonconformist spirit awoke, internal divisions lost their importance, and the Opposition became a fighting force. It was not until the autumn session, when non-payment of rates, as a drastic assertion of the rights of conscience against legislation, was launched as a definite policy, that this change in the atmosphere of the House of Commons had much reverberation in the world outside.

Tariff Reform.—The situation had hardly time to develop seriously before it was lost in a far more startling political storm. On May 15, 1903, Joseph Chamberlain, who had spent the winter in an official—indeed almost a State—visit to South Africa, made a speech to his constituents in Birmingham in which he pleaded for a closer economic bond of empire in an imperial preferential tariff. At first sight there is something astonishing in the speed with which this pronouncement became the cardinal factor in public affairs. But three considerations provide an explanation. Firstly, there had for some years been increasing complaint of the unfair position of the British manufacturer in an open home market against the protected competition of the foreigner, and of the "dumping" of foreign products, to which much of the unemployment in Great Britain was attributed. Secondly, there had been, in remarks by recent chancellors of the Exchequer about a need for broadening the basis of taxation, hints of a reconsideration of fiscal policy, to which the reimposition of a shilling "registration" duty on corn during the Boer War had given point. Thirdly, the commanding position of Chamberlain in the cabinet, and his popular reputation as a vigorous driving force beside the somewhat placid, academic figure of A. J. Balfour, who had succeeded Lord Salisbury as prime minister in 1902, were enough to bring together in a flash, when he made such a pronouncement, all the half-suggestions of a change in the tariff system. It is no wonder that this speech, though in fact he had used much the same language to the Imperial Conference of 1902, became the storm-centre; nor is it any wonder that Liberals raised at once in its broadest aspect the old issue of Free Trade and Protection (*qq.v.; see* also CHAMBERLAIN, JOSEPH).

During the session of 1903 it remained principally a House of Commons question; the attack lay along the line of the precise degree of cabinet responsibility for the new pronouncement. C. T. Ritchie's attitude, in introducing the budget, and the discussions on the budget, revealed a strong free-trade element among the Conservatives. But Balfour refused to admit any vital difference between himself and Chamberlain, and reiterated that the whole question was one for enquiry and investigation, not for immediate party warfare. Almost immediately the simple imperialism of the first stage had become complicated with the other issues of national finance and the protection of national industries. This became clearer in the autumn of 1903, when the campaign on both sides developed rapidly outside parliament. The controversy lacked no skill or competence on either side; and in the analysis of statistics, the estimation of the comparative position of employers and their employees in Great Britain and elsewhere, the elucidation of the subtle reactions of our long free-trade policy upon high finance, banking and international credit, much was achieved in the course of a struggle which enlisted, quite unprecedentedly, practically the whole academic as well as the whole political force of the nation. It made public life vivid and extraordinarily active for the next two years. It was obvious, once division of opinion had become clear, that Chamberlain and the free traders could hardly remain in the same cabinet. Resignations were to be expected; when they came, they seemed only to make the situation more bewildering. The notable free traders, Ritchie, Lord George Hamilton, Arthur Elliot, Lord Balfour of Burleigh, resigned in September. But Chamberlain had resigned as well. In the reconstruction his son, Austen Chamberlain, succeeded Ritchie at the Exchequer. Another distinguished free trader, the duke of Devonshire, resigned in October.

The controversy did not occupy the whole field in 1904. A

licensing bill, the outcome of much recent discussion about the excessive number of licensed houses in proportion to population in many towns, set up a statutory compensation fund for unrenewed licences in every quarter sessions area. It added a minor weapon to the Liberal armoury, inasmuch as it gave implicitly legal recognition to the growth of a legitimate, though not hitherto properly legal, expectation of steady renewal of a licence, and limited the discretion of the justices. Of no controversial importance was the act for licensing and numbering motor-cars; the insertion of a 20m. speed limit betrays the mind of the time.

The Entente Cordiale.—The achievement of the year 1904 which most justified Balfour's continuance in office was undoubtedly the agreement which Lord Lansdowne, who had succeeded Lord Salisbury at the Foreign Office in 1902, concluded with France. Its terms provided for French recognition of British influence as preponderating in Egypt, in return for a similar recognition of French interests in Morocco. The welcome it received grew out of something much deeper than the end of the long friction over the dual control in Egypt. The agreement was taken as a sign that the policy of "splendid isolation," which had had aspects of something more than discomfort during the early stages of the Boer War, was being in some measure abandoned. The establishment of better relations with France was attributed largely to King Edward's influence, and to his personal popularity in Paris. From this time onwards he was considered to have found a sphere in which a constitutional monarch might very well take a real share in the work of his ministers.

If 1904 was thus a year which kept some breadth of interest in politics, 1905 was so nearly a year of exclusive concentration upon tariff reform that Balfour, by remaining in office, seemed to do little more than make a present to his opponents of 12 months' electioneering. Under the new Tariff Reform League on one side and the revived Cobden Club on the other, the battle was fairly joined. Reputations were made on the free trade side; Lloyd George, already prominent from his opposition to the Boer War, greatly increased his power over Liberal meetings; and Winston Churchill, who had refused an equivocal position, and left the Unionists in 1903, reached the front rank of politics at a bound. As the year drew on to the inevitable election, argument naturally deteriorated. Tariff reformers' cries of "the foreigner will pay," and "tariff reform means work for all," were matched by Liberal posters of the big loaf and the little loaf. Steadily it became more and more clear on which side the British public as a whole was ranging itself; and not even the palpable presence of thousands of unemployed, to point the tariff reformers' moral, made the mass of working men willing to risk the gamble of food taxes for the chance of more steady employment.

On Dec. 4, 1905, Balfour at last resigned, having, it must be admitted, pulled his party over the first shock of the controversy. Some faint hope existed among the Unionists that the internal divisions of the Liberals might revive to weaken them. But when Sir Henry Campbell-Bannerman's Government was announced on Dec. 16 it was seen that H. H. Asquith (afterwards Earl of Oxford and Asquith) was at the Exchequer, Sir Edward (afterwards Viscount) Grey at the Foreign Office, and R. B. (afterwards Lord) Haldane at the War Office; and a speech by Lord Rosebery a few days later made it as clear as any such thing could be made that nothing had gone on behind the scenes; Liberal imperialists had simply accepted the prime minister's invitation to join him. The new prime minister, it may be remarked here, has his place in constitutional history; he was the first to hold the post as an office. Hitherto the head of the Government had always been obliged to take some office recognized by the constitution—usually the sinecure dignity of first lord of the Treasury, for "prime minister" was, in strictness, only a descriptive appellation. Now by a royal warrant, giving the prime minister, under that title, a place of official precedence, the king established his position as a formal office of State. (*See* PRIME MINISTER.)

The Landslide Election.—The general election which followed was the most startling that the country had ever seen. Member after member of the late Government lost his seat, including Balfour himself. The astonishing new house was composed of 397 Liberals, 57 Labour members, 83 Irish Nationalists and a mere 157 Unionists. The Government had a possible maximum majority of 374. Free Trade had beyond all question played the largest part in the results; the introduction of indentured Chinese labour into the Rand gold-mines had also provided Liberals with an electoral weapon which they used with effect. It was obvious, too, that Balfour's long continuance in office after his party had become disunited had not only stimulated to an unusual degree the mere desire for a change, but had also revived in the electorate that sense of inefficiency in their Government which had been strongly vocal during the Boer War. There was undoubtedly another important element in the situation. While the labour world had been rapidly becoming more politically energetic and more articulately conscious of its strength, it was not yet in a position to appear in full force as a distinct party, and therefore its effect at the polls was a heavy reinforcement of the Liberal vote. Two things above all had profoundly affected Labour. One was that in 1899 after long and patient work by Keir Hardie (who had been returned in 1892 as the first true Labour member) and others, the various elements in Labour politics—trade unionism of the old-fashioned strictly industrial kind, Fabianism and Socialism—had been drawn together in the foundation of the Labour Representation Committee; in the intervening years this first success was consolidated; the party pledge, after some internal struggles, was imposed, with a compulsory levy on members of certain trade unions. But what most of all inspirited it, and helped towards the acceptance both of the party pledge and the levy, was the famous Taff Vale case of 1902, in which, after a railway strike, the unions had, to their dismay, found that the law, as it stood, could be held to render them liable for damages for the actions of any individual union member during a strike. The labour world naturally drew together wholeheartedly to demand amendment of the law; and since Liberal candidates sympathized entirely with this demand, the Taff Vale case must be added to the reasons for the overwhelming Liberal success. So must the Labour demand for a more active social policy generally. The early years of the century were on the whole free of serious labour disturbances. But active political Labour was aware that employers were working on an ever-narrowing margin of profit, and that, with prices slowly but distinctly rising, there must be determined and difficult wage-struggles ahead; and the wider social conscience was increasingly concerned about unemployment, "sweated" industries, bad housing and the helplessness of the manual worker in sickness and old age.

The Struggle with the House of Lords.—All this, while it meant that the new Liberal Government entered upon its career full of ideas of social reform, meant also that every element in the country afraid of, or intellectually cautious about, social and economic change, drew together, aghast at what representative government might suddenly come to imply, with such a House of Commons as then existed. A process at once began of undermining, in the public estimation, the status of the large majority. It was obviously a freak; the country could not have seriously intended such an obliteration of Conservatism. It was due to the sweeping effects of one particular question—Free Trade—and could not be taken as an overwhelming mandate for drastic social legislation. There was truth in this; and a House of Commons so notoriously unbalanced in composition could not be surprised if the House of Lords acted in redress of the balance. Thus the history of the next eight years is one of considerable legislative achievement, in the presence of forces of opposition which, by the very nature of the case, tended more and more to weaken parliamentary and ministerial authority in the mind of the public.

Much was achieved. The Trade Disputes Act of 1906, definitely placing trade union funds above the normal operations of the law in actions of tort; a reorganization of the military system in 1907, which created, in the Expeditionary Force and the Territorial Army, a machine which was to meet the first strain of the World War in 1914; the Coal Mines Eight Hours Act and the Old Age Pensions Act of 1908; the Housing and Town Planning Act, the Trade Boards Act for "sweated" industries and the

Labour Exchanges Act of 1909. But the harvest was gathered with perpetual friction; many bills were lost, and in matters of education and licensing especially the Government was not allowed to carry its proposals. On the Liberal side of the house there was constant agitation on the question of the power of the House of Lords. In one matter at least the latter had been unwise: instead of waiting for the Licensing bill of 1908 (against which, with its proposals of terminating after 14 years all "monopoly value" in a licence and restoring its strictly annual character, there had been much outcry) to come before them in the usual way, they decided, at a meeting of peers at Lansdowne House, to reject it, and announced the decision. Nothing could have been more useful for rousing Liberal opinion against them: it lent itself so well to the complaint that the Lords did not even pretend to act properly as a house of parliament when Liberal measures were in question.

Yet no practical politician could expect to rouse really strong feeling in the country by a generalized attack upon the Lords for their conduct during three sessions. It would become a dry constitutional question, and the electorate, now that its fear of Protection was over, would fall back into all sorts of cross-divisions. And, finally, the attack must be striking and, as far as possible, sensational. For the public mind, losing its single interest of the tariff reform years, had scattered itself upon many things—the rapid expansion of motor transport; the extension and linking up of "tube" railways; the early successes in flying (mainly, as yet, with dirigible balloons, but Farman and the brothers Wright had flown in aeroplanes in 1908); a growth of the week-end and country cottage habit; and an increase in pleasant ways of spending money.

The "People's Budget."—Battle, then, must be joined on a new and large issue, to work up the electorate; on an issue of social policy, to secure Labour support, and, if possible, on an issue that should bring into the open the kind of opinion which was behind the House of Lords. Liberal strategy based itself, very skilfully, on a frankly socialist budget. If the Lords threw it out, they would startle the nation by an action which, from long disuse, had become constitutionally almost unthinkable. They would appear to Labour to be refusing openly at last to provide the necessary implement for ameliorations. And it might well be argued that the strength of the hostility to the Government would be revealed as lying in the apprehensions first aroused by their second budget, which had introduced differentiation between earned and unearned incomes, a graduated income-tax and a super-tax death-duty on estates of over a million; so that the power behind the Lords would be displayed as capitalism selfishly concerned for itself. Thus, in 1909, the "People's Budget" was launched, making further differentiation between earned and unearned incomes, applying the super-tax to large incomes as well as large testamentary dispositions, and laying a tax on the "unearned increment" of land enhanced in value by industrial or other developments in the neighbourhood. The Lords based their action on the fact that the "unearned increment" tax involved a land valuation scheme, which was not legitimately part of a finance bill. They had the precedent of the paper duties affair in 1861. No doubt, too, they relied upon the obvious ebb of the amazing tide of 1906, and upon a fairly general feeling that Liberal legislation had already gone rather far. Therefore, accepting the challenge, the Lords, late in a stormy political year, threw out the Finance bill, and opened a struggle which occupied the whole of 1910. Two general elections were held—the first in Jan. 1910 for authority to force through the "People's Budget"; the second in Dec. 1910 for authority to carry the measure that was to end such struggles between the two houses—the Parliament bill.

In both cases the Government was able to achieve its object; in neither case, however, in such a manner as to put an end to the Opposition's questioning of the nature and true extent of its authority. The election of Jan. 1910, on the issue of the budget, seemed to support the view that, Free Trade apart, the Liberals had no overwhelming mandate from the nation; the Conservatives now returned actually in a slight majority over the Liberals, and the Government therefore depended upon the Labour members and the Irish Nationalists. The Opposition accepted this as a decision on the budget, which was passed; but mainly because the holding-up of the national finances was an awkward and dangerous way of carrying on a contest, which, after their action on the budget, had better be fought out fundamentally on the issue of a great constitutional change. The problem was twofold. One of the peculiar provocations of the budget incident had been that a house with no element of election in it had the right to render futile a House of Commons majority. Hence the simplest aspect of the question—a statutory limitation of the power of the Lords—was complicated with the possibility of a reformed upper house to which large powers might still be left because of its more satisfactory character.

The Parliament bill was, at any rate, ingenious. Postponing in its preamble for later consideration the possibility of an amended upper house and the powers it might be given, it proceeded to lay down that, until such reform, measures which had passed the Commons unaltered in three separate sessions might be presented for the royal assent without the consent of the Lords; and that financial measures might be so presented, in similar circumstances, without repeated passage, a month after passing the Commons. It was the gravest constitutional measure since the Reform Bill of 1832—perhaps, even, since the Act of Settlement; and there were those on both sides who looked for some agreement that might evade such drastic enactment. It was significant of the position King Edward had attained that hope, at this crisis, pinned itself to his tact and sagacity; but his death, in May 1910, removed the hope centred in him; and it must be said that it had been cherished rather by the popular mind than by serious politicians. Conferences continued through the year, until in November it was announced that they had failed. The gravity of the announcement of another appeal to the country was enhanced by Asquith's statement (he had become prime minister on Campbell-Bannerman's death in Feb. 1908) that he had only advised dissolution upon such conditions as would enable the Liberals, if successful at the election, to place the Parliament bill on the statute book against all resistance by the Lords. This was immediately taken as a reproduction of the guarantee given by King William IV. to Lord Grey for the passage of the Reform bill: although in the present case this must mean reducing the House of Lords to an absurdity by a mass creation of 400 or 500 peers, there could be no other interpretation of Asquith's words. The election of Dec. 1910 made little change; a gain of four seats by the Liberals was hardly conclusive, and there were Conservatives in both houses (they added the name of "die-hards" to political nomenclature) who would have had the Lords reject the bill, believing that the country would never stand such a creation of peers as was threatened. Others were for accompanying the rejection with a voluntary reform of the house, or with the institution of a referendum for solving deadlocks. Through all such proposals the Government held steadily on its way with the Parliament bill; the Conservative leaders shrank back at the last, and in Aug. 1911, by the abstention of the majority, the bill passed the House of Lords by 131 votes to 114.

The Years of Militancy.—The battle had been won, but the cost was now to appear. Extreme Conservative opposition in the country began to feel that against a Liberal and Labour majority, thus clear of constitutional obstacle, any and every form of obstruction and resistance might be used. Unfortunately, the temper of the nation had become one in which such notions could flourish. Twice within two years the country had been shaken by a considerable crisis, and each time with a violence of political methods hitherto unknown. The Tariff Reform controversy had begun it, with the "raging, tearing propaganda" of both sides; later by-elections and general elections had been consistently stormy. Undoubtedly the new Woman Suffrage campaign had been responsible for much of this. It had its justifications. Fifty years of quiet argument had had no effect, and women had no votes to compel politicians to listen. Their large processions and demonstrations, forcing the police to physical violence, courting imprisonment and producing there every possible problem for the prison authorities, had shown what might be done by

"militant" methods; and already the opposition to the Government's licensing bill and mining measures had taken the hint, and turned by-elections with whirlwind attack. (*See* WOMEN'S SUFFRAGE.) Militancy was in the air; it was to be the keynote of the next three years; and no class shrank from it. Indeed, restraints of all kinds seemed to be disappearing. The old exclusive "society" was being invaded by new wealth; Cubism in painting and new conventions in sculpture ruthlessly "scrapped" all the rules that earlier generations had valued; a new music did the like with conventions of rhythm and harmony.

The Government, after the interruption of 1909–10, returned to its social programme, passing in 1911 the Shops Act, establishing the weekly half-holiday; and Payment of Members (*q.v.*). But the principal measure—the National Health Insurance Act—was met with the new kind of opposition. It was open to some objections; the friendly societies were apprehensive of its effect upon their own finances; the actuarial calculations were not beyond criticism; the Labour Party translated the "right to work" policy into an attack upon its contributory basis. But reason was lost in a violent newspaper campaign, which attempted to bring about a strike of the medical profession against the duties which the act would lay upon them, and actually succeeded in inducing a large meeting of respectable, and even important, women at the Albert Hall to pledge itself not to "lick stamps" to affix to the cards of insured persons. It was absurd, but it had its alarming side. The Government also set itself to fulfil the statutory conditions for placing Welsh Disestablishment and Irish Home Rule on the statute book by passing them through the requisite number of sessions. They had other causes of anxiety. The hopes raised, in the first flush of the agreement with France, that our relations with all foreign Powers would grow happier, had waned. It had been becoming apparent that the exchange of visits between British and German municipalities, British and German journalists, and so on, were only superficially cordial; and even King Edward was able to maintain no more than a superficial friendliness in that quarter. In 1911 the Agadir crisis showed that Germany was far from consenting to that predominance of France in Morocco which Great Britain had recognized. Approaches to Russia made it rather appear that the end of isolation meant taking a place in the grouping of Continental nations. The launching of the "Dreadnought" in 1906, at first a source of pride as the originating of a new type of battleship vastly more powerful in speed and gunfire than anything afloat, had been seen to involve less flattering implications. If battleships of this kind, battle-cruisers and submarines, were to replace the old fleets, then another country might start in a naval race more on a level with Great Britain than had before been possible. The subject had come into prominence in 1908, when it appeared that Lord Tweedmouth, then first lord of the Admiralty, had been in correspondence with the German emperor, on the latter's initiative, on the subject of naval expenditure. Winston Churchill, who succeeded Lord Tweedmouth, made offers of a "naval holiday" which, however, met with no response. The whole matter was an uneasy background to an uneasy period.

But only a background; the British public during these years was more concerned with other aspects of public affairs. A railway strike in the hot summer of 1911, though not complete, had held up railway traffic for several days, and created a new anxiety about the power and the purpose of Labour. Syndicalism was finding its way into England from France, the *New Age* voicing this policy; and the first Labour daily newspaper, the *Daily Herald*, appeared in this year. Trade union membership was increasing; it advanced from 2½ millions in 1907 to 4 millions in 1913 (including those not affiliated to the Trade Union Congress). In 1912 the loss of the "Titanic" (*q.v.*), the biggest passenger vessel yet launched, on her maiden voyage, struck people aghast; and a strike of coal-miners showing as irreconcilable a temper on either side as the railway strike had shown, and, forcing parliament to pass a minimum wage bill for coal mines, raised spectres of what "direct action" might come to mean. There were worse spectres in the following year, when the huge sympathetic strike started in Dublin under James Larkin; and though the movement did not spread to the unions in Great Britain, and the "Triple Alliance" of railwaymen, miners and transport workers, established early in 1914, made a subtle distinction between a "sympathetic strike," which it repudiated, and a simultaneous strike for the individual objects of each union, the sense of the threat to the community grew more alarming.

The Verge of Civil War.—With so much hostility in the air, so much social and intellectual restlessness, the nation hardly noticed at first the precipitous slope down which it was hurrying in Irish affairs. Nothing could prevent the Home Rule bill becoming law in 1914. Unionists concentrated, as in 1885–86, on the injustice to Ulster; but this time Lord Randolph Churchill's phrase of the earlier years, "Ulster will fight and Ulster will be right" was transformed into action. As early as Nov. 1913 armed resistance was in preparation; it was not until March 1914, when some officers stationed at the Curragh sent in their papers rather than face the carrying out of orders which the Government might shortly have to issue, that the public generally woke up to the fact that civil war was at the gates. In April arms and ammunition were being openly landed at Larne and distributed by motor transport throughout Ulster; a "provisional Government" had been organized. During the first stages of the bill in the Commons and the Lords efforts for peace were still being made; the Home Rule bill itself, if it were to obtain the sanction of the Parliament Act, could not be amended; but the Government produced in June a bill allowing Ulster counties to "contract out" of Home Rule. It met with so much amendment in the Lords that there seemed to be no hope at this stage of reconciliation. When it was announced on July 20 that the King had summoned a conference in the privacy of Buckingham Palace, matters were felt to be grave indeed. The graver stage still, when the conference, after four meetings, broke up without having reached an agreement "either in detail or in principle," hardly had time to impress itself on the mind. For on July 28 a Balkan incident, which had been occupying some space in the newspapers, culminated in a declaration of war by Austria upon Serbia, and after a week of suspense, Great Britain was at war herself.

THE WAR PERIOD

This is not the place for even a brief history of the war (*see* WORLD WAR); all that can be attempted is a sketch of the course of events in England and the reactions to them and to the fluctuations of the war in the national mind and temper. The actual moment of the declaration of war, Aug. 4, was in many ways fortunate. Aug. 3 had been a bank holiday; by a proclamation prolonging the closing of the banks for three days and a "moratorium" period suspending for a month settlements in finance, the Government was able to prevent both panic withdrawal of gold by individuals and panic measures in industry and business generally. Then again, the August bank holiday was habitually a time when Territorial troops were "in being" for training; with the least possible friction the Territorial troops could be mobilized, while the Expeditionary force was being transferred to France. Altogether the nation entered more smoothly and more unitedly upon war than could have been thought possible. It was satisfied with the immediate changes in the cabinet; Lord Morley, John Burns and one or two others resigned, and the announcement that Lord Kitchener, at home as commander-in-chief, had become secretary of State for war was thoroughly popular. He appealed immediately for volunteers, and, without much regard to his warning that the war would last four years, civilians poured in to the recruiting offices. The warning was taken seriously by hardly anyone; all other considerations apart, how could a vast European war possibly be financed for more than a few months? The Germans themselves were looking to another swift campaign like that of 1870–71, and the first week of the war seemed to promise it. The news of the retreat from Mons and the anxious days of continued retreat looked as if Paris would be besieged almost before the war had really begun. Then came the turning aside of the German armies, the check at the Marne and the recovery of ground by the French and British troops. And as the hostile lines settled down for the winter, the

first battles of Ypres (*q.v.*) showed the magnificent stuff of the regular army in a way which the public could understand better than it understood the excellence shown during the retreat.

The First Months.—"K's armies" were already armies in numbers, so swift had been the response of youth; and, out-running all conceivable supply of uniform or equipment or camp accommodation, they drilled and route-marched and learned their job as best they could from re-enlisted N.C.Os, of the old army, making light of their conditions. To the making of the new armies the nation added the care of masses of refugees pouring over from Belgium, and the first steps towards the expansion of hospital services in the formation and training of V.A.D. detachments. At first there had been a tendency to panic purchasing of domestic supplies and "food hoarding," but it had rapidly died down. Spy hunting had not been long in beginning; and, as the terrible casualty lists struck home, recruiting posters grew more raucous, and there were soon indications of looking askance at healthy young men not yet in the training camps. There were shocking reports—the worst were later to be proved to have no foundation in fact—of devastated villages in Belgium and wholesale massacres of inhabitants, to which many of the refugees added what was taken as evidence. It culminated, perhaps, in the accounts of the burning of Louvain, with its priceless library; but that was only the most striking of a long catalogue of destruction and slaughter which seared the British mind, and had its part in the stimulation of recruiting. It would, however, be true to say that the hatred had not yet the added sting of fear. The Allied lines were holding; the new armies were constantly growing; the Dominions were mustering great contingents; and there was a profound belief in the enormous strength of Russia, once she could "get going" (the rumour that Russian troops had been seen in England on their way to the western front was one of the most extraordinary incidents of the war in the flat opposition of strongly authenticated statements and downright official denial). The country had quickly become accustomed to the first restrictions of the Defence of the Realm Act, and to the use of Treasury notes of £1 and 10s. instead of gold pieces, which had in the early days of the war been called in to the banks. There was a short recurrence of alarm in November. Hitherto the few scattered naval encounters had been satisfactory on the whole to Great Britain. Then came the news that three cruisers, caught by German ships off Coronel (*q.v.*) in the Pacific, had been sunk. The reply was amazingly swift, and restored confidence in Lord Fisher, the first sea lord. He had instantly despatched battle-cruisers, which in December, at the Falkland islands (*q.v.*), had fallen in with those German ships and destroyed them.

1915.—It was principally an impatience due to lack of understanding of the real nature of the war that accounted for the signs of a less admirable temper in the spring of 1915. It even began to attack Lord Kitchener. The long casualty lists of the winter grew ghastly with the failure of the Neuve Chapelle offensive in March; and then that event began to make known to the people at home—what the troops in the field had long known—that this war was going to demand wholly new conceptions of massed artillery and shell-fire. This, and what appeared to be delay in the use of the new armies, roused a storm of criticism. At about the same time the first use of poison-gas by the Germans in the Ypres section terribly embittered the public mind and roused a new war-spirit; taken in conjunction with the already considerable sinking of merchantmen by German submarines it fitted in with all the reports of ruthlessness in Belgium, to create the sense of an unscrupulous, indeed a savage, enemy. Something was done to steady the British mind by the introduction of a bill in parliament to set up a Ministry of Munitions. Under an extension of the Defence of the Realm Act all factories concerned with munitions had been taken over by the Government in March.

More immediately steadying, perhaps, was the reconstruction of the Government in May; the Liberal ministry was replaced by a coalition including all the Conservative leaders; and Lloyd George's daemonic energy was felt, even by those who had in the past regarded it as a national danger, to be in a good place at the head of the new Ministry of Munitions. Meanwhile, a new phase of the war had been launched by the Dardanelles expedition. The public, knowing little of the divided mind of the Government, in spite of Lord Fisher's resignation from the Admiralty, welcomed it as offering an attack upon the further side of the Central Powers, and as a move to keep the Balkan Powers from intervention.

The heavy casualties of the heroic landing, the drain of man-power, steady and appalling, of the trench warfare in France, roused the nation to a new realization of its task. Compulsory military service was beginning to be discussed in June; but one more effort of a different kind was to be made first, in the shape of the "Derby scheme," under which men registered in groups according to age and their married or unmarried condition, not for immediate enlistment, but for the calling up of groups as required. The sinking of the "Lusitania" on May 7 had aroused the public more than the loss of a good many merchant vessels (incidentally it was hoped that the number of American passengers on board would stir the United States to action); but the summer did bring some concern for food supplies. Since early in the war the Government had more or less controlled sugar supplies; there was now an appeal to everyone who could grow any kind of food to do so, and flower-gardens and lawns gave way to vegetable beds. During the summer and autumn the first Zeppelin raids brought the war home in a new way. Camps and hutments were springing up, housing the first Canadian contingents as well as the home recruit. (Australian and New Zealand contingents had been diverted on their way, to take part in the Dardanelles campaign, and South Africa was using her contingents against the German settlements on that continent.) Women were throwing their power into the war; all over the country they were taking the places of chauffeurs and grooms who had gone; they were working on the land in the place of farm-labourers; they were largely staffing the munition works; and they were establishing and working canteens in camps and factories. Britain was already a changed country when it could hear ministers talking in December of an army of four million men.

Yet, though by now the true character of the war was apparent, and Lord Kitchener's prophecy of four years was beginning to be understood, the great changes were being left, of set policy, as far as possible to the impulse of the nation itself. The belief was that British people rose to a crisis best with as little as possible of statutory compulsion. It was felt that a nation unaccustomed to the military conscription and the far more constant State action in civil affairs under which Continental nations had lived, would suffer rather than gain by a sudden subjection to compulsion. Not only would there be resentment that might become sullen; the effect of drastic State intervention might be to create nervousness and apprehension, instead of the confidence and self-reliance which were needed. In every way, therefore, unusual methods were avoided. The Treasury had set itself to avoid them as far as possible. By steady increase of taxation, especially the income-tax and the duties on alcoholic liquors, and later by the imposition of the excess profits duty it forced up the revenue amazingly; and beyond that it relied during the early years upon votes of credit financed by advances from the banks, rather than upon the launching of any big public loans. The rapid and large increase of currency, which the inconvertible paper basis made possible, swelled banking figures to a point which enabled them to keep the Treasury's quiet policy going for some time. Equally the Government set itself to avoid conscription and food-rationing, which began early in Germany. Throughout the war opinion on this policy was strongly divided, and to the end the British effort remained a mixture of wholly devoted volunteering, and a piece-meal kind of compulsion.

1916: The Man-power Demand.—Throughout 1916 the real heart of the war was seen to be the western front, and it was a year of heavy, deadly fighting. The great defence of Verdun (*q.v.*) lasted from February to June, and the new armies were by now ready to take over more and more of the lines to free French troops for their terrible effort. In July came the British offensive on the Somme. The "tanks" made their appearance in September, heartening the country with the sense that the Germans were not

to be alone in new devices; and to the end of the year trench warfare was constantly active. Inevitably the question of man-power was more urgent. There was much dispute as to the extent of evasion of attestation under the Derby scheme by men of military age, and resentment at the idea that, because of this, groups of the married and older men who had attested would be unfairly called up. The result was the introduction of a conscription bill, applied to all men between 18 and 40, with exemption for those engaged in absolutely necessary national service and those who had a conscientious objection to military service. Local tribunals were set up to grant these exemptions. They were soon to create bitterness of feeling—the casualties were touching so many homes now—and active men without the silver badge, showing that they had served and been discharged as disabled, had no comfortable time. In another way the nation's man-power had its problems. There was an amendment of the Munitions Act, to force upon workshops and factories which still tried to maintain old union rules the "dilution" of labour by unskilled men. This, and the growing fear that the Conscription bill would in effect mean military discipline in factories, led to a serious strike on the Clyde in March and April ignited by revolutionary opposition to the whole war. In finance new efforts had to be made. The country's credit had responded amazingly to the strain; but now, besides the raising of the income-tax to 5s. in the £, increase of excess profits duty and other efforts of the budget, a campaign was started for "War Savings" certificates to include the small investor and spread the fiscal burden. Continuance of the Zeppelin raids brought growing pressure upon the Government for improvements in the air forces.

Twice in the first half of the year the public mind received sudden shocks. At the end of April, armed rebellion broke out in Dublin for a terrible week, followed by many executions on the spot, and months later by the trial and execution of Roger Casement in August for high treason in securing German help for the rising. The rebellion was quite unexpected; Birrell, the chief secretary, acknowledged that the significance of a new influence at work in Ireland had been underestimated. The Home Rule Act had been placed upon the statute book soon after the outbreak of war, but to meet the protests of those who objected to advantage being taken of the abandonment of party strife, it had been accompanied by an act suspending its operation till after the war. Irish regiments had maintained all their old reputation; and little attention had been paid to the new movement of Sinn Fein, until the rebellion made clear how forcefully it had been working in detachment from the old political nationalism (*see* IRELAND: *History*). The other shock came, very differently, in June, when Lord Kitchener, starting to visit the Russian front, was drowned by the mining of the cruiser in which he was travelling. Accusations of treacherous betrayal of his plans lasted for years, so sharp was the effect on the public mind. A great deal of uneasiness was also caused by the one great naval affair of the war, the battle of Jutland (*q.v.*) on May 31; not all the power of the censorship could make it appear a victory. There was, indeed, as the year went on, a growing tendency to wild accusations. Members of the Government were charged with having treasonable sympathies; Lord Haldane, whose reorganization of the military machine had done more than anything else to enable the country to take the first strain of the war, had had to resign from the Government, because much of his education had been in Germany; others, especially Asquith, were charged with an over-tenderness for German prisoners of war. More and more loud, too, grew the complaints that in every direction the attempts to make the nation put out all its strength were being evaded. Khaki was now everywhere, but it was said that it covered a multitude of shirkers. Conscientious objectors were increasingly hounded. The tribunals had been interpreting exemption in such cases from military service to mean exemption from actual combatant service, and not to cover non-combatant enlistment; public opinion, in any case impatient of these exemptions, supported this view. But there were many conscientious objectors who went much further than this; some from deep religious conviction, like the stricter Quakers, and some from violent political opinions, like the extreme Labour men, refused any service connected with the prosecution of the war; and many of them were sent to prison.

Appeals to cut down luxury expenditure and to use food economically, were felt to be so useless that the Government was pressed to introduce compulsory rationing. Labour was accused of putting its old quarrels in front of the national need in striking at such a time; another serious trouble in the south Wales coalfield in November led to the putting of coal-mines under the Defence of the Realm Act, with power for the Government to take them over if necessary. A man-power distribution board was set up in September, with promises of "combing out" all employment at home. Compulsory rationing was refused, but in November the appointment was announced of a food controller with wide powers; the submarine campaign was growing serious. The real response to all the dissatisfaction came in December when Asquith, who had been peculiarly grossly attacked, resigned. Lloyd George became prime minister, with a "war cabinet" of four members—himself, Lord Curzon, Lord Milner and Arthur Henderson—and a Government that included three new ministries—of labour, food and shipping—brought in "business men," and promised a universal national service scheme.

1917: The New England.—With no illusions left on the nature of the war, the country entered upon 1917. It was a strange year. Towns, at first because of air-raids, and later also for the saving of coal, were in complete darkness at night. Food, without actual rationing as yet, was often short, and, with the increase of Government control of supplies and prices, was no longer freely obtainable; restaurant meals were definitely restricted. Alcoholic liquors had been largely given up (the King had set the example at the beginning of 1915), and in munition areas licensing was under strict control. Alcoholic liquors were, in any case, becoming very expensive, with the steady raising of revenue duties upon them; and were deteriorating in strength and quality with the Government control of the materials of manufacture. Yet there was much spending of money, and much rather fevered gaiety. This was partly because the enormous Government requirements had vastly increased the currency and spread money all over the country in high factory pay, military pay, camp and equipment contracts; partly because of the feeling that all the hard work justified the turn to what distraction was possible. A grimmer phase of the same feeling permitted any extravagance to the armies, to the men back from France, or on their way there, hung about with the bewildering mass of trench equipment—gas-masks, entrenching tools, weapons, food-tins, packs—half buried in coats and mufflers, the strange, heroic infinitely patient figures which poured out of and into the leave-trains at Victoria station. So in a tragic England there was dining and dancing and theatre-going as never before. It was only too easy to feel that no one could count on life; the hour must be taken as it came, whatever morality might say. Everyone was extraordinarily free, for home life had come to mean little to the mass of people at war work. Hundreds upon hundreds of thousands, moreover, were earning more money than they had ever dreamed of; and this applied specially to young women. Munition wages were unstinted; there were good pay and keep in the Women's Auxiliary Army corps, and its sister organizations for the air force and the naval air service. Women were as completely swept away from their past as men. They were largely staffing factories and commercial offices, and replacing men on the land; and the vast expansion of hospital work and motor transport absorbed the rest.

Every aspect of life was new, and yet incredibly accustomed. The armies were new, for the men of the old armies were nearly all dead or disabled, or in the higher command; their training was new; the officering was new; the speedy discovery of the terrible costliness of the war in the commissioned ranks had been met by the formation at home of officer cadet battalions to which men from the armies in France were steadily drafted for training; they had never known anything but the new fighting and the command of the new soldiers. Much that the old army valued might have gone; but the new armies understood their job.

There was in 1917 the feeling that the crisis of the war was at

hand, especially with the first important news of the year, the great withdrawal of the Germans to the Hindenburg line. But for the rest of the year events conspired to make a strained fluctuation of hopes. The capture of Vimy Ridge in April had been preceded in March by the Russian Revolution. The third battle of Ypres (*q.v.*) in July, and the capture of Hill 70 in August were followed by the Caporetto (*q.v.*) disaster to the Italian army; and the long dreadful struggle in the mud of Passchendaele in November was followed by Russia's withdrawal from the war in December. The main result at home was renewed agitation about man-power, and pressure upon the Government for a re-examination of discharged men, and for drastic "combing out" of the civil service, of munition works and of other occupations where exemptions had been granted largely to "indispensables," as well as an equally drastic "combing out" of the non-combatant military organization in the back areas in France.

At home life was growing more painful in many ways; yet sweeping measures of control were avoided, mainly with the idea that the less enforced restriction there was, the better for the *moral* of the "home front"; fox-hunting was not abandoned till the spring of 1917, and racing not till later in the year. Thus, although the submarine menace was most alarming in April and May, only voluntary rationing was called for; one special ground for anxiety was that the last potato crop had been very bad. The Germans had announced an "unrestricted" submarine campaign; it was answered by an amazing display of ingenuity and undaunted courage in the "Q ship" anti-submarine campaign. And above all it turned the scale in America; the United States declared war, and began to muster and train contingents on the new war-scale of millions. Without going as far as a full imposition of rationing, the Government steadily increased their control of purchasing and prices. But this was largely due to a violent outburst of complaint about "profiteering." It was not till long after the war that people began to understand that an enormous increase in currency was bound to make high prices, and to enrich many people; at the moment it was all taken as a preying upon the nation's necessities. At any rate, it helped to finance the war; a loan put out in January was subscribed to over a thousand millions; and there was another huge one in October; while excess profits duty and the income-tax were forced up every year. This kind of extensive and heavy diversion to the State of the profits of commerce and industry was seen by Labour leaders as a lesson and an actual hope for the future. And similar hopes appeared in many directions. The control of licensing and the drink traffic; the energetic organization of housing and welfare schemes in munition areas; the reorganization of the railways under Government control; the semi-nationalization of mining and industry; even such a purely internal development as the banking fusions which, in 1917 and 1918, produced the "Big Five," so prominent in the post-war financial world—all this seemed to indicate that the nation might have finished with much ill-organization. An economic conference of the Allies in Paris in June 1916 had outlined large schemes for future co-operation. And in quite a different way, imperialism was becoming a new thing, not only by the presence of great contingents of colonial troops, but by the activities in England, first of W. M. Hughes, the prime minister of Australia, and then of Gen. Smuts, the latter being made a member of the war cabinet in June 1917.

There were several bad strikes during the year—of munition workers at Barrow in March, of engineers in Lancashire in May, of railwaymen in November—partly on "dilution" quarrels, partly on wage disputes. Irish affairs were dispiriting; all attempts to make a *modus vivendi* during the suspension of the Home Rule Act broke down, and there was a growing sense of the control of opinion in Ireland passing from the old leaders to the new Sinn Fein movement. Parliament, indeed, set itself to some constructive work, with a large franchise bill establishing virtually adult suffrage, and, at last, women's suffrage (*q.v.*). A useful education bill was passed. During the summer, raids by squadrons of German aeroplanes, at first on moonlit nights, and then in broad daylight, packed the "tube" railways with refugees, and led to complaints of the insufficient defence of London.

1918.—Although compulsory rationing for some foods came before the end of Feb. 1918, the worst of the submarine menace was over; the combination of successful anti-submarine tactics with a vigorous construction of new shipping was at last balancing losses and replacements. Finance, too, was bearing the strain, for besides successful issues of war bonds and war loan (for which there was another strenuous appeal in February) and the forcing of the revenue up to the unheard-of figure of 842 millions, there had been heavy borrowing from America. At first British requirements from the United States had been financed by the purchase of American securities from private hands; but since the entry of the United States into the war 500 millions had been borrowed. There was another military service bill early in the year, calling up men between 40 and 45, and the "comb-out" was steadily proceeding. Rather grimly by now, but still without the gravest apprehensions, Great Britain settled down to "carrying on," when the news of the very serious German "break-through" in April shook even the most confident. The deduction was obvious; the Germans could not afford to wait for the entry of the American troops, and were making their big effort. For days the balance hung; if they reached Amiens, no one could tell what the result might be. Then the impetus was checked; the distorted Allied lines held once more. But from that time on, there remained a feeling that the crisis must now come. The immediate result was the unified command in the single control of Gen. Foch.

With the sense of the crisis for the armies, the people at home passed under much more restriction. Restaurants and theatres were obliged to close early; the purchase of clothing was regulated; there was restriction of railway travelling; and finally, in July, extended rationing, which now included sugar, butter, margarine, lard, butcher's meat and bacon. These restrictions (though nothing in comparison to the sufferings in Germany) were serious and were causing much anxiety about the children growing up in such conditions, most of all, of course, the children of the homes where poverty was added to rationing. National food kitchens had been opened and were doing much good; rations gave the best results where they could be used in bulk; and the fat ration especially went furthest in this way; so that private individuals began to learn, here and there, to "pool" their preparation of meals. Another service bill called out men up to 50 years of age; the "comb-out" required more and more elderly men to fill up the non-combatant parts of the service; and with this last calling-up it became apparent that there was only the "comb-out" to depend upon now for supplying the wastage of the trenches.

Some events of the summer provoked the question whether even now the country was whole-heartedly at war. The news of another violent German effort in July, this time farther south, which was causing again an alarming withdrawal of the Allies, coincided with the outbreak of another considerable strike in munition works at Coventry, which had spread to Birmingham and into Yorkshire, before the Government's threat to draft the strikers into the army caused it to collapse. There were more strikes in August, including the astounding spectacle of the Metropolitan Police Force itself on strike, for bonus pay, to meet war prices, and for recognition of their right to form a union. Luckily there was a kind of substitute force available. From early in the war men over military age had all over the country been doing excellent service as special constables; and as the needs of the army grew heavier, this force was more and more highly organized and used. It did splendid work in times of air-raid, and gave a new meaning and status to the special constable.

The Armistice.—By the time of these later strikes the public mind, though irritated by them, had very different things to attend to. With an almost incredulous excitement and hope it was watching Foch's reply, so patiently prepared and timed, to the last German attack. By the middle of September the issue could hardly be in doubt; all that remained was the question of how long the final stage could last. There was even now little jubilation. After the long years of war the strain lay too heavily for outbreaks of excitement, and vitality was perhaps a little too low; the ravages of a bad epidemic of influenza, with the deaths rising to nearly 400 a week, seemed to indicate this. Yet when the end

came, the joy and relief had their way. It was known in the first week of November that an armistice was in preparation. At 11 o'clock on Monday Nov. 11, 1918, the bursting of maroons over London (so lately grimly associated with air-raid warnings) brought everyone out, and for the rest of the day and till far into the night the streets of London were packed tight with people and alive with noise. At the very moment when to the troops at the front the strange thing was the sudden silence of an air that for years had never been free of gunfire, to the people at home the strange thing was the unaccustomed volume of sound, in an air where for so long everyone had gone quietly.

The contrast is worth making; for there is this last word to be said in an attempt to depict the mind of Great Britain during this period. Throughout the war there had been, on the whole, a wonderful sense of unity between those at home and those in the fighting forces. Leave had been as well organized and probably as generous as was possible; the postal service had been little short of marvellous. Experience had been shared, as far as it could be. But shared in the real sense it could not be. What "the front" really was, only those who were there knew, or ever will know. And what "home" really was, in the agony and the blind waiting, waiting, waiting, only those who lived through time that was timeless knew, or ever will know. With all the unity there remained a deep unbridgeable gulf. The men of the armies would not have bridged it if they could. They lived their own heroic lives and died their own heroic deaths.

BRITISH HISTORY SINCE THE WAR

The war was over; few people, if any, discerned the dangers lurking in the full play which was given to that feeling. The Coalition Government, precipitating a general election in Dec. 1918, not merely played upon it, but played down to it. Little was before the electors except a loose and far too easy summary of the mind of the moment provided by Lloyd George. Some of it was an idealistic, if rather sentimental, programme of social amelioration to cement the comradeship between classes which, it was hoped, would prove to be one great good amid the evils of war. The rest of it was hasty generalization about bringing to book those responsible for atrocities (it was believed generally that the German emperor, in self-sought exile in Holland, could actually be brought to trial) and about indemnities and reparations from Germany. Loose appeal as it was, it succeeded handsomely. There was to be no chance of a return yet to party divisions; Lloyd George insisted on pledged candidatures, and all independent candidatures were outlawed. In the end Labour, the one party which could afford to defy the outlawry, secured 57 seats; Liberals, as such, secured only 26. Pledged Coalition supporters numbered 484.

The Return to Civil Life.—Lloyd George, departing with the other British representatives, Balfour, Bonar Law and G. N. Barnes, for the opening of the Peace Conference in Paris (*see* PARIS, CONFERENCE OF and VERSAILLES, TREATY OF) which held its first session on Jan. 18, 1919, left to his colleagues the troubles which very soon began to arise. No one, indeed, paid much attention at the moment to the fact that Sinn Fein had not only secured 73 of the 77 Irish seats, with candidates pledged not to come to Westminster, but had also on Jan. 22 opened a "Republican Parliament" in Ireland. There were troubles nearer at hand. Miners' grievances broke out again in a strike, only composed for a time by the appointment of a royal commission in February with orders to issue an interim report as quickly as possible. During that month there was an epidemic of strikes. Worse still, all plans for gradual demobilization were being ruined. Since long before the end of the war the Government, foreseeing the difficulties of returning five millions of men to civil life, had been elaborating plans of demobilization, which included not merely methodical return by classification based as far as possible on the probabilities of the labour market, but also plans for giving to the men held back facilities for education and vocational training, which might compensate them for the delay in their return. But the men in the armies cared about nothing but getting home again, and felt that they had earned the right to return; and this pressure came at a time when industry was suddenly shorn of the fictitious demand for production, and was disturbed by the strikes. There were serious troubles in demobilization camps, some known to the public, since they occurred in England, some not known so widely, since they occurred in France. In the end, demobilization had to be carried out wholesale, and problems of unemployment left to take their chance.

The interest of politicians was centred rather on the Peace Conference at Paris, where a good many hopes were vanishing, than in the progress of home affairs. The public mind was still too much accustomed to the vast demands of war expenditure to pay much attention to the budget; it showed that the National Debt stood at nearly £7,500,000,000, with some £1,500,000,000 of floating debt. The setting up of a Ministry of Transport, and the changing of the Local Government Board into the Ministry of Health suggested that some lessons of organization had been learned (*see* GOVERNMENT DEPARTMENTS), and a housing bill was intended to redeem some of the election promises of better conditions for millions who had served in various ways in the war. A "profiteering" bill, setting up local tribunals to deal with cases of exorbitant prices, was little but a sop to popular outcry. In an autumn session a further stage of experiment in the government of India was entered upon by the act giving effect to the proposals of the Montagu-Chelmsford report; the Enabling Act setting up the Church assemblies was passed; and the first woman member, Lady Astor, took her seat. But the public generally had not much concern for such doings. It was settling back, as best it could, into business and industry, the difficulties being for the moment partly masked by the war gratuities; and it was finding matter for concern in Ireland, where an Irish Republican army was drilling, and where, throughout the autumn, there was a series of murders and murderous attacks by Sinn Fein adherents.

Guerrilla War in Ireland.—Nobody saw the terrible pace at which this was to grow into a situation of almost blind despair. Little else mattered in 1920. The Government were trying to meet the situation in the old way, with a mixture of coercion of disorder and concession to the demand in the shape of a new Home Rule bill, introduced on Feb. 25, setting up two Irish parliaments, one for Ulster and one for the rest of Ireland, with a single "Council of Ireland" to bring about harmonious action. This met to some extent the Ulster difficulty, though the proposal for a single council was mistrusted. It did nothing to meet the Sinn Feiners, who not only refused to accept any partition of Ireland but demanded nothing less than an independent Irish republic. The Government were able to reinforce largely the Irish constabulary with men who had served in the war, and being unable to find civilian jobs were glad to return to active service; they went to Ireland without any of the constabulary traditions, and soon acquired a grim notoriety as the "Black and Tans." Ambushings, kidnappings, raids, marked by merciless killing on either side, with violent street-fighting occasionally in Dublin and Belfast (*see* IRELAND: *History*) seemed to be working up to a bloody climax of English and Irish relations.

With this appalling kind of war on its hands in Ireland, with the rumours of war in Russia, where assistance was still being given to anti-Bolshevik armies, with the incident at Amritsar in the spring, where a threatening Indian crowd had been fired upon in a confined space, with many casualties, the Coalition Government had little on the other hand to satisfy it at home. The country was, indeed, saved from what threatened to be a serious situation in the early summer, when the Trade Union Congress showed an inclination to act in sympathy with the strike of railwaymen in Ireland against handling military traffic, and to forbid the handling of any traffic in England until the transport of men and munitions to Ireland and to Russia was stopped. But it was not saved from a strike of miners in the autumn, as the Government failed to act upon the nationalization clauses of the coal commission's report (clauses, however, which had only been passed on the casting vote of the chairman, Mr. Justice Sankey). Nor was it saved from such an alarming state of unemployment in the winter that parliament had to make hurried grants to enable municipal bodies to undertake schemes of work to absorb labour.

The unveiling of the Cenotaph in Whitehall and the burial of the Unknown Soldier in the Abbey, on Nov. 11, 1920, came at a time when the country was most depressingly aware of what war could do to the whole productive system of a nation.

Decontrol and Its Troubles.—The Irish problem remained for another six months one of bloodshed and anger, with a great deal of fighting in Dublin in March, but the crisis in England began to matter more. The rapid destruction of any real meaning in "money" in Germany and Austria, and the signs that similar currency disasters might conceivably spread to Belgium, Italy and even France, began to have their effect on the British mind. The enormous expansion of revenue was seen as concealing the seeds of these very disasters; it really meant a vast creation of currency. The result was a demand for drastic economy, and the limitation of State action, with its corollary of paid servants, in every direction. "Decontrol" of railways, mines, food and drink, prices and agriculture took place, the last-named involving abandonment of the minimum wage for agricultural labourers. The Coalition Government was giving up every means of that organization of the country for a better national life which had been its appeal to the electorate in Dec. 1919. Large undertakings surviving from the later days of the war, like the huge depot at Slough, were hastily wound up; and in August a committee for economizing in the public service—the "axe" committee—was set up under the chairmanship of Sir Eric Geddes. Decontrol of the railways was, indeed, accompanied by some small remnant of the war's lessons of organization, in an amalgamation of systems which left only four great railway companies. Decontrol of mines, another indication that the old piece-meal struggle was to be left to go on, led to another strike in April and to the calling-out of the reserves, and armed defence of the mines. At the end of June Lloyd George was able to announce a settlement, but he had bought it by a subsidy of ten millions to allow maintenance of wages.

The Decline of the Coalition.—In the latter half of the year Irish affairs took a turn for the better. Negotiations had been opened in May, but many difficulties had to be met (*see* IRELAND: *History*) and it was not until the early days of December that terms of peace were arranged. No small part of the difficulty had been due to an uncompromising attitude on the part of the "die-hard" Unionists in parliament, who maintained their opposition throughout the debates on the ratification of the Irish Treaty. By the beginning of 1922 their opposition had developed into a serious rift in the Coalition. Disagreement arose in Jan. 1922 between Lloyd George and Sir G. Younger (Viscount Younger), the Unionist chief whip, as to the best date for an election, the former again being for precipitation; and the rise of a discussion as to the distribution of political honours, alleged to have filled an electioneering war-chest which was under Lloyd George's control, hastened the desire to draw the Unionist Party clear. The year 1922 becomes, therefore, a tale of the decline of the Coalition. There were other influences at work, besides Unionist disaffection. Inflated revenue figures were coming down, and budgets, instead of being balanced at 1,400 or 1,200 millions, were down to 900 millions or so, with the consequences of a shrinkage of currency and a fall in prices; the index-figure of the cost of living had dropped from the highest peak of 176 to 92. The fiscal severity, however, meant not only drastic cutting down of the public service, but the abandonment of any really generous assistance for housing and little prospect of much more subsidy for work for the unemployed. Reparations from Germany had never meant quite as much to the British people as to the French; but as it became more and more apparent that they would have to shoulder the whole burden of their war debt, and could look for little or no relief of taxation, it did the Coalition no good to have made promises which now, they had to explain, had always been futile. The failure of the Genoa Conference (*q.v.*) to "settle Europe" was followed by a period of real tension between Great Britain and France over the operations in Asia Minor which ended in the complete rout of the Greeks by the Turks. A Coalition which could give no fruits of peace at home, and seemed actually to risk peace abroad, had reached the end of its tether. Moreover, there had been growing a strong feeling that the power, and especially the electioneering power, behind the Coalition was speculative capitalism. This was what gave sharpness to the charges about the sale of party honours. It has been remarked that the general public never understood the true economic reasons for the rise of prices, but attributed it mainly to profiteering. Similarly they did not now understand the economic reasons for cutting down budget figures, or for lightening the excess profits duty while leaving other duties unaltered. Again, it merely looked as if the "profiteer" were able to secure terms for "big business" at the cost of schemes for housing and relief of unemployment. The war with Bolshevik Russia could be regarded as an expensive affair undertaken for the financiers whose loans had been repudiated. The troubles in Asia Minor were openly put down to the scramble of oil interests for territory to exploit. The Genoa Conference was thought to have failed—even, by now, the Peace Conference at Versailles was felt to have declined from great ideals—because high finance alone had national and international politics in hand. And a pledge-bound Coalition House of Commons, lacking the normal party strife in which truth may sometimes emerge, was accused of being the ideal instrument for influences that preferred to be unobserved.

The Return to Party Politics.—Lloyd George resigned on Oct. 19. There followed a curious period of political history. The King sent for Bonar Law, who in March 1922 had resigned his post in the Coalition Ministry on the ground of ill-health. Austen Chamberlain had, since then, led the party and the House of Commons; but the Coalition in which he served having resigned, Bonar Law was the only possible leader to send for. The position was, in a sense, regulated by his election as their leader on Oct. 23 by a Unionist Party meeting of Lords and Commons. This, however, implied that the party was determined to return to normal political conditions whether the strong group of its chiefs in the late Coalition Ministry liked it or no. In fact, they nearly all held aloof. The sound instinct of the Unionist move was clear from the election results. Although, owing to triangular contests increasing largely in number from the existence of two Liberal groups and a rapid increase of strength in the Labour Party, those results were a somewhat distorted representation of the voting, the Unionists returned 347 strong, confronted by 159 Labour members, 59 Coalition Liberals and 60 Independent Liberals. So in the least democratic of parties a rank-and-file movement met with success.

The Ruhr and Reparations.—The new Government had almost immediately to deal with a grave turn in our relations with France. To the French, as has been remarked, with their terribly devastated regions, reparations from Germany had always been a much more urgent subject than to the British; and they were moved by no argument of economists on the subject. On the ground that some form of coercion must be applied to Germany, France proposed to occupy the Ruhr (*q.v.*) district of mines and metal-works, and expected the active co-operation of Great Britain, which the Government, wholly mistrusting alike the wisdom and the use of such a step, could not offer. Conferences in Paris in December and January ended simply in leaving France a free hand, as amicably as might be in face of French anger at this "betrayal" of the alliance. Stanley Baldwin, the new chancellor of the Exchequer, was in America early in the year to negotiate the funding of Great Britain's debt to the United States. It stood now at 978 millions, and was funded with the interest fixed at 3% for the first ten years and 3½% for another 52 years, with a sinking fund of ½%. Baldwin's first budget, actually with a surplus of 100 millions, expenditure being now down to just over 800 millions, enabled him to make the first slight reduction in the income-tax; and good sense approved of his application of the surplus to debt reduction rather than to any considerable lightening of taxation. The Unionist Government applied itself mainly to the further securing of our finances in a Europe of uneasy currencies; the French franc was showing signs of a bad fall. Unemployment displayed itself in the "hunger march" from the north in January; and grievances of ex-service men in particular roused a stormy debate in the Commons in April. In the following month the Government had some bad days over the question of men deported to Ireland; an act of indemnity had to be passed to save the home secretary

from his breach of the Habeas Corpus Act.

Otherwise the session passed mainly in debates on finances, reparations and the Ruhr occupation. The most hopeful event of the session was, perhaps, the announcement that a new conference on reparations was in prospect, in which America would co-operate. This latter fact was full of promise; if America, with her financial power, was consenting to abandon her aloof attitude, much might be achieved; but, besides this, the phrase implying that the conference might even amount to an "overhauling of the Versailles Treaty" especially suggested hopefulness, for only a new basis of understanding could bring France and Britain together again. Lord Curzon had some meetings with Krassin, a Soviet representative, with a view to better establishment of trade relations with Russia; but it was a precarious question; a very little while before these meetings the British Government had been protesting against the carrying on by the Soviets of political propaganda under cover of the trading agreement.

The Protectionist Election.—The whole session indicated that the Government, while making provision for relief works, were mainly listening to the economists, and trying, by ending the uncertainties of reparations and in other ways, to re-establish busy markets as the only real remedy for unemployment. There was the more surprise when, during the autumn, Baldwin (he had become prime minister in May, on the resignation of Bonar Law, whose ill-health had become so serious that he died in the following October) suddenly announced that Protection was the way to fight unemployment. The suddenness must not be exaggerated. Baldwin had been prominent of late years in welcoming and extending wherever possible the import duties on manufactured goods which had from time to time been imposed under the financial strain of the war. The process had begun with some duties resulting from the Allied economic conference in 1916; and others had been imposed since. That these steps had not been unobserved is shown by the fact that Bonar Law, to avoid awkward cleavages in the late election, had had to promise not to introduce any general protection during the existence of that parliament. In one sense, therefore, there was nothing very surprising in Baldwin's announcement; but the hint soon after from his chancellor of the Exchequer that the Government would have to seek release from Bonar Law's pledge revealed a completeness of protectionist purpose which certainly had a sudden appearance. A very large section of the Unionist Party felt it to be little short of wanton to risk throwing away, after a single year, an excellent majority, especially when a certain amount of tariff reform by instalments had been proved to be possible. Nor were they less disgruntled when it began to be plain that leaders were not at one; Baldwin, fresh from an Imperial Conference (*see* BRITISH EMPIRE) was insisting mainly upon imperial preference without taxation of staple foodstuffs; and Chamberlain was objecting to any limitation of protectionist policy. But for all the party discontent, Baldwin took his way, and dissolved parliament on Nov. 16. He relied, to a great extent, on divisions in the Liberal Party. He relied, too, on the fact that the Labour Party was entering the campaign with a capital levy in its programme, which would alarm the country. Yet in the end such calculations did not save the Unionists from the loss of their majority. They returned only 258 in number, against 191 Labour members and 158 Liberals.

The First Labour Government.—Again political history entered upon a curious period. Here were three parties, no one of them in a majority. At the very moment when cabinet responsibility was beginning to recover from the drugged years of the pledged Coalition, a new problem in cabinet government presented itself. But all this mattered much less than the other new experience for Great Britain—the first Labour Government. In face of the Liberal weakness at the last two elections Labour had for four years claimed to be the official Opposition; and they were still outnumbering the Liberals. There was some hope that the Liberals might not be inclined now to help Labour to power; unless they did, Baldwin could carry on. But Asquith dashed such hopes when the new parliament met in Jan. 1924; he announced that he and his supporters would vote for the Labour amendment to the Address. The Government was defeated, Baldwin resigned, and on Jan. 22 the King sent for Ramsay Macdonald. Nine months of office disposed quite sufficiently of doubts whether "Labour could govern." Its ministers not only did well in public, but also earned the good will of the departmental staffs. They had some advantages not of their own making; the revenue returns gave Philip Snowden (chancellor of the Exchequer) a surplus of 43 millions; the Reparations Conference produced in April the "Dawes Plan," (*see* REPARATIONS AND THE DAWES PLAN), which in every way opened up the better prospects that had been hoped for. And on quite another plane, the Wembley Exhibition distracted a public which had of late had only too much seriousness. The Government set itself to work within the sober limits which its position as a minority government imposed; it had no great assurance of Liberal support. The budget, on an expenditure of 790 millions, made no "socialist" proposals. An unemployment insurance bill was also far from initiating strong measures; and the housing bill, if it revived vigorously a policy of subsidies which had lately been more and more drastically curtailed, at least made no very excessive demands. But it never became law. The Government was always on sufferance, and the announcement of its Russian policy brought the sufferance to an end. Ramsay Macdonald, who had courageously, if not altogether wisely, taken the Foreign Office as well as the premiership, had immediately opened negotiations with Russia in a new spirit. In July the results were announced in the form of a treaty, in which, besides the arrangements for trading facilities, there appeared a limited recognition by the Soviets of the debts of the tsarist regime, but in return for this a British loan to the Soviets was to be arranged. While there was much to be said for access to the Russian market, there was still too much distrust of the Soviets to permit of such a treaty. Their propaganda was feared; their promises were not believed. The matter remained in suspense during the summer recess; it reappeared at once in the autumn session. But another question had also arisen by then—the dropping of the prosecution of a Communist journalist, accused of tampering with military discipline. In the end it was on this issue that it was decided to defeat the Government. It fell early in October and Macdonald dissolved parliament.

The Zinoviev Letter.—In any case it is probable that the Unionists would have secured a safe working majority, but in the end they secured a majority beyond all calculations. A few days before polling day there was published in a newspaper the notorious "Zinoviev" letter—a document alleged to have been attached to a Soviet communication to the Foreign Office, inciting disorder in Great Britain in the interests of international Communism. The bombshell did its work; middle-class voters were thoroughly scared into belief in an imminent "Red" peril. The Unionists returned 413 strong, against 151 Labour members and 40 Liberals. Liberals, in fact, suffered more from the Zinoviev letter than Labour; their less stalwart adherents either resented the fact that a Liberal vote had put Labour into power, or felt that a three-party balance must not occur again. Labour, on the other hand, had rallied strongly to the denunciation of the letter as an electioneering trick. Analysis of the voting showed that the Labour poll had actually gone up by a million, while the Liberal vote had declined by a million and a quarter. The production of the letter raised two hotly disputed questions—that of its authenticity and that of the method of its publication. Ramsay Macdonald's own utterances were somewhat bewildered. Immediate enquiry by his successor at the Foreign Office, convinced Austen Chamberlain of the authenticity. Information not available at the time, but at Baldwin's disposal in March 1928, when the subject was raised again in connection with an investigation touching the conduct of certain individuals in the Foreign Office, proved that copies of the letter had been sent elsewhere than to the Foreign Office, and that its publication had not been due to improper communication of an official document. But it affected more than the election; Chamberlain at once put an end to the Russian treaty negotiations.

1925: The Coal Crisis.—Great Britain at the beginning of 1925 offered no very cheering spectacle to a new Government. In many directions there seemed to be no lack of money. If there was some tendency among the older county families to give up great expensive mansions there seemed to be plenty of other peo-

ple to take them. Moreover, an enormous increase in the less expensive types of motor-car, a move out to more and more pleasant country suburbs, the maintenance of undiminished numbers at public schools and universities in the face of increased costs, showed that the professional and middle-classes also could command money. Lower still in the scale of expenditure, crowded charabancs in holiday time, a tendency everywhere to expect some kind of summer change, abounding prosperity of cinemas and the pullulation all over the poorest parts of towns of "wireless" aerials, showed a command of money among the mass of industrial workers. And yet unemployment was still showing figures well over a million; business men and manufacturers were gloomy; the labour world restless and aggressive. The Government certainly set out to combine fiscal purity with direct social ameliorations. The budget was notable for the return to the gold standard—a very strong assertion that continued budget balancing, even if a heavy burden to the taxpayer, had at any rate conclusively saved our currency and credit. With the budget came the promise of a considerable extension of the benefit of pensions, the old age pension to be granted at the age of 65 instead of 70 and widows of insured men to be pensioned without waiting for old age. The granting of the insurance pay to the unemployed was, however, stiffened up somewhat by insistence on a minimum number of contributory payments to qualify for receipt of the pay. Discussion of the Geneva Protocol—an attempt at an all-round international guarantee of security which the British Government felt to be likely to commit the country to far too vague and perilous responsibilities —occupied much time; and the pensions bill, when it appeared in May, was debated at great length, as being another "burden on industry."

But throughout the year the real concern lay outside parliament. There were clear signs of a very serious national crisis approaching. The immediate danger-point was, as for so long past, the coal-mines. There was another wages dispute in the summer, the owners giving notice of a reduction; and the Government's appointment of a court of enquiry was met on the miners' side by refusal to consider possible reduction as a subject of enquiry at all. But behind this far greater shadows were looming. A. J. Cook, a leader of the miners, had early in the year been talking of a wide alliance of all labour to back their claims; and this only put into words an uneasy sense that labour and capital were massing opposite one another as never before. How deep the alarm was, and at the same time how perilously responsible people were making up their minds to a fight, was shown in Nov. 1925, when the Government announced a scheme of an organization to deal with essential services in time of emergency. Commissioners, with the necessary staff, were to operate in ten districts into which the country was to be divided, to maintain, with volunteer aid obtained through "recruiting centres," transport, postal services and the supply of food and coal. The truth was that the mining troubles showed no signs of a likely solution. Another coal commission had been appointed in September, under the chairmanship of Herbert Samuel; and quiet was being preserved for a time by the continuance of a subsidy for keeping up wages. But the subsidy would end in April at latest; it was far too costly to renew after that; and yet no one hoped much from the commission's report. The issue between miners and mine-owners was too fundamental. On the one hand mine-owners could prove that, with a loss of markets during the World War which threatened to be permanent, and with the rising costs of working and transport, the industry was not paying its way. The miners' reply was that the real trouble was the wastefulness of piece-meal ownership, the struggle of small, poor mines and the selfishness of big rich ones; and their demand was for nationalization, or, pending that, such a pooling of mines as would, by throwing the returns of rich mines into the common stock, enable the poorer ones to keep up the wage-level. On that issue there was not the faintest hope of agreement.

1926: The General Strike.—Little else mattered in 1926. The narrative can go straight to the presentation of the commission's report on March 10. It recognized that the parlous condition of the market necessitated some new arrangements between the two sides, calling especially for some sacrifice on the men's part in longer hours of work on a smaller wage minimum. But it recommended that wage agreements should be national, and suggested large reorganization of the industry; and contemplated some degree of State ownership in certain circumstances. The Government immediately professed a readiness to act on the report, even against some of its convictions, if the two parties concerned would agree. They could not. The mine-owners posted late in April their new wage offers, which the miners described, and acted upon, as lock-out notices, and on April 30 the stoppage began. On May 1 the Government proclaimed a state of emergency, thus bringing its scheme of November into operation. The instant reply from Labour was the ordering of a general strike to begin at midnight on May 3. Last-minute efforts were made, and Labour leaders were in consultation with ministers when the negotiations were abruptly broken by the latter because a strike had broken out in a newspaper office; compositors had refused to set up a certain leading article on the situation. The ministerial view was that this was treachery to the whole basis of the negotiations; the Labour view was that a small and really isolated incident had been seized upon and magnified because now that war had been declared there were too many on the side of capital who were ready to fight it to a finish. So the strike began. (*See* GENERAL STRIKE.)

For a day or two there was intense anxiety; newspapers could not be published, and no one knew how near the country might be to armed conflict. Then the tension slightly relaxed: an official organ called *The British Gazette* was published daily, and one or two newspapers managed to issue themselves in much diminished shape. Not that their contents tended to a peaceful state of mind; the relaxation of tension was mainly due to the good spirit shown in spite of these publications. The response to recruiting for the maintenance of the four essential services was rapid; and as, on the whole, youth brought to its strange tasks the enjoyment of novelty and a good temper, there was far less friction than might have been expected. Amateur railway work and amateur driving of trams and buses was attended by more hilarity than ill-feeling, though there were occasional ugly incidents. The enlistment for the work of special constables was the most dangerous part of the scheme; youth was not in its place there. The Government's refusal to support in any way an appeal to the nation by its religious leaders on May 6 had an uncompromising look; the mustering of large food convoys in the London parks was accompanied by some conflict; and it was obvious that tempers which could stand a short strain might break under a long one. Fortunately it was not long. On May 8 the prime minister broadcasted a conciliatory message; negotiations were opened, and on May 12 the general strike was called off. It had not been whole-hearted, and it was showing signs of crumbling. But the original dispute in the mines remained as it was, and the stoppage of work dragged on for months. With a budget that again, after the better years, was showing a deficit, due to the mining subsidy, and with business generally bad, even the strong old industries like cotton and steel being in distress, there would, but for the feeling that Labour had "put itself out of court," have been a more healthy pressure upon both sides. As it was, the mine-owners held out for their whole position; and the miners, resentful of the collapse of the general strike and therefore little inclined to heed criticism or advice from the rest of the labour world, stuck to their own extremists. Yet collapse came upon them too. By September a drift back to work had begun, slowly at first, but increasing week by week, in spite of the leaders' efforts, until by late in November half the men at least had gone back. Surrender came on Dec. 1, when the stoppage was declared at an end.

1927.—There remained the aftermath of the general strike and the only question was how serious it would be. Financially, it was bound to be grave; the chancellor of the Exchequer put the total loss at 59 millions, and he had to budget for an actual deficit of 36 millions. He had now to help him the chances offered by the Safeguarding of Industries Act, which had been passed in Dec. 1926, and the betting tax which, imposed by the previous budget, had only become operative in November; this tax was soon to meet with unexpected complications in the sudden craze for greyhound racing. Nothing could be done to lighten the burden of taxation.

Politically, too, the aftermath looked grave. The Government introduced a Trades Disputes bill, making a general strike illegal, and intimidation and threats illegal, with such definition as was possible of the meaning of the words; and, further, altering the basis of the trade union levy. The Osborne judgment in 1909 had laid it down that a trade union had no right to spend money in financing the Labour Party, and as a result a compulsory political levy on members was impossible. The Liberal Government in 1913 had passed an act the effect of which was to allow a levy, but to permit members of the union to "contract out" of it. This principle was now to be reversed, and no levy was to be made except upon members who "contracted in." Regarding the whole bill as the triumphant outcome of the past year, the Labour Party opposed it tooth and nail, and the debates were prolonged, but it passed into law before the summer recess. Happily a year which began with the open hostilities of the Trade Disputes bill ended in the acceptance by the general council of the trade unions of an invitation to send accredited representatives to discuss, with representatives of groups of employers, the vital aspects of a modern industrial community. An unemployment insurance bill, and a bill to foster the production of British cinematograph films were also passed. In this year also broadcasting in Great Britain passed under Government control.

Foreign affairs occupied a good deal of the session. A defence force had to be sent to protect British residents in the disturbances which had become more widespread and threatening in China. The trade agreement with Russia was broken off, after a raid upon a London office-building which revealed evidence of political activities, again under cover of the trading agreement. There was considerable discussion, too, of matters arising out of the League of Nations. Naval expenditure had been coming heavily upon budgets which, in every other direction, were being cut down; and the fact aggravated the failure of the Disarmament Conference in the summer at Geneva. It appeared to have broken down largely from imperfect diplomatic preparation beforehand between Great Britain and the United States. However, the great impression made by Sir Austen Chamberlain's speech at Geneva, on the proposal to revive the Security Protocol—an impression of truth and sincere plain-speaking—maintained the vitality of interest in the League. (*See* DISARMAMENT.) An incident of the very end of the year—the rejection by the House of Commons of a proposed new prayer book, presented to it by the convocations and Church assemblies under the Enabling Act of 1919—was chiefly remarkable for the quite unexpected public interest aroused in matters of doctrine and religion.

1928.—But it was an interest which showed that religious controversy must still turn on very deep-seated historical prejudices. A second attempt, in which some endeavour had been made to compromise with opposition (mainly in modification of the proposals for reservation of the consecrated elements in Holy Communion), met with a similar fate in May 1928; and as the compromise proposals had alienated some of the support of the proposed new book, the attempt to adjust the forms of 1662 to the practices of modern times ended in a failure, mainly regretted, perhaps, by the ordinary individual as a disappointment to the aged archbishop of Canterbury, who had hoped thus to crown 25 years' direction of the Church of England which had, especially of late years, brought him a steadily increasing reputation for statesmanship. His resignation was shortly afterwards announced.

The session showed no failure of vitality in the Government, for its main piece of work was a budget of first-rate importance. The finance of English local government, a piecemeal growth out of petty parochial circumstances, was for the first time envisaged nationally in the light of modern industrial and social developments; and proposals were made in the budget which, by transferring in the course of two years, much of the responsibility for local government finance to the Treasury, would, it was hoped, remove from industry the burdens of an old "rating" system which had become inequitable in its operation.

The problem of the coal-mining areas passed into a new phase of sober common-sense. It was becoming obvious that, from loss of markets and from the inability to work some of the mines on a proper economic basis, the mine-fields could no longer support their old population. The Government, therefore, set up an industrial transference board to find employment in other industries, with some provision for vocational training if necessary, for men who could be absorbed elsewhere; the most striking early success of the Board was in arranging with the Canadian authorities for the employment as harvesters of more than 8,000 men, many of whom, it was hoped, might find permanent work in the Dominion.

During the summer there was a steadily growing interest in a draft treaty, originated by F. B. Kellogg, President Coolidge's secretary of State, aimed at the renunciation of war as a normal feature of international relations. It was eventually signed in Paris on Aug. 27 by several great Powers, including Germany, the adhesion of the other Powers at a later date being hoped for. While it could no more than any other international document make war really impossible, it was nevertheless felt to mark a real advance as the most specific and deliberate declaration that war was no longer to be considered by civilized nations as a recognized implement of their ends. (R. H. GR.)

An Anglo-French compromise on the limitation of naval armaments, announced on July 31, was prematurely revealed in the Press, and at once subjected to severe criticisms—especially from the Government of the United States, which in a note of Sept. 29 refused to accept its terms. At home the autumn municipal elections showed a marked advance for the Socialist Party. Parliament was mainly concerned with the progress of the Local Government Bill. The year closed in an atmosphere of anxiety, caused by the seriously increased distress in the mining areas, and the prolonged illness of the King, necessitating the return of the Prince of Wales from East Africa and the appointment of six counsellors of State to act for the King in the transaction of the necessary business of State. By the beginning of 1929 His Majesty had begun to show signs of recovery, to the relief of the whole nation, which had been roused to remarkable demonstrations of sympathy and affection. (X.)

SOURCES AND AUTHORITIES FOR ENGLISH HISTORY

In this brief section it is impossible to attempt more than three things, viz.: (1) to indicate the nature of the chief sources of English history; (2) to mention the leading authorities in which the evidence derived from these sources is examined and formulated; and (3) to point the reader to fuller bibliographies where the sources and authorities relating to either the whole or part of English history are treated in detail. Since the materials on which our knowledge of the earlier periods of English history is based differ radically from the materials which give us our information concerning the later periods, it is necessary, for purposes of classification, to divide the story of southern Britain and its people into chronological sections, and to deal with them individually in turn.

1. Pre-Roman.—Our knowledge of the incalculable ages prior to the Roman Conquest during which the land now called England was inhabited, is derived almost entirely from the remains which the primitive inhabitants left behind them. These consist in the main of earthworks and burial-mounds, of monuments such as Stonehenge and Avebury, of flint or bronze implements and weapons, and of bone and other tools. Human relics also have, in some places, survived; of these the most notable is the Piltdown skull, discovered in 1912, considered by experts to be not less than 100,000 years old. The most convenient summary of the approved results of archaeological research respecting this period is provided by D. A. Mackenzie's *Ancient Man in Britain* (1922).

2. Roman.—The most considerable references to Roman Britain are to be found in Caesar's *Gallic War;* Strabo's *Geography;* Tacitus's *Agricola, Histories,* and *Annals;* Suetonius's *Lives of the Caesars;* Dion Cassius's *Roman History;* the *Itinerary of Antonine;* Ammianus Marcellinus's *History* (A.D. 353–378), and the *Notitia Dignitatum.* The relevant passages from these and other less important Latin writers are usefully collected in the one and only volume of the *Monumenta historica Britannica* (1848), edited by Henry Petrie and John Sharpe. For the Roman occupation of Britain, however, literary sources are supplemented, and

to some extent superseded, by archaeological evidence. Summaries of this evidence will be found in F. Haverfield's *Romanisation of Roman Britain* (4th ed., 1923); B. C. A. Windle's *Romans in Britain* (1923); R. G. Collingwood's *Roman Britain* (1923); and G. Home's *Roman Britain* (1927).

3. Anglo-Saxon.—For the Anglo-Saxon conquest of southern Britain there are four main literary sources, viz.: Gildas's *De Excidio Britanniae,* Nennius's *Historia Brittonum,* Baeda's *Historia Ecclesiastica,* and the *Anglo-Saxon Chronicle.* None of these is contemporary, and the two former are very scanty. Nineteenth century historians, such as Freeman and Green, constructed their narratives of the coming of the English almost wholly on the basis of Baeda and the *Chronicle.* Archaeology, however, reinforced by ethnology and philology, has compelled criticism of these sources; the stories of Hengist and Vortigern, of Cerdic and Cynric, of the process of West Saxon conquest, and many others, are called in question. For statements of new views, *see* H. M. Chadwick, *Origin of the English Nation* (1907) and E. T. Leeds, *Archaeology of the Anglo-Saxon Settlements* (1913). For the story of the English people from their first settlement till the Norman Conquest, the *Anglo-Saxon Chronicle* remains the primary source; it is authoritative and invaluable from the time of Alfred. It is supplemented by a number of minor chronicles, such as Asser's *De Rebus Gestis Alfredi,* Ethelweard's *Chronicon,* and by numerous imaginative *Lives of Saints.* For constitutional history the large collections of Anglo-Saxon Laws and Charters are indispensable. The best edition of the former is F. Liebermann's *Gesetze der Angelsachsen* (1898 *seq.*); for the latter, either J. M. Kemble's *Codex Diplomaticus Aevi Saxonici* (1839–48) or B. Thorpe's *Diplomatarium Anglicum* (1865) may be consulted. A useful selection is provided by F. L. Attenborough's *Laws of the Early English Kings* (1922).

4. Mediaeval.—The main sources for the history of England from the Norman Conquest to the Battle of Bosworth can be classed under the two heads, chronicles and records. The most important and valuable of the chronicles are those which, in the form of annals, were compiled in the great monasteries, and of these easily the best are those which emanated from the abbey of St. Albans, *e.g.,* Roger of Wendover's *Flores Historiarum,* and Matthew Paris's *Chronica Majora* and *Historia Anglorum.* Monastic chronicles form a large proportion of the 235 volumes known as the Rolls Series. A popular account of them will be found in James Gairdner's *Early Chroniclers* (1879); fuller and more critical estimates are provided in C. Jenkins's *Monastic Chronicles and the Early School of St. Albans* (1922), and R. L. Poole's *Chronicles and Annals* (1926). Besides the monastic chronicles, there are a few written by secular clergy, *e.g.,* Henry of Huntingdon's *Historia Anglorum* and Roger of Hovenden's *Chronica.* Towards the close of the middle ages city chronicles began to be compiled by laymen; those of London are particularly valuable as sources of information (*see* C. L. Kingsford's *English Historical Literature in the Fifteenth Century* [1913]).

The records—that is to say, official documents, financial, legal, administrative, and legislative—are legion and to those who can interpret them they are sources of information unique in authority and significance. First in order of time comes the famous *Domesday Book* compiled as a geldbook by order of William the Conqueror; then come the *Pipe Rolls;* and, after these, innumerable *Court Rolls, Plea Rolls, Year Books, Patent Rolls, Close Rolls, Charter Rolls, Hundred Rolls, Rolls of Parliament,* and others too numerous to mention (*see* S. R. Scargill-Bird's *Guide to the Public Records* [3rd ed. 1908] or the more extended guide in process of publication under the editorship of M. S. Giuseppi). Towards the close of the middle ages, chronicles and records are supplemented by letters, such as the *Paston Letters* and the *Stonor Letters;* by *Political Songs;* and by literary works such as the writings of Wycliffe, Chaucer, and Peacock. For the whole course of English history up to 1485 the student should refer to Charles Gross's admirably complete and well-arranged *Sources and Literature of English History* (2nd ed. 1915).

5. Tudor.—In the Tudor period several of the mediaeval sources of information cease to be available. For example, the chronicles dwindle away, giving place to formal histories such as Herbert's *Henry VIII.,* or to biographies such as Cavendish's *Life of Wolsey.* The records, moreover, change their characters. The *Rolls of Parliament* develop into the *Journals of the House of Lords* (1509) and the *Journals of the House of Commons* (1547). Further, the *Statutes of the Realm* for the first time become of primary importance, English superseding French as their language from 1485. But the immense increase of the power and competence of the central government under the Tudors involves the appearance of enormous new classes of official documents which soon dwarf the old ones in historical importance. These are, for the most part, included under the title *State Papers,* consisting primarily of correspondence of the government with its agents at home, or with its representatives abroad. These invaluable sources of knowledge are stored in the Public Record Office. Calendars, in two great series, one domestic, the other foreign, containing summaries of the more important information, are in rapid course of publication by His Majesty's Stationery Office. The series for the Tudor period is fairly complete. Besides the documents in the Public Record Office, however, there is a rich store in the British Museum. Many important collections of papers, moreover, exist in private hands, *e.g.,* the Cecil manuscripts at Hatfield House: good work in making the contents of these collections known to students has been done by the Historical Manuscripts' Commission, whose Reports are a mine of historical wealth. In the Tudor period, too, the Law Reports, beginning with Keilway's *Cases,* become regular sources of knowledge; they take the place of the mediaeval *Year Books.* It should be noted, moreover, that with the spread of printing, collections of historical materials, such as the *Chronicles* of Fabyan, Hall, Grafton, and Holinshed, popularized the study of history, provided writers like Shakespeare both with subjects for their works and with understanding audiences, and handed down to modern readers useful books of reference respecting mediaeval legends.

6. Stuart Period.—In addition to the sources specified for the Tudor period, the following may be noted. The struggle between monarch and parliament gave rise on the one hand to numerous unofficial reports of debates in parliament and to parliamentary diaries, and, on the other hand, to an enormous pamphlet literature. It is estimated that between 1640 and 1660 no fewer than 25,000 pamphlets were printed and circulated. Of these, two extensive collections are contained in (1) the *Harleian Miscellany* (1808–15), and (2) the *Somers Tracts* (1809–15). Numerous memoirs and autobiographies now begin to throw sidelights upon the course of history, *e.g.,* Gilbert Burnet's *History of My Own Time;* Clarendon's *Life,* and the famous *Diaries* of Samuel Pepys and John Evelyn. Contemporary biography, too, is valuable: *e.g.,* P. Heylyn's *Life of Laud,* and Mrs. Hutchinson's *Memoirs of the Life of Colonel Hutchinson.* Further, the letters of eminent men, such as Temple, Marvell, Halifax, and Sidney, are now available in large quantities, and mainly in printed and well-edited editions. Towards the end of the Stuart period, in the reign of Anne, the periodical literature, *e.g.,* the *Spectator,* becomes important.

7. Hanoverian.—In dealing with the period from 1714 onward the main difficulty is embarrassment of riches. All the official sources—statutes, state papers, journals, reports, etc.—are present in overwhelming masses. In addition, large and important collections of private papers exist, *e.g.,* the Newcastle papers in the British Museum. Much published correspondence also is accessible, *e.g.,* Lord North's correspondence with George III. The periodical literature is immense; to the magazines are added the files first of weekly, then of daily, newspapers. In 1759 the *Annual Register,* an invaluable record of contemporary events, began to appear. After the vindication of the publication of parliamentary debates in Onslow's case (1771), reports of speeches in the two houses became fuller and clearer. Before the end of the eighteenth century Cobbett's *Parliamentary History* supplied the fullest information: in 1803 it was merged in Hansard's *Parliamentary Debates,* the quantity of which leaves nothing further to be desired. Political writing continually increases in

importance as the Hanoverian period advances: the writings of Swift, Defoe, Bolingbroke, Johnson, "Junius," and Burke, are historical sources of prime interest.

8. Modern Period.—Of the sources for the period dating from the accession of Victoria to the present day, little need be said. All the materials which serve for the 17th and 18th centuries continue to exist and to increase in bulk; although, of course, for very recent times not all of them are yet accessible to the historical student. The main addition to the older sources is the long and valuable series of *Blue Books* and other Government publications, the fruits of special enquiries made by various committees and commissions. For the list of these the student should consult the *Catalogue of Parliamentary Papers 1801–1900* issued by P. S. King and Sons. The newspaper sources of information for the 19th century are made the more readily discoverable by the index volumes of *The Times* which run from 1803 onward.

Such, in briefest outline, are the principal original sources for the history of England. When we turn from these to the authorities by whom they have been used and in whose works they have been put to the best account, all that can here be done is to direct the reader to a few bibliographies where detailed information can be found. First, and most convenient, are the appendices to the twelve volumes of *The Political History of England,* edited by W. Hunt and R. L. Poole, and published by Longmans and Co., and the appendices to the seven volumes of *The History of England,* edited by Sir Charles Oman, and published by Methuen and Co. These may be supplemented by selected bibliographies in the *Cambridge Mediaeval and Modern Histories.* An older, but still serviceable, guide is S. R. Gardiner and J. B. Mullinger's *Introduction to the Study of English History* (3rd ed. 1894). The biographical articles in the *Dictionary of National Biography, The British Museum Subject Index* (covering acquisitions 1881-1925) and Sonnenschein's *The Best Books* (Part III., 1923) should also be consulted. Finally, mention should be made of the excellent bibliographical leaflets published by the Historical Association (22, Russell Square, London), and to the *Annual Bulletins of Historical Literature* issued by the same body since 1911.

(F. J. C. H.)

ENGLISH LANGUAGE. It is usual to divide English chronologically into three main periods of development—*Old English,* from the earliest records to about 1100; *Middle English,* from this date to about the first third of the 15th century, and *Modern English* from then onwards. The dates given for the limits of the Old and Middle periods are only approximate, and it is impossible to mark off, with precision, epochs in a process of change and growth which is continuous. It is sometimes convenient to subdivide more minutely into *Early and Late O.E., Early and Late M.E., Early and Late Modern,* but it is often preferable to refer to the characteristic features of a specific century as revealed in the records.

Documentary Records.—The documentary records of English extend over a period of more than 1,200 years, the earliest documents being charters, in Latin, but containing names of English persons and places, written in the closing years of the seventh, and the first few years of the eighth centuries. (*See* Charters i., ii., iv. and v., in Sweet's *Oldest English Texts.*) The Moore ms. of Bede's *Ecclesiastical History* (*c.* 737) not only contains very early forms of English names, but preserves also a few lines of verse in the Northumbrian dialect, said by the historian to be the opening lines of Caedmon's poem on the Creation, of which only this fragment has come down to us. Glossaries and charters form the chief sources of our knowledge of English derived from mss. of the 8th century and the great bulk of documents in the oldest form of English belongs to the 9th and 10th centuries.

English, as is clearly revealed by the language of these early documents, belongs to the West Germanic branch of the great Germanic or Teutonic family, itself one of the subdivisions of Aryan. Germanic (Indo-European) speech was brought to these islands during the 5th and 6th centuries of our era, by heathen invaders drawn from three main tribes, the Angles from what is still called Angeln, the Saxons, from the country north of the Elbe now called Holstein, and the Jutes from further south in the same region. These various tribes were designated collectively by the Britons as "Saxons," after the tribe with whom they first became acquainted, *cf.* Modern Welsh *Sassenach,* applied to Englishmen generally. Bede uses the phrase "Angli sive Saxones," implying that both terms mean the same thing, though he usually refers to the people of the country generally as *Angli,* to the language as *sermo Anglicus.* In the 9th and 10th centuries *Angel cynn* and *Engle* are used for the people, *Englisc* for the language, and *Englaland* for the country. On the other hand *rex Anglosaxonum, Angel seaxna cyning* are found in the 10th century. The term *Anglo-Saxon* seems to have been revived in the 18th century for the oldest form of English, and is still much used, though perhaps *Old English* is now rather commoner among students of the language.

Of the ancient West Germanic languages of the Continent, the most closely related to the dialects of the conquerors of Britain were first Old Frisian, then Old Saxon, that is the speech of the Saxons who remained in their old homes. The Old High German dialects are considerably more remote especially in phonological character, from Old English, owing partly to the comparative fidelity with which the former adhered to the old vowel sounds which the English changed to a remarkable degree, partly to the characteristic changes in the consonants which distinguish the High German type from all the other West Germanic dialects. Some authorities consider the agreements between Old English and Old Frisian sufficiently close to justify the assumption of an early period of development common to both, from which it is but a step to postulate an Anglo-Frisian branch of West Germanic which, as some believe, was subsequently differentiated into English and Frisian. To this it may be objected that the earliest Frisian mss. are several centuries later than the English, and that the supposed phonological unity may be illusory, and due to similar, but much later, and independent changes in Old Frisian.

The differentiation from the old West Germanic type exhibited by the English dialects in their oldest recorded forms, while foreshadowing already the tremendous new developments in the future, had not yet gone so far in the 9th and 10th centuries, but that the Old Saxons and the English must have been able perfectly to understand each other's form of speech. By one of those extraordinary pieces of good fortune by which the industry of scholars is occasionally rewarded, a fragment of Old Saxon poetry in a 9th century hand was discovered some 30 odd years ago in the Vatican library, which was recognized as being identical with a passage in a well known Anglo-Saxon poem dealing with the story of Genesis, long attributed to Caedmon. On comparing the Old Saxon fragment with the Old English, it was obvious that the one must be based on the other, and the internal evidence makes it certain that the Old English as we possess it, must be a translation from the Old Saxon. The following short extracts from both versions show how close the two languages were in vocabulary, specific poetic diction, in the characteristic Germanic compounds, in accidences, word order, and general structure. The differences in spelling between the two reflect phonological differences, considerable indeed, but not sufficient to render either language unintelligible to speakers of the other.

Old Saxon

nis hebanriki
not is the Kingdom of heaven
gilic sulicaro lognura; thit uwas alloro lando sconiust
like to such flames; this was of all lands the loveliest,
that wit hier thuruh unkas herran thank hebbian muostun,
that we two here through our Lord's grace have might,
thar thu them ni hordis, thie unk thesan haram giried,
where thou to that one (him) not heard (obeyed), who for us two this calamity has decreed
that unit nualdandas nuord farbrakun
In that we two the ruler's (wielder's) word have violated (broken)
hebankuningas
the heavenly King's

Old English

nis heofonrice
is not the Kingdom of heaven
gelić tham lige: ac this is landa betst
like to this flame: but this is of lands the best

þæt wit þurh uncres hearran anc habban moston
that we two through our lord's grace have might,

þær þu þam ne hierde, þe unc þisne hearm geræd
there thou to that one (him) not heard who for us two this calamity has decreed

þæt wit waldendes, word forbræcon
in that we two the ruler's word (command) have broken

heofoncyninges
the heavenly King's

EARLY DIVISIONS OF ENGLISH

Dialectical Differences.—The different Germanic tribes which gradually overran Britain spoke, already in their ancient homes, dialects which were to some extent differentiated, and doubtless these differences were enhanced by the circumstances of political and geographical separation incidental to the settlement of a country of the size and physical character of Britain. But the dialectal differences of the Old English period do not amount to much. These differences consist chiefly in a slightly various development of the original West Germanic vowel system. This variety was rich in potentialities of later differences, rather than important in the 10th and earlier centuries. It could certainly have formed no bar to social intercourse. The old records enable us to distinguish four main dialectal types—the Northumbrian; Mercian; Kentish; Saxon.

Northumbrian and Mercian, which have much in common, represent the speech of different tribes of Angles, and are often referred to together as Anglian. Mercian was spoken in the greater part of the area between the Humber and the Thames; it is, speaking generally, the dialect of the West Midlands. From the Mercians (Mierce) a group of Anglians are definitely distinguished by name as East Anglians (Eastengle) who settled Norfolk and Suffolk. Unfortunately the dialect of East Anglia is hardly recorded before the Norman Conquest, but the copious remains of this type from the 12th century onwards show marked differences from the West Midland type.

Saxon Settlements.—The Saxons settled the whole country south of the Thames with the exception of Cornwall which remained Celtic, part of Hampshire and the Isle of Wight and Kent, which were settled by Jutes. Certain areas to the north of the Thames were also Saxon territory, namely Gloucestershire, Worcestershire, south-west Warwickshire, and, as the names themselves imply, Middlesex (Middlesexe, "Middle-Saxons") and Essex (Eastsexe, or "East Saxons").

Of the dialects of the Middle and East Saxons not enough is preserved in pre-Conquest documents to furnish data for a clear conception of their linguistic character, but from King Alfred's time onwards, West Saxon is recorded in the most considerable prose texts of this early period, and a form of Saxon, sometimes known as the Saxon Patois, is preserved in a collection of homilies, and some glosses of the 10th century. This latter dialect has some features characteristic of West Saxon, and others characteristic of Anglian, and is probably the dialect of Worcestershire. Kentish, preserved in various charters, glosses, and two sets of verses of no literary merit, covering the period from the late 7th to the 10th century, shows quite distinctive dialect features which mark it out, from the beginning, on the one hand from West Saxon, and on the other from Mercian.

The English, together with other ancient Germanic peoples, originally made use of the Runic alphabet (*see* RUNES), which speedily gave place to a form of handwriting which, with certain modifications, persisted during the whole Old English period. This was a special adaptation of the Roman alphabet in use among the Irish, and taught to the English by Christian missionaries from that nation. The age of the surviving English Runic inscriptions is uncertain, and most of them were probably, some of them certainly, produced at a time when the ordinary writing was already in use.

The Roman or Irish alphabet was soon rendered more suitable for expressing the sounds of English by the introduction of the Runic symbols þ ("thorn") for *th* and ƿ ("wēn") for *w*, for which *th* and *uu* were written in the earliest English records.

Old English Spelling.—The spelling of Old English is fairly consistent and represents, on the whole, an attempt to render the actual sounds as far as the alphabet, somewhat inadequate for its purposes, will permit. The characteristic vowel sound, approximately that in present-day English *cat*, is rendered by *æ*, a combination of *a*, and *e*; marks of quantity are used in many mss. though by no means consistently, and sometimes a vowel symbol is doubled to express length. Doubling of consonant symbols is consistently carried out to express a long, or double, consonant sound. On the other hand the symbol ʒ or ʒe is used to express at least three sounds, the stop *g*, and the back ("guttural") and front ("palatal") open consonants or spirants. Similarly *c* is used for the *k*-sound, and for a front ("palatal") stop which subsequently became "ch" as in *chin*.

The chief changes wrought in the West Germanic sound system in the dialects of Old English were in the domain of the vowels. As a result of isolative tendencies, the West Germanic *ā* became *ǣ*, *ă* became *ǣ*, the old diphthongs *ai*, *au*, *eu*, became respectively *ā*, *ēa*, *ēo* in O.E. Among characteristic English changes due to the influence of neighbouring sounds, may be mentioned: the diphthonging (fracture) of old *ǣ*, *ĕ*, *ĭ* to *eă*, *eŏ*, *iŏ* before certain consonantal combinations, and, in varying degrees in different dialects, also when followed by *o*, and especially, by *u*, in the next syllable (*u*-mutation); the fronting, or palatalizing of back vowels (*ā̆*, *ō̆*, *ū̆*) when originally followed in the next syllable by *i* or *j* (*i*-, or *j*-mutation). The old Germanic stress upon the "root" syllable of words was retained, and the vowels in the unstressed, inflexional syllables were consequently weakened and altered from their original sound. This weakening of unstressed vowels had advanced very far before the end of the O.E. period, and in Earliest Middle English had obliterated the earlier distinction between *a*, *e*, *u*, which are first confused, and then levelled under one sound which is written *e*.

OLD ENGLISH INFLEXIONS

The inflexions of Old English are of the typical Germanic and West Germanic character. Grammatical gender is preserved and the definite article, an old demonstrative, is fully inflected in singular and plural of all three genders. In addition to the case distinctions exhibited also by nouns, the article still preserves the old instrumental. The nouns retain traces of the oldest declensional types inherited from Aryan, but the best represented are the masculine and neuter *-a*-stems, and the feminine *-ō*-stems. In addition to the vowel stems the old *-n*-stems are very common. The *-n-* (weak) declension is also found in adjectives when preceded by the definite article or by a possessive pronoun. The comparative of adjectives ends in *-or*, *-er*, and the superlative in *-ost*, *-est*. The personal pronouns of the first and second person and of the third person singular feminine, agree with those of other Germanic languages, but the forms of the third person masculine and neuter—*hē*, *hēo*, *hit*, etc., differ from those of O.H.G., Gothic and O.N., but agree with the O.Fris. and O.Sax. forms, and are derived from an Aryan demonstrative *ki-*, etc., and traces of which are found in Gothic *hita*, "this," neuter *himadaga*, "this day," *cf.* O.E. dat. masc. and neut. *him*, and in *hina-dag*, "this day," *cf.* O.E. *hine*, acc. masc. O.E. agrees with other old Germanic languages in having two main types of verbal inflexion to express past time, the "weak" which form the Pret. and P.P. with the suffix (O.E. *-de*, *-ede*, *-ode*, and *-ed*, or *-od*), derived ultimately from an Aryan base, **dhē*—,"to put, place," seen in Greek τί-θη-μι and in English *do*, and the so-called "strong" conjugation, in which an alternation of vowels occurs according to the principles of Aryan and Germanic *Gradation*, *e.g.*, inf. *sprecan*, "to speak," Pres. *ic sprece*, "I speak," Pret. Sing. *spræc*, "I, he, spoke," Pret. P. *spræcon*, the same type occurring also in *spræce*, "thou spakest," P.P. (*ge*)*sprecen*; Inf. *cēosan*, Pres. *cēose*, etc. Pret. Sing *cēas* (Sec. Pers. *cure*) Pret. Pl. *curon*, P.P. (*ge*)*coren*.

The personal endings of verbs agree generally with Germanic and Aryan. The *-t* usual in the ending of the Second Person Singular is not original but derived from the following pronoun, in inverted constructions such as *liofast þu*, "livest thou," etc. O.E. agrees with other Germanic languages in having certain anomalous

auxiliary and preterite-present verbs. In the verb "to be" *eom*, "am," shows a trace of the old verbs in *-mi*, the Pret. *wæs*, "was," *wǣron*, "were," is common to all Germanic tongues. The same is true of *sċeal*, "shall," *sċeolde*, "should"; *cann*, "can" (Pres. Pl. *cunnon*), Pret. *cūþe*. *Wāt*, "I know," Goth. *wait*, cognate with *οἶδα*, has Pl. *witon*, Pret. *wisse* from Aryan **wid-tho* which shows the same gradational form as Greek *ἴδ-μεν*.

Vocabulary.—The vocabulary of O.E. is essentially West Germanic in character, and practically identical with that of O. Sax. and of O. Frisian. A certain number of Latin words had already been incorporated into O.E. during the Continental period, and indeed before the differentiation of West Germanic speech, as is proved in many cases by the forms, and by their occurrence in other West Germanic languages. Among words of this class, which still survive in English are *strǣt*, "paved road, street," Lat. *strāta (via)*; butere; Lat. *būtyrum*, from Greek Βούτυρον, "butter"; *ċiese*, *ċēse*, Lat. *cāseus*, "cheese"; *mynet*, whence *mint*, "a coin," Lat. *monēta*, "a coin, money"; *ynċe*, "inch," Lat. *uncia; pund*, "poundweight," Lat. *pondus*, "a weight"; *mil*, "mile," Lat. *milia; win*, "wine," Lat. *vinum*. A second small group of words in O.E. was derived in Britain from the Latin-speaking inhabitants of the towns.

Some of these forms show that changes characteristic of Late Popular Latin, or Romance, had already taken place before the borrowing into English. Examples are:—O.E. *cæfester*, "a halter," Lat. *capistrum; prāfost*, "officer, provost," Lat. *praepositus; cugele*, "monk's cowl," Lat. *cuculla; cylene*, for Lat. *colonia*, occurs in an old form of the ending of *Lincoln*, which exhibits traces of characteristic Celtic modifications in the Latin word, as well as the later O.E. process of *i*-mutation. The former made **colōn* into **colin;* the latter turned this into **culin*—whence *cylen(e)*. The common O.E. *ċeaster*, *ċæster*, originally applied to a Roman fortified town, then to a town or city in general, from Lat. *castra*, which survives in *Chester*, *Winchester*, etc., shows three typical O.E. sound changes—the fronting of *ă* to *æ*, the fronting of the initial consonant, and, in the W. Sax. form, the diphthonging of *æ* to *ea* after this consonant.

During the 6th and 7th centuries England was converted to Christianity, and through the Roman missionaries a fresh stream of Latin words less popular in character and form, was introduced —*sācerd*, "priest," from *sacerdos; discipul*, from *discipulus; munuc*, "monk," from *monachus; pāpa*, "Pope"; *martyr; crēda*, "creed," from *credo; ælmesse*, "alms," from *alimosina; mæsse*, "the Mass," from *missa*, and many others. Equally interesting and important are the new applications and adaptations of old native elements for the expression of Christian ideas. Thus *hūsl*, "sacrifice," *cf.* Goth. *hunsl*, is applied to the eucharistic sacrifice, and survives in the now archaic verb *to housel; sċearu*, "cutting, shearing," formed from the base of *sċieran*, "to cut, shear," is applied to the ecclesiastical tonsure; *fulwian*, "to baptize," from earlier *full*, "complete, full" and *wīhan*, "to make holy, consecrate," together with the noun, *fulluht* and *fulwiht*, "baptism." Other examples of adaptation are *hūsl-þegn*, "acolyte," lit. "housel servant, or thane"; *godspellere*, "gospeller," perhaps originally a literal translation of Lat. *evangelista*, though the first element was later probably identified with the word *God*.

The number of Celtic loan-words in O.E. is astonishingly small. The word *riċe*, "rule, dominion, kingdom," must be a very early Primitive Germanic inheritance, since it is found in varying forms in Gothic and Scandinavian, as well as in O. Sax. and O.H.G. and its *k* (as in Goth. *reiks*) shows that it must have been borrowed as **rig-* from a Celtic source, before the characteristic Germanic "shift" of voiced to voiceless stops. The O. Irish is *rī*, Gen. *rīg*, cognate with Lat. *rēg-*, "king," as in *rex*, Gen. *rēg-is*. The English word survives only in *bishop-ric*.

EARLY ENGLISH BORROWINGS

Although the English acquired no inconsiderable number of Latin words from the Romanized town-dwellers of Britain who spoke Latin, it is remarkable that they borrowed hardly any Celtic words from the country-dwelling Britons who had retained their own language. O.E. *dunn*, "brown, dun-coloured," and *binn*, "a manger," Mod. Eng. *bin*, are probably among the few words borrowed from the native speech of the Britons. *Dūn*, "hill, a down," is Celtic, but may have been borrowed in Continental times. O.E. *drȳ*, "wizard sorcerer," is from O. Irish *drui*, "soothsayer," and derived from the Irish missionaries to the north of England. The English *druid*, a late word, is from Lat. *druidae*, itself borrowed from a Celtic cognate of *drui*. Although the archaeologists are divided on the question, it seems probable that the humbler classes of Britons, speaking generally, were neither completely exterminated, nor all driven away, but rather that many were gradually absorbed into the English population. It was formerly widely held that in such names as *Walton*, *Walcot*, and others the prefix was derived from O.E. *weala-*, Gen. Pl. of *wealh*, "foreigner, Briton," later often used in the sense of "serf," especially "British serf," and that such place-names implied the existence of villages or homesteads where groups of Britons were allowed to remain, and live separate from their English conquerors. This view is now largely discredited, and the linguistic evidence derived from the earliest forms of the greater number of the *Wal-* names, as well as other considerations, makes it more likely that the prefix is O.E. *weall*, "wall," a word used in various senses, and possibly in place-names, implying a boundary wall or a sea wall, or embankment. (*See* Zachrisson, *Romans, Kelts and Saxons in Ancient Briton*, Uppsala, 1927, pp. 39, etc.) But whatever the truth in this matter, whether the Celtic speaking Britons were wiped out, or driven to the western borders; whether they were here and there permitted to dwell in communities segregated from the English, or, on the other hand, were gradually absorbed by marriage, the fact remains that their language has left no appreciable mark upon that of the conquerors.

A certain number of Celtic words referring to geographical features are found in place-names scattered in many parts of the country. A few of these may be mentioned. *Pen*, "head, top, hill, top of a hill," in *Pendledon*, *Penhill*, *Pentridge*, *Penburg*, etc.; British *cronkā*, "hill," *cf.* Cornish *cruc*, Irish *cruach*, variously modified in O.E. to *cric*, *ciric*, *cyrc*, etc., and appearing in Mod. English as *Crich*, *Crook*, *Creech*, *Church*, etc.; British *keto*, "wood," *cf.* Welsh *coed*, in Modern *Cheetwood*, *Chetwood*, *Cheetham*, *Chute*, *Chettle*, O.E. *cēthyll*, and so on (*see* Zachrisson, *op. cit.* pp. 47, etc.).

Scandinavian Element.—The Scandinavian element may be treated here since the O.E. period was that in which these words passed into English speech, although they appear only in inconsiderable numbers in our records before the Norman Conquest, and it is not before the 12th century that they become really numerous and then chiefly in the Eastern dialects and not until later still that certain of them become essential elements in English of other areas. About 790 a long series of raids and piratical incursions on our coasts began, carried out by Danes and Norwegians. Later, much larger hosts landed upon English shores whose aim was not casual piracy but serious conquest, and in 851 the "heathen" first spent the winter in England. After much fighting in which the English had the worst of it, by 877 or so, the invaders had obtained a firm grip on the whole of Northumbria, and a great part of eastern and central Mercia. In January 878, a fresh onslaught was made by the Danes on Wessex, from which they had been repelled in the previous year. For a time there was panic among the English, and the fortunes of Wessex and its royal house were trembling in the balance. During the third week of March, however, the nobles of Devonshire inflicted a decisive defeat upon the invaders in that country, and a month later the great king Alfred, at the head of an army composed of the levies from Somerset, Dorset, Wilts and Hampshire, gave battle to the main Danish army at Eddington in Wilts, and after a fiercely contested struggle, completely routed the enemy. The fighting strength of the Danes was utterly broken, and their chief Guthrum was constrained to withdraw entirely from Wessex, and he and many other leaders accepted Christianity and were baptized. The invaders departed eastwards and occupied East Anglia and Essex.

Within the vast area now settled by Scandinavians it is probable that the two populations, English and Danish, were first separate, each speaking their own language; gradually a fusion of peoples

took place, and there was a time when the inhabitants were bilingual. Then English remained as the sole tongue, but profoundly affected in vocabulary, and to some slight extent also in inflexions by Danish.

The later invasion of England by Svein in 1013 led to the flight of the English king, Ethelred, to Normandy. After the sudden death of the Danish leader came the election of his son Cnut as king of the Danes. Ethelred died in 1016 and was succeeded by his son Edmund Ironside as king of England. The English and Danish kings made an agreement whereby the country was divided between them, but a year later Edmund died and Cnut became king of the whole land. Danish kings ruled England till, on the death of Cnut's son Harthacnut in 1042, another son of Ethelred, Edward, later known as the Confessor, came back to the throne of his ancestors. Such very briefly were the historical events which led to a very deep penetration of our language by Scandinavian influence in many areas, and introduced innumerable words into the English vocabulary of everyday life.

The language of the Danes and Norsemen of the O.E. period, although belonging to a different branch of Germanic, was still so like English that hundreds of words in both were almost identical in form and meaning. In spite of many important differences the two peoples can have had little difficulty in understanding each other. As Jespersen remarks (*Growth and Structure of English*, p. 64), if we had no remains of English before the Conquest, it would now be quite impossible to tell, in regard to a large number of common words, whether they had come down to us from the O.E. native tongue, or had been borrowed from the Danes. He gives as examples among others, *man, wife, mother, folk, house, thing, will, can, meet, come, see, stand, sit, full, wise, will, better, mine, thine, over, under*, etc. All of these are, as a matter of fact, pure English and are found in the oldest sources, but had they been Scandinavian their forms would hardly have been different. Among undoubted Scandinavian words found in pre-Norman times, are several for special kinds of ships—*sicġþ, cnearr, barda; ōra*, the name of a Danish monetary unit; and the Anglicized (W.Sax.) *ċeallian*, "to call, shout," the later form of which is nearer to the original *kalla*. It is probable that O.E. *lagu*, "law," is an early borrowing, through a common word in O.E., by the side of the purely native *ǣ (w)*. *Hūsting, hūsþing*, "council, meeting," also raised dais, occurs in the latest O.E. period.

During the 12th and 13th centuries Norse words appear in large numbers in texts from the north, and from the east Midlands. From the latter area many gradually penetrated into the speech of London, and survive to this day in standard English, while hundreds more survive in local dialects.

In some instances the Scandinavian words have completely ousted the native words expressing the commonest ideas or objects, or have become more current than the former. In some cases both English and Scandinavian words are in use with differentiation of meaning. Examples of complete supersession in common words of native words by Scandinavian, are *sky* for O.E. *lyft, uprodor*, etc.; *die*, verb for O.E. *steorfan, sweltan, starve*, surviving in a specialized sense, the new verb being closely associated with Eng. *dead* and *death; take—took*, O.N. *taka, tōk*, for native *niman; fellow* for O.E. *ġefēra; knife* for *seax; leg* for O.E. *sċeanca*, "shank"; *low*, adj., for O.E. *niþer-, neoþoric; window* for O.E. *ēag-þyrel*, literally "eye-hole," or *fenester* from Latin; *egg*, for O.E. *æġ*, pl. *ǣgru*, M.E. *ēi, ēy-ren; awe* for O.E. *eġe*, "fear," M.E. *eie*. The following are Scandinavian and native English respectively, with differentiation of usage: *ill—sick; skirt—shirt; trigg—true; skin—hide; root—wort*. Sometimes where forms in the two languages bore a close resemblance, the English type has disappeared in favour of the Scandinavian. Thus *give* instead of O.E. *ġiefan, ġefan*, M.E. *ȝive, ȝeve; get* instead of O.E. *-ġietan* (which only appears with the prefix *and-, be-, for-*, etc.), M.E. *ȝēte; sister*, O.N. *systir*, instead of O.E. *swestor*, M.E. *swester, swuster, suster*, etc.

Often the Scandinavian word has imparted its meaning to its English cognate:—*brēad* in O.E. meant "crumb, morsel," while in M.E. and Mod. Eng. the sense is due to O.N. *brauþ*; O.E. *dream* meant "joy," but the word is used in M.E. as now with the same sense of O.N. *draumr;* O.E. *plōh* was a measure of land, but O.N. *plōgr* was the implement with which land was broken up for sowing, a meaning transferred to the present-day *plough* which has dispossessed O.E. *sulh;* O.E. *eorl* was originally "a man of noble birth, a gentleman," but it gradually acquired the sense of Scandinavian *jarl*, a title applied to the governor of a province, corresponding to O.E. *ealdormann*, and later still the name of a grade in the peerage corresponding with Fr. *count*. The English *þeigh* was ousted by *þouh*, "though"; in some eastern dialects of M.E. Scand. *oc* is found for O.E. *eac*, "also, and"; Norse *kettle* has taken the place of English *"chettle,"* O.E. *ċ(i)etel*.

The English borrowed from the Danish settlers a certain number of words expressing legal ideas, and some names of territorial divisions and kinds of jurisdiction. Thus *wapentake*, O.E. *wæpnageťæċ*, from O.N. *vapnatak;* O.E. *hāmsœn* from O.N. *heimsokn, "house-breaking,"* and the punishment for this; *þræll*. "thrall"; *North-, East-, West-riding* (Yorks) from O.N. *þriþjūngr*, "third part"; *By-(law)*, and the same element in *Derby* and other place-names, from Danish, meaning "town, village."

Perhaps the most remarkable fact connected with Scandinavian influence on English, is the gradual introduction of the O.N. pronouns of the third person plural, *they, their, them*, which have finally entirely superseded the native *hir, her, hem*, except for the colloquial survival *'em*. This process was no doubt facilitated by the use of the plural forms of the O.E. Def. Art.*þæra,þæm*, in much the same way.

In concluding this account of the O.E. period, two important facts call for mention. The first is the use of West Saxon from the 9th century onwards as a common literary standard. This was due to the hegemony of Wessex established by King Alfred and his successors, to the great king's zealous activities in the cause of education, his own copious writings, and the decay of the ancient learning in Northumbria. The great bulk of O.E. literature, both verse and prose, has survived only in a West Saxon form, and later local documents such as the boundaries in land-charters are written mainly in this dialect, with only an occasional typical local form.

The other characteristic feature of O.E. is the existence of a peculiar and highly developed poetic diction. Not only is there a large number of words whose use is confined to poetry, but we find a most elaborate system of metaphorical expressions and roundabout ways of referring to such things as the sea, the sun, ships, the sky, battle, a prince, a sword, the human body, and so on. Many of these become stereotyped and recur again and again; some of them are purely conventional and have no particular poetic value, while others are vivid and bear the impress of the poet's individuality. (*See*, on this, Wyld, "Diction and Imagery in Anglo-Saxon Poetry," in Vol. vi. of *Essays and Studies* by Members of the English Association, Oxford.)

MERGING OF OLD AND MIDDLE ENGLISH

It is not to be supposed that English underwent no change in phonology and accidence during the O.E. period. On the contrary, many of the features which are characteristic of M.E. were, gradually but surely, coming into being during the centuries before the Norman Conquest, although, owing to the rigidity of scribal tradition prior to this event, the language of the 11th century still continues to be spelt, as though no important change had taken place since the days of Alfred. But in spite of the fetters of convention, the vigilance of the scribe is occasionally relaxed, and scattered spellings in which the writer lapses for a moment into something like a faithful record of pronunciation, allow us to perceive that the vowel usually written *æ* had become *e*, that the diphthong *ea* had been monophthongized to *th*, and in eastern areas *eo* had become *e*, and that in unstressed syllables, the vowels *u, a, o, e*, were no longer distinguished in pronunciation. Less than 100 years after the Conquest, it is evident from the chaotic spellings of the latest entries in the Peterborough *Chronicle*, which ends in 1154, that the old scribal rules were but dimly remembered, at least in this East Midland area. On the other hand, it is possible, in spite of the numerous orthographic inconsistencies of this ms., to arrive at a fairly clear view of the sounds of the dialect, and it is evident that the new era in Eng-

lish speech has begun. It might indeed appear as if greater changes had come about in the 90 years since the Conquest, than during the whole period covered by the records before the death of the Confessor.

In reality no such rapid development has taken place, and the discrepancies in spelling, accidence and syntax between this part of the *Chronicle* and "pure" Anglo-Saxon of the latest pre-Conquest type, are due to the fact that the written documents had ceased for centuries to give a true picture of the language as it was actually spoken, while the Peterborough ms. is a pretty faithful record of living speech. There was, indeed, no break or sudden upheaval in the development of English caused by the Norman Conquest, and it is probable that apart from the vocabulary, our language would have developed into its present form, if that great historical event had never happened. So far as prose is concerned, the old purely literary tradition largely perished through the removal of English clerics and scholars, and a new style, based upon the spoken language, had to be formed.

Retention of Old Spellings.—English texts from the 12th to about the middle of the 13th century often retain O.E. spellings, especially when, as in some homilies and chartularies, the scribe had older documents under his eye which he copied or adapted, but the spelling is not consistent, the symbols, while occurring in their old places, are also put to new uses, and we find new and phonetic spellings by the side of the old stereotyped mode of writing. It is a period of scribal experiment. Owing to the tentative and unsettled character of the spelling, this is often regarded as a transition period between O. and M.E., as though the spelling faithfully reflected processes of change active in the language itself. Apart from the obvious fact that every age is one of transition, it would probably be more just to suppose that in actual speech the passage between the two epochs had long been made, that most of the characteristic phonological features of M.E. had already developed, although the scribes had not yet hit upon a fixed and consistent manner of expressing them.

One of the most enterprising spelling reformers of this age is one Orm, apparently of Scandinavian stock, the author of an exceedingly tedious scriptural metrical paraphrase of over 20,000 short lines, himself the scribe of the unique ms. This writer, whose work was, for sufficient reason, evidently not much in demand, hit on the plan of doubling a consonant after a short vowel, which makes his book valuable to the modern philologist as one of the chief authorities on English quantities round about the year 1200. He also invented a special form of the letter *g* to express the initial sound in *good.* Yet Orm does not recognize in his spelling the change, which by his time had certainly come about, of O.E. *ā* to *ō*, *e.g.*, O.E. *hām*, M.E. *hōm*, "home," and he adheres to the use of the O.E. symbol *ae* to express a long vowel in words where it is quite misleading as expressing the pronunciation of his own dialect.

During the later part of the 13th and the early part of the 14th century, English spelling gradually became more or less fixed, and the sounds are written in the various great dialectal areas, with fair consistency, to express the several characteristic regional types. English spelling was really benefited by the adoption of several symbols and graphic devices from Norman scribes, such as the Continental form of *g* to express a stop, leaving *ȝ* the modification of the O.E. symbol, free for the expression of the *y* (consonantal) sound for which *g* is also used; the use of *qu-*, as in *queen*, etc., instead of O.E. *cw-*; the use of *v*, or *u* instead of O.E. *f*, to express a voiced sound as in *over, ouer* for O.E. *ofer; ou* instead of *u* to express the vowel in O.E. *hūs*, "house"; the Fr. symbol *u* instead of O.E. *y* for the sound in O.E. *hyll, hȳdan*, "hill, to hide," etc. (that of Mod. Fr. *u*); *o* instead of O.E. *u* for the sake of clarity when the surrounding letters were *n, m, w*, e.g., *sone*, "son," for O.E. *sunu.*

In Fr. *c* before *i*, etc., expressed the *s-* sound, and this was sometimes written also in words of native origin, *e.g., seldcēne*, "rare," etc., and it still survives in *mice.* Since *c* to Norman eyes would, or might, imply *s* before *i* and *e*, *k* was written to prevent ambiguity where O.E. had usually *c*, in such words as *kin, kēpen*, O.E. *cynn, cēpan*, "kin, keep," etc. The sound expressed in O.E. by *cg*, as in *bryċġ*, "bridge," was written *gg, dg*, in M.E., and the front consonant written *c* in O.E., which occurred before original front vowels, was written *ch*, and later *cch, -tch*, medially or finally, *e.g.*, O.E., *ċin*, "chin," *ċeorl*, "churl," *ċeac*, "jaw," *sēċean*, "seek," *tæisan*, "teach," *wreċċa*, "exile, wretch," O.E. chin, *cherl, chēke, sēchen, tēchen, wrecche*, etc. The sound, or its forerunner, expressed by *sc* in O.E. was written *sch, sh*, O.E. *sċeal*, "shall," M.E. *s(c)hal*, O.E. *wȳsċean*, "to wish," M.E. *wis(c)hen*, etc.

These innovations in spelling, however, do not indicate changes in pronunciation. On the other hand the language of the M.E. period is distinguished from that which precedes it by many notable changes in phonology. The chief of these may be briefly summarized. O.E. *ā*, as already stated, was rounded, and acquired a sound, written *o*, or more rarely, *oa*, resembling most probably the vowel now heard in *saw.* This change took place in the dialects of the midlands and the south, but in the north, O.E. *ā* was fronted, whether long or short, to a sound which by the end of the 13th century, was probably approximately that of Fr. *é.* The diphthongs *ea* and *eo* were monophthongized—the former to a sound, not very different from that heard in Fr. *tête*, the latter to a vowel like that in Fr. *peu*, which subsequently was unrounded to *é*, long or short, in the more easterly dialects of the south and South Midlands, while farther west it remained a round vowel, and was later raised to a sound like that of Fr. *pu.* O.E. *ăe* in the Midlands, for the most part, and in Essex, was retracted to *ă*, while in Kent, Middlesex, and parts of the South-West midlands it was raised to *ĕ*. The corresponding long vowel became *ā* in Essex and a limited area in adjacent counties, but, in those dialects in which it had not, already in O.E., become *ē* (=sound of Fr. *é*), it appears to have passed into the vowel heard in Fr. *père.* O.E. *ȳ̆* (=Fr. *u*) was unrounded gradually to *ī̆* over a large area, a process which probably began in O.E. itself in the East Midlands, and spread west and south, while in many westerly areas of the south and Midlands, it appears to have retained for centuries later its old sound, and as stated above, was written *u* in M.E.

New diphthongs developed from the O.E. combinations *-ŏh, -ăh-, -ā̆eg-, -ā̆eh-, -ĕh-*, which became respectively *-ouh-, -auh-, -ei-, -eih-.* The diphthong *ēi* was monophthongized to *ī* over a wide area, in some regions of the south-east, as early as the 13th century. Great changes were wrought in the external form of English by a lengthening process which affected *ă, ĕ, ŏ* in open syllables (those not "closed" by a consonant) so that *bĕran*, "to bear," became *bēren, brŏcen*, P.P. became *brōken*, and *tăcan*, "take," became *tāken.* These changes were extremely important for the later history of English, since, while M.E. short vowels underwent comparatively little change, the long vowels were subsequently completely altered in character. Before double consonants, and most combinations of consonants, long vowels were shortened. This fact also had considerable effect upon the outward complexion of the language. For instance O.E. *fēdan*, "to feed," had a Pret. *fēdde.* In M.E. the long vowel remains in *fēden*, but is shortened before *-dd-* in *fĕdde*, which explains the difference between the present-day *feed—fed*, and similar shortening in dozens of other weak Prĕterites.

GRAMMATICAL CHANGES

The changes in accidence can only be very briefly summarized here. The decay, as it is often called, in the inflexional system of O.E., and the levelling out of older distinctions, was primarily due, not to the Norman Conquest, but to a tendency which continues to this day, and is a deep rooted characteristic of English, to obscure vowels in unstressed positions.

The elaborate inflexions of the definite article gave way very early in the north and Midlands before the newly-formed invariable þe used in all cases, genders and numbers. By the middle of the 14th century, except in a few rare survivals, the old inflected forms had everywhere disappeared. Nouns retain, after the earliest period, no case distinctions except the possessive, which was formed according to the commonest O.E. type, in *-es.* A certain number of scattered survivals of feminine possessives without *-s* occur throughout M.E., and into the 16th century; a few fossilized

forms such as *Lady Chapel* still persist. The main plural type of inflexion for nouns in M.E. is *-es*, though in some southern dialects weak plurals in *-en, -yn*, are fairly frequent, and sporadic forms such as *soweyn, Halwyn, applen*, etc., are found in late 15th century texts. A few examples of mutated Pl.—*tooth—teeth, mouse—mice*—still survive to the present time, and in M.E., a few others survive here and there—*gēt*, "goats," the rare M.E. *bēch*, "books," *kȳ*, "cows," etc. In O.E. neuter words consisting of one long syllable had no ending in the Nom. and Acc. Pl., and a few of these invariables such as *sheep, deer, swine* (now felt as a collective) survive, but as late as the 15th and 16th centuries, *thing, horse, apple, thank, year*, etc., are not infrequent in the plural.

The case-endings of adjectives are for the most part levelled under *-e* in M.E. Scattered survivals of the old strong endings are found, however, into the 13th century and even later in some areas, *e.g.*, Acc. Sing. Masc. *mucelne*; Dat. Sing. Fem. in *-re*; Dat. Pl. in *-en* after prepositions; Gen. Pl. in *-re*. Chaucer has occasionally *aller*, O.E. *ealra*, Gen. Pl. and fossil forms such as *alderbest*, etc.; *allermost* is found in the 15th century. The weak suffix *-en* hardly persists after the 12th century in adjectives.

Adoption of Scandinavian Forms.—The gradual adoption of the Scandinavian forms *they, their, them* in place of the native forms has already been noted. A curious form *his* in O.E. is used as an Acc. Pl. in the Third Pers. Masc. in 13th century texts, especially in S.E. Midlands, the south-east and in Middlesex; in Kent as late as the first half of the 14th century. The O.E. Acc. Sing. Masc. *hine*, is found as *hine, hin* into the 13th century, and survives to-day as *'en*, in many provincial dialects. In M.E. its place is taken by the Dat. *him*. The old Fem. *heo* remains as *heo, he, hue*, etc., in the south right into the 15th century, but in the north-east Midlands, and by Chaucer's time in the London dialect, it is superseded by *scho, sche, she*. Peterborough *Chronicle* already has this pronoun, written *scæ*. The origin of this form has not been satisfactorily established. The Possess. Fem. is *hire, here*, or in those dialects which use *hue* for Nom. Fem., *hure*. Some texts distinguish between *hire*, "her," and *here*, "their," but many use both forms indifferently. *Hir* or *her* is used generally for the Acc. Fem., though a few texts use *hi* for this. The Neuter *hit* is found with the aspirate as late as Queen Elizabeth's letters, though *it* is frequent from early M.E. onwards. The Possessive Neuter is *his* right into the Modern period, *its* being apparently first recorded in the first third of the 17th century. All the pronouns had weak forms without *h-* in unstressed positions, *e, im, er, it*, occurring very early. The Duals *inc* and *unc* are still used in the 13th century. In the Sec. Pers. *ȝē*, "ye," is used in the early 14th century in respectful address of a single person. In the Pl. *ȝē, ye* is strictly confined to the Nom. and *you* to the Acc. and Dat. until about the middle of the 16th century, when many writers begin to use the forms indiscriminately.

The main differences between O. and M.E. in the forms of strong verbs, apart from the normal qualitative and quantitative changes in the vowels, arise from new analogical formations, as when a verb is influenced by and assimilated to those in another gradation class, *e.g.*, P.P. *spōken* instead of *spēken* through the influence of *brōken*, or when a simplification of forms takes place, as in the difference between Pret. Sing. and Pl. is eliminated, both forms taking either the type of the Sing., or of the P.P. Such distinctions are *fōnd*, Pret. Sing. "found," *founden* Pret. Pl.; *can*, Sing., *cunnen*, Pl.; *rōd* Pret. Sing. of *rīden*, "to ride," *rīden*, "they rode," etc., still survive in Chaucer.

The possibilities for new analogical formations in the strong verbs are very numerous, and common verbs such as *give, get, bid, choose*, have an enormous number of variant forms in M.E. and Early Modern. The history of these and many other strong verbs demands individual treatment.

The personal endings of the verbs undergo little change in M.E. One novelty is the gradual elimination of *-eth* in the Third Sing. Pres. in favour of *-es*. The latter can be traced to O.E. *-as* in the north, but during the 14th century is fairly common in the more northerly areas of East Midlands and to a certain extent in Norfolk. It is doubtful whether the *-s* in Third Pres., which later appeared also in the London dialect, and during the 16th century in standard and literary English, can be traced to this source, and whether it may not rather be due to the analogy of *is*. The *-s* form was certainly colloquial in origin and was felt as unsuited to the most exalted prose style in the 16th century, though in poetry it is frequently used, by the side of *-eth*, for metrical reasons. A Pres. Pl. in *-en*, in place of older *-eþ*, was found on the analogy of the Subjunctive or of the Preterite and became typical of the Midland dialect. This form appeared to be getting the upper hand in London texts by the middle of the 17th century, and later became the sole form. The Pres. Part. has originally three forms in M.E. *-inde, -ende, -ande*. Speaking generally, the first is typical of the south, including London; the second of the Midland dialect; the last of the north. During the 13th century a new ending *-inge* of a doubtful origin, comes into use, first in the more southerly areas, but early in the next century, this form is found, together with *-and*, in N.E. Midlands. Early London texts have *-inde*, but in the 14th century *-ing* is firmly established as the sole form in this area. The P.P., which in O.E. had the prefix *ġe-*, preserves this, first as *ȝe-* later as *i-* in southern dialects of M.E., including that of London. Strong P.P.'s end in *-en* in the Midlands, but in *-e* in the south and very commonly in the dialect of London.

DIALECTS IN THE TEXTS

Among the most interesting problems for the student of M.E. are those connected with the numerous varieties of dialect exhibited in the texts, and the gradual emergence of one regional type as that of preponderating importance, and of wider currency than any other, that is the formation of a standard of literary usage. The dialectal variety revealed by the mss. of the M.E. period is far richer and more complicated than that discoverable from the written records before the Norman Conquest. This does not mean that a new process of speech differentiation was at work, associated with, or promoted by, the altered social and political conditions, whereby fresh dialect types were created. The linguistic variety, the multiplicity of regional forms of speech, differing from each other in varying degrees, according as they were severally spoken in adjacent or distant areas, existed before the Conquest, but most of the variants found no expression in written form in the O.E. period, owing to the outstanding supremacy of the West Saxon type.

Of the features which mark dialect individuality, some are phonological and consist in a characteristic development of O.E. vowel sounds, others consist in details of inflexion. Vocabulary is an uncertain guide to dialect, as the regional distribution of particular words is at present but imperfectly ascertained. It may be admitted, however, that the presence of a large number of Scandinavian words in a M.E. text would tend to show an easterly, Midland, or northern origin, rather than one from the south. The difficulty of deciding with certainty from what precise area a given M.E. text emanates, arises from the fact that this is known concerning so few texts, that a standard or touchstone which can be applied as a test of dialect is often lacking, so that, while it may be possible to say generally that a text is, say East Midland or South-western from the character of its dialect, it may not be easy to determine whether the text in question was written in Norfolk, Suffolk, Lincs., or Cambridgeshire, whether in Wilts, Dorset, or Devon, and so on.

Since about 1910, considerable fresh light has been shed upon the problems of the geographical diffusion and distribution of phonological features in M.E. by a series of investigations into the early forms of place-names (*see* PLACE-NAMES) in a number of areas. These names are composed of elements which are familiar also as independent, separate words in English, and these elements vary from area to area in accordance with dialect habit, no less when compounded as names, than when occurring as independent words. Such elements as O.E. *hyrst*, "wood," *hyll*, "hill," *hȳþ*, "landing-place," *leāh*, "field," *heāh*, "high," *stiēpel*, "steeple," *neoþor*, "lower," *heorot*, "hart," *mæd*, "meadow," *hæþ*, "heath," and so on, exhibit, when recorded in place-names, in local chartularies, etc., of the early centuries after the Conquest, the forms characteristic of the dialect of the

area in which the place is situated. The written forms of place names also reflect the changes which are taking place within the dialect from age to age. By the systematic use of this new source of information, the area of origin of many M.E. texts, and that within comparatively narrow limits, has been settled with a considerable degree of probability.

It has further been shown that certain combinations of dialect features found in texts, formerly supposed to be mutually incompatible, and ascribed to scribal influence, really are typical of a genuine dialect, and occur in the place names forms of a particular area. The results of recent investigations in this field have yielded a far more minute knowledge of the areas over which the main distinctive phonological features are distributed, a knowledge of the possible combinations of features, and of the way in which the general complexion of a dialect may vary according to the period. A general principle of some importance which has been established by recent regional surveys of M.E. dialects is that these were not severally confined within clear-cut borders but that they dovetailed and melted by imperceptible stages, each into those of adjacent areas. Further, there were many areas which were definitely what may be called border areas, in the speech of which, features characteristic of several dialect types were intimately intermingled.

All this is not without significance for the proper understanding of the development of what, by the end of the 14th century, was rapidly becoming the leading form of English in literature and in written documents of all kinds, which was destined to become the sole type used in writing, and to gain universal currency as the polite spoken standard. As long ago as the '80s of last century, Morbach, basing his observations on the 14th and 15th century sources, proved conclusively that the language of Chaucer was ultimately the dialect of London, and of the official documents. Chaucer's dialect exhibits what used to be called a "mixture" of types, some features of which were called "Kentish," others East Midland, while yet others were described, generally, as "Southern." The prevailing view was that this London dialect had grown up from a combination of elements imported from outside, chiefly by traders coming from East Anglia to the great market and centre of commerce in the metropolis. The facts may now be differently explained.

In the early 13th century, from the sources now available, it is possible to distinguish two markedly distinct types of dialect in the areas from which the later London dialect sprang—a city type which is almost identical with that of Essex, and what may be called the county dialect of Middlesex. There is further, a third, intermediate, type preserved in a collection of charters written at Westminster about 1250 or a bit later. The later 14th century London dialect of Davie, Chaucer and the official Records, is a blend of the old City and Middlesex types, together with certain features which, apparently, are to be traced to the adjacent areas of Herts. It is essentially a regional dialect. The chief feature formerly regarded as Kentish ($\check{\bar{e}}$ for O.E. $\check{\bar{y}}$) is certainly of the old City-Essex type, the "southern" features are those of the old Middlesex type, which was very near to West Saxon in many respects, while of the "Midland" characteristics, some are found in the 13th century City documents, and others, as stated, have come in from Herts. (For the latest account of the early and later London dialect in M.E., together with references to sources and authorities, *see* the work of B. A. Mackenzie *cit.* in Bibliography.)

THE SPREAD OF LONDON ENGLISH

The fact that the form of English which had grown up in the area of the metropolis and its immediate environs was that in which Caxton and the other early printers produced their books, undoubtedly promoted its rapid dissemination in all parts of the country, but the use of London English as the common language of literature, though facilitated by the introduction of printing, was not the result of this. There is plenty of evidence to show that a knowledge of this type, and its use in writing, were widespread before the art of printing was thought of. There are collections of private letters, literary works and official documents written during the first half of the 15th century and a few years later, in areas as remote from London as Norfolk, Devonshire, Oxfordshire and Worcestershire, for instance, in which the traces of local dialect are so few, that the language is hardly distinguishable from that of London. This does not imply that the old regional dialects had ceased to be spoken, but merely that their use *in writing* was gradually discontinued. (For an admirable account of the profound effects of Norman French upon the English vocabulary, the reader should consult Jespersen's *Growth and Structure of English,* and works there referred to.)

Meanwhile the external form of English had not remained unaltered during the centuries which elapsed between the coming of the Normans and the death of Chaucer in 1400. Opinions differ as to the most suitable approximate date at which to place the beginnings of the modern period of the language. Most of those who have considered the subject in the light of a knowledge of the written sources down to and into the 15th century, will recognize the abundant signs that what has been called the "great vowel shift," that is, that remarkable series of changes in pronunciation which distinguishes Modern English, was not the result of a process which started suddenly and produced its effects within a few years, but of slow-working, gradual tendencies, which had been at work for centuries. From the 13th century onwards certain occasional spellings occur scattered in mss. written in various parts of the country, which must be regarded as unconscious scribal lapses in the direction of a more phonetic expression of actual pronunciation, than was exhibited by a mode of spelling which had already become more or less fixed and conventional. Thus the (13th century) spelling *sichen,* "seek," in place of the normal *sechen,* suggests a sound nearer to the modern one in *beseech,* than that which *e* was originally intended to express, namely, a long vowel closely resembling in quality that written *é* in French. The M.E. scribe generally adheres pretty closely to the models in which he was trained, and his lapses are comparatively few, but during the 15th century, and still more in the 16th, when writing became an art no longer confined to professional scribes, these unconscious, occasional phonetic spellings are very numerous, in documents of all kinds written by private persons who followed the rules less rigidly.

It is in the 15th century that we first get really copious evidence from spellings that great changes have come about, not only in the vowels and stressed syllables, but in those of unaccented syllables, and in many consonantal combinations. Caxton, however, and other early printers, adopted the conventional scribal spelling of the late 14th century, and this, with very slight modifications, and these not of a phonetic character, has been retained, so that we learn next to nothing from them of the beginning of the new era in pronunciation which must have been well under way before the end of the 14th century. The M.E. vowels had the so-called "continental" values, and the symbols express, for the most part, the sounds which they expressed in Italian or in French.

The main changes which distinguish Modern English pronunciation from that of the M.E. period are: M.E. *ă, hădde,* "had," etc. (with sound of German *mann*) has been fronted; M.E. *ā* (with sound of Ital. *capo*) has likewise been fronted, M.E. *māde,* "made," etc.; M.E. *ē,* in *sēchen,* "seek" (with sound of Fr. *é*) has been raised; M.E. *ē* as in *mēte,* "meat" (with sound of Fr. *ê*) was first made into a sound like that of Fr. *é,* and later, in some dialects, also raised to the same sound as that of *ē′;* M.E. *ī,* in *wīf,* "wife," *chīld,* "child," etc. (with sound of Fr. *cire*) was diphthongized; M.E. *ō′,* as in *mōne,* "moon," etc. (with sound of German *roth*) was over-rounded, and raised to the present *ū*-sound; M.E. *ō* as in *bōt,* "boat" (with sound resembling that in present-day *saw*) was made tense as in German *roth,* etc.; M.E. *ū* in *hūs, hous,* "house" (with sound of the present vowel in *hoot*) was diphthongized; M.E. *ai,* as in M.E. *rain,* "rain," etc. (with sound of present vowel in *rite*) had the first element fronted, lost the second element, and was levelled under the same sound as M.E. *ā;* M.E. *au,* as in *taughte,* "taught" (with a diphthong similar to that of present-day *shout*) was monophthongized, the first element being rounded, and the second element gradually weakened and

lost, giving the present sound; M.E. *ou,* as in M.E. *doughter,* etc., simply lost the second element of the diphthong and was levelled under the new sound derived from M.E. *au;* M.E. *ŭ,* as in M.E. *sŭne,* more often written *sone,* "son" (with vowel as in present-day *pull*) was unrounded and lowered to the characteristic Modern English vowel heard in *shut, hurry,* etc.; M.E. *ü* in French words such as *judge, just,* etc., and the same sound, when it occurred in English words, *suche, bundel,* etc., was retracted to the sound of English *ŭ,* and together with this, was unrounded, etc.; M.E. *ū* in French words, *pure, fruit, rude,* etc., retained the French sound, and was, perhaps during the early 16th century, diphthongized to the sound we now give in naming the letter *u.*

From the evidence of the occasional spellings, and of certain rhymes which now appear for the first time, it seems certain that, by the first third of the 15th century, most of these considerable changes had progressed at least far enough to justify the statement that the old M.E. vowel system had passed away, and that what may fairly be called modern pronunciation was approaching while some vowels had fully attained this. By the end of the 15th century something very near the present day must have been reached, though the processes of change were not perhaps absolutely complete for all vowels, nor had the exact shades of sound which we now regard as the standard type finally developed, nor become everywhere current.

Pronunciation Problems.—The problems of the history of English pronunciation during and after the 16th century are closely bound up with the spread of a spoken standard, and the varying complexion of this. Henceforth it is not so much a matter of changes in the actual character and quality of the sounds, as a question of the relations between various existing types, current among different groups of speakers. During the 16th century there is the first definite evidence of the existence of a spoken standard, that is, of a sense that one mode of speech is superior to another, and therefore to be used by polite speakers. The standard of the 16th century was the ultimate speech of the London area, and more particularly, that variety of it spoken by the court and the upper grades of society. But the standard, far into the 17th century at least, was nothing like so fixed and definite as at present, where there is an accepted pronunciation of the vast majority of words in ordinary, common, polite use, deviation from which is regarded either as a provincialism or as a vulgarism. It appears from all the sources of information available, that in the 16th and 17th centuries, and in a great part of the 18th, considerable variation of pronunciation existed, and was tolerated, among those who were regarded as speaking according to the fashionable standard. It is certain that rustic forms of speech were in use among many of the country gentlemen who came to London from time to time from their estates to taste the pleasures of the gay and fashionable world, to which they found a ready entry from their family connections and their personal rank. To speak the dialect of one's native village, or at least to have an appreciable rustic smack in one's speech, might provoke the mirth of town wits and make a man the butt for writers of comedies, but it did not disqualify him from frequenting the politest society.

The prevalence of regional dialect among the upper grades of society is evident, for instance, from many of the letters in the incomparable Verney collection, the writers of which nearly all belonged to the landed class, from the novels of Fielding and Smollett, while the rhymes of such poets as Waller and Dryden here and there betray regional influence. But another, and perhaps more important factor, in moulding the spoken standard, and in determining which type should ultimately prevail, was the influence of class dialect, and especially is this observable in the gradual elimination of the old types of unstudied, careless, traditional pronunciation common to the upper classes during the 16th, 17th and 18th centuries, in favour of a more careful mode of speech which aimed at a greater "correctness" and a closer adherence to utterance suggested by the spelling. This tendency, to which we owe much in our present habitual pronunciation, came from the educated middle and lower classes, who, lacking established tradition of easy polished conversation current among the superior ranks, though often exceeding these in learning, were compelled to build up a colloquial tradition of their own which should be worthy of their culture and their taste.

Somewhere about the middle of the 18th century there seems to have been an appreciable reaction against the fashionable carelessness of pronunciation so long in vogue, and slowly but surely the ideals of the purist, and, as many must have thought, the pedant, began to prevail. Thus the standards of what was polite, or what was ridiculous or vulgar in speech, were slowly modified; much hitherto held fashionable was eliminated, and much formerly felt as strange and pedantic, was permanently adopted as correct. This process of deliberately substituting a new, careful pronunciation based on the spelling for what is ancient, traditional and unstudied, is for ever at work, though many of the older types of pronunciation die hard, and will probably linger for many generations still among the upper classes who are ever more conservative in their speech.

As recent examples of the process may be cited the introduction of an aspirate a few generations ago, in *herb, humble, hospital,* and within the last few years, among certain classes of speakers in *humour;* the substitution of *"-ing"* in pronunciation, in the ending of present participles, for the old *"-in";* the introduction of a *"t"* sound in *often, soften; landscape* for old *lanskip; waistcoat* pronounced as spelt, instead of "weskot"; the introduction of an aspirate in the last syllable of *forehead,* and *neighbourhood.* Yet earlier innovations of a similar kind are the present pronunciation of *gold,* in place of the traditional *"goold," London* with a *d* sounded, instead of older "Lunnon," the long vowel in *leap* instead of "lep," *hundred* for "hunderd," *Rome* (probably from French or Ital. type) for older "Roome," *china* instead of "chayney," the ousting of the pronunciation "dooer" for *door,* the sounding of *w* in *forward, Edward,* and many other words in which this sound was normally lost at the beginning of an unstressed syllable.

The older pronunciations here indicated were those used by the best speakers in the 17th and 18th centuries, and many of them might still be heard among old-fashioned speakers of the upper classes far into the last century. Two other important changes in speech habit may be mentioned, involving whole groups of words. The first is almost certainly due to the influence of class dialect though it may be regional in origin. M.E. *ē,* in such words as *steal, meat, heat, seat, sea,* etc., was by most good speakers pronounced like *stale, mate, hate, sate, say,* etc., far into the 18th century. Another type, having the *"ee"* sound, had existed at any rate in the 16th century, though for a long time it seems to have been confined to a relatively small group of speakers, and was not fashionable in standard English. During the 18th century word after word was gradually transferred, as it were, to the *"ee"* type, until by the early 19th century, it had become fashionable to pronounce all words of this class in this way except *great,* and *break,* and even these may be heard in some dialects with *"ee."* The spelling *ea* which is used in most words containing M.E. *ē,* is one of the last attempts at a phonetic distinction in orthography which has become fixed.

The other large class of words for which a different type of pronunciation from that in use in the 17th and 18th centuries is now current, is that group spelt with *er.* Such words as *serve, servant, swerve, diversion, divert, vermin, fervent* and many others, as appears both from numerous spellings in private letters, and from the rhymes of poets, were commonly pronounced "sarve, sarvant, swarve, divarsion," etc. The only words which retain the "ar" pronunciation are *clerk,* and the proper names *Derby* and *Bertie,* and in these the *"er"* pronunciation is still a vulgarism, just as, on the other hand, "sarve, divarsion," etc., would be.

CONTINUITY OF FORM

The study of English as preserved in the documents of the past, decade by decade, from the earliest records of every kind, down to the present day, leaves upon the mind a sense of a wonderful continuity. The language is felt indeed to be always changing, but so gradually that the speech of one age passes by almost imperceptible degrees into that of the next. It is impossible to

say at what point one period comes to an end and the next begins. And what is true of the external form of the language is true also of the spirit and genius, the atmosphere reflected in the style. To regard the changes of human speech as deliberately brought about, and the language as it exists at a given moment as the result of conscious effort, is an error. Even the vagaries of fashion, which play a large part in determining the character of a standard of speech, are not so wholly artificial as they appear, since the choice of fashion, often an unconscious act, can as a rule be exercised only within the limits of what actually exists in this or that dialect, and consists in the selection of one from among several types, each of which has been developed by a natural, unconscious process, among a community of actual speakers. It is impossible to say by what social currents a given form from some external dialect may have been brought within the ken of speakers of standard English at a certain moment, nor what subtle drift of tendency or motive may have led to its gradual adoption as a current and accepted form. The only really artificial elements in English are such as have been deliberately concocted from the spelling, by speakers who either through ignorance or prejudice, substitute such innovations as we have cited above, for the established traditional forms. But even these novelties, artificial as they may be in origin, often pass, in a few generations, into the storehouse of traditional speech.

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American Dialects.—Dialects of American English are not so important or so marked as those of the mother country. The settlement of much of the United States is so new, and its inhabitants and educators so migratory, that local peculiarities have had, as a rule, little time in which to develop. The leading types of regional dialects are those of New England, the South, the Central West and the Far West. But between the speech of Boston, which had for a time a certain prestige partly because the early dictionaries were made there, and the speech of New York, New Orleans, Chicago and San Francisco, there are, despite the distances involved, no very great differences. Denial has been made, indeed, of the existence of American dialects.

There are, however, in outlying regions and in settlements of foreigners, local varieties of speech that are genuinely dialectal. James Russell Lowell summarized many peculiarities of Yankee

linguistics in his *Biglow Papers* (1846, 1866). The vernacular of the Maine coast or of the Cape Cod region exhibits local peculiarities. The language of the Tennessee and Carolina mountain region found literary preservation in the stories of Charles Egbert Craddock (Mary N. Murfree, 1850–1922) and others. The Ozark mountain district has distinctive idioms, vocabulary and pronunciation, revealing many archaic features. Cape Hatteras island has preserved many colonial or Elizabethan turns of expression, now fast fading. Throughout the United States, ranging from the Adirondack country to the flats of Georgia or the Sandhill region of Nebraska, are communities having curious local expressions or characteristics. The "worst English in the world" is said to be that spoken by the Gullah negroes of the Georgia and Carolina coasts and sea islands. It differs from and has more archaic features than the familiar negro dialect of the works of J. C. Harris, T. N. Page and their successors. Gullah dialect was lifted into literary notice by the "Black Border" stories of A. E. Gonzales (1857–1926). Harris had written a few stories in the Gullah dialect.

The dialects spoken by foreign populations have received attention from scholars, but more should be given them. To be taken into account are the French-Creole of Louisiana, French-Canadian, Spanish-Mexican of the Southwest, Italian-English dialects, German, Yiddish, Swedish, Norwegian, and Danish-American, Jersey and Pennsylvania Dutch, Slavic-English and other hybrid tongues. The Chinook or Trade Jargon of the Pacific North-west, once widely used by Indian tribes and by the white men with whom they traded, has bequeathed a few words to the English vocabulary, but it now has no utilitarian purpose and is fast dying out.

Some of the interesting features of American dialect speech are the wealth of ancient or historical words, now extinct in the literary language, that linger in remote regions; localisms of vocabulary; pronominal, verbal and other grammatical peculiarities; colourful exclamations and interjections in great numbers; varied and numerous indefinite terms used to avoid finding a specific one; terms of disparagement and of encomium; ablaut or rhyming compounds; saws; proverbs; striking similes or metaphors. There are popular names, needing special compilation by folklorists, for birds, insects and plants. A study of dialect has social as well as linguistic significance, since the customs, superstitions and daily interests of a community are reflected in its speech.

The dialects or special jargons of separate classes or professions, as apart from regional dialects, may be illustrated by the vocabularies of hoboes, crooks, vagabonds, drug addicts, the vocabularies of oil-well workers, loggers, miners, sailors, vaudeville artists, actors, circus employees, moving-picture people. The special jargons developed by educators, sociologists, psychologists and other professional groups of various types are also sometimes termed dialects.

An American Dialect Society was formed in 1899, and it has collected a large amount of material. In 1927 it began the preparation of an American dialect dictionary, to be made in cooperation with the Historical Dictionary of American English, in progress at the University of Chicago. (L. P.)

ENGLISH LAW. In the language of English jurisprudence "legal memory" is said to extend as far as, but no further than, the coronation of Richard I. (Sept. 3, 1189). This is a technical doctrine concerning prescriptive rights, but is capable of expressing an important truth. For the last seven centuries, little more or less, English law has had not only an extremely continuous, but a matchlessly well-attested history, and, moreover, has been the subject matter of rational exposition. Already in 1194 the daily doings of a tribunal which was controlling and moulding the whole system were being punctually recorded in letters yet legible, and from that time onwards it is rather the enormous bulk than any dearth of available materials that prevents us from tracing the transformation of every old doctrine and the emergence and expansion of every new idea. If we are content to look no further than the text-books—the books written by lawyers for lawyers—we may read our way backwards to Blackstone (d. 1780), Hale (d. 1676), Coke (d. 1634), Fitzherbert (d. 1538), Littleton (d. 1481), Bracton (d. 1268), Glanvill (d. 1190), until we are in the reign of Henry of Anjou, and yet shall perceive that we are always reading of one and the same body of law, though the little body has become great, and the ideas that were few and indefinite have become many and explicit.

Beyond these seven lucid centuries lies a darker period. Nearly six centuries will still divide us from the dooms of Aethelbert (*c.* 600), and nearly seven from the *Lex Salica* (*c.* 500). We may regard the Norman conquest of England as marking the confluence of two streams of law. The one we may call French or Frankish. If we follow it upwards we pass through the capitularies of Carlovingian emperors and Merovingian kings until we see Chlodwig and his triumphant Franks invading Gaul, submitting their Sicambrian necks to the yoke of the imperial religion, and putting their traditional usages into written Latin. The other rivulet we may call Anglo-Saxon. Pursuing it through the code of Canute (d. 1035) and the ordinances of Alfred (*c.* 900) and his successors, we see Ine publishing laws in the newly converted Wessex (*c.* 690), and, almost a century earlier, Aethelbert doing the same in the newly converted Kent (*c.* 600). This he did, says Beda, in accordance with Roman precedents. Perhaps from the Roman missionaries he had heard tidings of what the Roman emperor had lately been doing far off in New Rome. We may at any rate notice with interest that in order of time Justinian's law-books fall between the *Lex Salica* and the earliest Kentish dooms; also that the great pope who sent Augustine to England is one of the very few men who between Justinian's day and the 11th century lived in the Occident and yet can be proved to have known the Digest. In the Occident the time for the Germanic "folk-laws" (*Leges Barbarorum*) had come, and a Canon law, ambitious of independence, was being constructed, when in the Orient the lord of church and State was "enucleating" all that was to live of the classical jurisprudence of pagan Rome. It was but a brief interval between Gothic and Lombardic domination that enabled him to give law to Italy: Gaul and Britain were beyond his reach.

The Anglo-Saxon laws that have come down to us (and we have no reason to fear the loss of much beyond some dooms of the Mercian Offa) are best studied as members of a large Teutonic family. Those that proceed from the Kent and Wessex of the 7th century are closely related to the Continental folk-laws. Their next of kin seem to be the *Lex Saxonum* and the laws of the Lombards. Then, though the 8th and 9th centuries are unproductive, we have from Alfred (*c.* 900) and his successors a series of edicts which strongly resemble the Frankish capitularies—so strongly that we should see a clear case of imitation, were it not that in Frankland the age of legislation had come to its disastrous end long before Alfred was king. This, it may be noted, gives to English legal history a singular continuity from Alfred's day to our own. The king of the English was expected to publish laws at a time when hardly anyone else was attempting any such feat, and the English dooms of Canute the Dane are probably the most comprehensive statutes that were issued in the Europe of the 11th century. No genuine laws of the sainted Edward have descended to us, and during his reign England seems but too likely to follow the bad example of Frankland, and become a loose congeries of lordships. From this fate it was saved by the Norman duke, who, like Canute before him, subdued a land in which kings were still expected to publish laws.

In the study of early Germanic law—a study which now for some considerable time has been scientifically prosecuted in Germany—the Anglo-Saxon dooms have received their due share of attention. A high degree of racial purity may be claimed on their behalf. Celtic elements have been sought for in them, but have never been detected. At certain points, notably in the regulation of the blood-feud and the construction of a tariff of atonements, the law of one rude folk will always be somewhat like the law of another; but the existing remains of old Welsh and old Irish law stand far remoter from the dooms of Aethelbert and Ine than stand the edicts of Rothari and Liutprand, kings of the Lombards. Indeed, it is very dubious whether distinctively Celtic customs play any considerable part in the evolu-

tion of that system of rules of Anglian, Scandinavian and Frankish origin which becomes the law of Scotland. Within England itself, though for a while there was fighting enough between the various Germanic folks, the tribal differences were not so deep as to prevent the formation of a common language and a common law. Even the strong Scandinavian strain seems to have rapidly blended with the Anglian. It amplified the language and the law, but did not permanently divide the country. If, for example, we can to-day distinguish between *law* and *right,* we are debtors to the Danes; but very soon *law* is not distinctive of eastern or *right* of western England. In the first half of the 12th century a would-be expounder of the law of England had still to say that the country was divided between the Wessex law, the Mercian law and the Danes' law, but he had also to point out that the law of the king's own court stood apart from and above all partial systems. The local customs were those of shires and hundreds, and shaded off into each other. We may speak of more Danish and less Danish counties; it was a matter of degree; for rivers were narrow and hills were low. England was meant by nature to be the land of one law.

Then as to Roman law. In England and elsewhere Germanic law developed in an atmosphere that was charged with traditions of the old world, and many of these traditions had become implicit in the Christian religion. It might be argued that all that we call progress is due to the influence exercised by Roman civilization; that, were it not for this, Germanic law would never have been set in writing; and that theoretically unchangeable custom would never have been supplemented or superseded by express legislation. All this and much more of the same sort might be said; but the survival in Britain, or the reintroduction into England, of anything that we should dare to call Roman jurisprudence would be a different matter. Eyes, carefully trained, have minutely scrutinized the Anglo-Saxon legal texts without finding the least trace of a Roman rule outside the ecclesiastical sphere. Even within that sphere modern research is showing that the church-property-law of the middle ages, the law of the ecclesiastical "benefice," is permeated by Germanic ideas. This is true of Gaul and Italy, and yet truer of an England in which Christianity was for a while extinguished. Moreover, the laws that were written in England were, from the first, written in the English tongue; and this gives them a unique value in the eyes of students of Germanic folk-law, for even the very ancient and barbarous *Lex Salica* is a Latin document, though many old Frankish words are enshrined in it. Also we notice—and this is of grave importance—that in England there are no vestiges of any "Romani" who are being suffered to live under their own law by their Teutonic rulers. On the Continent we may see Gundobad, the Burgundian, publishing one law-book for the Burgundians and another for the Romani who own his sway. A book of laws, excerpted chiefly from the Theodosian code, was issued by Alaric the Visigoth for his Roman subjects before the days of Justinian, and this book (the so-called *Breviarium Alarici* or *Lex Romana Visigothorum*) became for a long while the chief representative of Roman law in Gaul. The Frankish king in his expansive realm ruled over many men whose law was to be found not in the *Lex Salica* or *Lex Ribuaria,* but in what was called the *Lex Romana.* "A system of personal law" prevailed: the *homo Romanus* handed on his Roman law to his children, while Frankish or Lombardic, Swabian or Saxon law would run in the blood of the *homo barbarus.* Of all this we hear nothing in England. Then on the mainland of Europe Roman and barbarian law could not remain in juxtaposition without affecting each other. On the one hand we see distinctively Roman rules making their way into the law of the victorious tribes, and on the other hand we see a decay and debasement of jurisprudence which ends in the formation of what modern historians have called a Roman "vulgar-law" (*Vulgarrecht*). For a short age which centres round the year 800 it seemed possible that Frankish kings, who were becoming Roman emperors, would be able to rule by their capitularies nearly the whole of the Christian Occident. The dream vanished before fratricidal wars, heathen invaders, centrifugal feudalism and a centripetal church which found its law in the newly concocted forgeries of the Pseudo-Isidore (*c.* 850). The "personal laws" began to transmute themselves into local customs, and the Roman vulgar-law began to look like the local custom of those districts where the Romani were the preponderating element in the population. Meanwhile, the Norse pirates subdued a large tract of what was to be northern France—a land where Romani were few. Their restless and boundless vigour these Normans retained; but they showed a wonderful power of appropriating whatever of alien civilization came in their way. In their language, religion and law, they had become French many years before they subdued England. It is a plausible opinion that among them there lived some sound traditions of the Frankish monarchy's best days, and that Norman dukes, rather than German emperors or kings of the French, are the truest spiritual heirs of Charles the Great.

The Norman Age.—In our own day German historians are wont to speak of English law as a "daughter" of French or Frankish law. This tendency derived its main impulse from H. Brunner's proof that the germ of trial by jury, which cannot be found in the Anglo-Saxon laws, can be found in the prerogative procedure of the Frankish kings. We must here remember that during a long age English lawyers wrote in French and even thought in French, and that to this day most of the technical terms of the law, more especially of the private law, are of French origin. Also it must be allowed that when English law has taken shape in the 13th century it is very like one of the *coutumes* of northern France. Even when linguistic difficulties have been surmounted, the Saxon Mirror of Eike von Repgow will seem far less familiar to an Englishman than the so-called Establishments of St. Louis. This was the outcome of a slow process which fills more than a century (1066–1189), and was in a great measure due to the reforming energy of Henry II., the French prince who, in addition to England, ruled a good half of France. William the Conqueror seems to have intended to govern Englishmen by English law. After the tyranny of Rufus, Henry I. promised a restoration of King Edward's law: that is, the law of the Confessor's time (*Legem Eadwardi regis vobis reddo*). Various attempts were then made, mostly, so it would seem, by men of French birth, to state in a modern and practicable form the *laga Eadwardi* which was thus restored. The result of their labours is an intricate group of legal tracts which has been explored of late years by Dr. Liebermann. The best of these has long been known as the *Leges Henrici Primi,* and aspires to be a comprehensive law-book. Its author, though he had some foreign sources at his command, such as the *Lex Ribuaria* and an epitome of the Breviary of Alaric, took the main part of his matter from the code of Canute and the older English dooms. Neither the Conqueror nor either of his sons had issued many ordinances: the invading Normans had little, if any, written law to bring with them, and had invaded a country where kings had been lawgivers. Moreover, there was much in the English system that the Conqueror was keenly interested in retaining—especially an elaborate method of taxing the land and its holders. The greatest product of Norman government, the grandest feat of government that the world had seen for a long time past, the compilation of *Domesday Book,* was a conservative effort, an attempt to fix upon every landholder, French or English, the amount of geld that was due from his predecessor in title. Himself the rebellious vassal of the French king, the duke of the Normans, who had become king of the English, knew much of disruptive feudalism, and had no mind to see England that other France which it had threatened to become in the days of his pious but incompetent cousin. The sheriffs, though called *vice-comites,* were to be the king's officers; the shire-moots might be called county courts, but were not to be the courts of counts. Much that was sound and royal in English public law was to be preserved if William could preserve it.

Royal Justice.—The gulf that divides the so-called *Leges Henrici* (*c.* 1115) from the text-book ascribed to Ranulf Glanvill (*c.* 1188) seems at first sight very wide. The one represents a not easily imaginable chaos and clash of old rules and new; it represents also a stage in the development of feudalism which

in other countries is represented chiefly by a significant silence. The other is an orderly, rational book, which through all the subsequent centuries will be readily understood by English lawyers. Making no attempt to tell us what goes on in the local courts, its author, who may be Henry II.'s chief justiciar, Ranulf Glanvill, or may be Glanvill's nephew, Hubert Walter, fixes our attention on a novel element which is beginning to subdue all else to its powerful operation. He speaks to us of the justice that is done by the king's own court. Henry II. had opened the doors of his French-speaking court to the mass of his subjects. Judges chosen for their ability were to sit there, term after term; judges were to travel in circuits through the land, and in many cases the procedure by way of "an inquest of the country," which the Norman kings had used for the ascertainment of their fiscal rights, was to be at the disposal of ordinary litigants. All this had been done in a piecemeal, experimental fashion by ordinances that were known as "assizes." There had not been, and was not to be, any enunciation of a general principle inviting all who were wronged to bring in their own words their complaints to the king's audience. The general prevalence of feudal justice, and of the world-old methods of supernatural probation (ordeals, battle, oaths sworn with oath-helpers), was to be theoretically respected; but in exceptional cases, which would soon begin to devour the rule, a royal remedy was to be open to any one who could frame his case within the compass of some carefully-worded and prescript formula. With allusion to a remote stage in the history of Roman law, a stage of which Henry's advisers can have known little or nothing, we may say that a "formulary system" is established which will preside over English law until modern times. Certain actions, each with a name of its own, are open to litigants. Each has its own formula set forth in its original (or, as we might say, originating) writ; each has its own procedure and its appropriate mode of trial. The litigant chooses his writ, his action, and must stand or fall by his choice. Thus a book about royal justice tends to become, and Glanvill's book already is, a commentary on original writs.

The precipitation of English law in so coherent a form as that which it has assumed in Glanvill's book is not to be explained without reference to the revival of Roman jurisprudence in Italy. Out of a school of Lombard lawyers at Pavia had come Lanfranc the Conqueror's adviser, and the Lombardists had already been studying Justinian's Institutes. Then at length the Digest came by its rights. About the year 1100 Irnerius was teaching at Bologna, and from all parts of the West men were eagerly flocking to hear the new gospel of civilization. About the year 1149 Vacarius was teaching Roman law in England. The rest of a long life he spent here, and faculties of Roman and Canon law took shape in the nascent University of Oxford. Whatever might be the fate of Roman law in England, there could be no doubt that the Canon law, which was crystallizing in the *Decretum Gratiani* (*c.* 1139) and in the decretals of Alexander III., would be the law of the English ecclesiastical tribunals. The great quarrel between Henry II. and Thomas of Canterbury brought this system into collision with the temporal law of England, and the king's ministers must have seen that they had much to learn from the methodic enemy. Some of them were able men who became the justices of Henry's court, and bishops to boot. The luminous *Dialogue of the Exchequer* (*c.* 1179), which expounds the English fiscal system, came from the treasurer, Richard Fitz Nigel, who became bishop of London; and the treatise on the laws of England came perhaps from Glanvill, perhaps from Hubert Walter, who was to be both primate and chief justiciar. There was healthy emulation of the work that was being done by Italian jurists, but no meek acceptance of foreign results.

Bracton.—A great constructive era had opened, and its outcome was a large and noble book. The author was Henry of Bratton (his name has been corrupted into Bracton), who died in 1268 after having been for many years one of Henry III.'s justices. The model for its form was the treatise of Azo of Bologna ("master of all the masters of the laws," an Englishman called him), and thence were taken many of the generalities of jurisprudence: maxims that might be regarded as of universal and natural validity. But the true core of the work was the practice of an English court which had yearly been extending its operations in many directions. For half a century past diligent record had been kept on parchment of all that this court had done, and from its rolls Bracton cited numerous decisions. He cited them as precedents, paying special heed to the judgments of two judges who were already dead, Martin Pateshull and William Raleigh. For this purpose he compiled a large Note Book, which was discovered by Prof. Vinogradoff in the British Museum in 1884. Thus at a very early time English "common law" shows a tendency to become what it afterwards definitely became, namely, "case law." The term "common law" was being taken over from the canonists by English lawyers, who used it to distinguish the general law of the land from local customs, royal prerogatives, and in short from all that was exceptional or special. Since statutes and ordinances were still rarities, all expressly enacted laws were also excluded from the English lawyers' notion of "the common law." The Great Charter (1215) had taken the form of a grant of "liberties and privileges," comparable to the grants that the king made to individual men and favoured towns. None the less, it was in that age no small body of enacted law, and, owing to its importance and solemnity, it was in after ages regarded as the first article of a statute book. There it was followed by the "provisions" issued at Merton in 1236 and by those issued at Marlborough after the end of the Barons' war. But during Henry III.'s long reign the swift development of English law was due chiefly to new "original writs" and new "forms of action" devised by the chancery and sanctioned by the court. Bracton knew many writs that were unknown to Glanvill, and men were already perceiving that limits must be set to the inventive power of the chancery unless the king was to be an uncontrollable law-maker. Thus the common law was losing the power of rapid growth when Bracton summed the attained results in a book, the success of which is attested by a crowd of manuscript copies. Bracton had introduced just enough of Roman law and Bolognese method to save the law of England from the fate that awaited German law in Germany. His book was printed in 1569, and Coke owed much to Bracton.

Reign of Edward I.—The comparison that is suggested when Edward I. is called the English Justinian cannot be pressed very far. Nevertheless, as is well known, it is in his reign (1272–1307) that English institutions finally take the forms they are to keep through coming centuries. We already see the parliament of the three estates, the convocations of the clergy, the king's council, the chancery or secretarial department, the exchequer or financial department, the king's bench, the common bench, the commissioners of assize and gaol delivery, the small group of professionally learned judges, and a small group of professionally learned lawyers, whose skill is at the service of those who will employ them. Moreover, the statutes that were passed in the first 18 years of the reign, though their bulk seems slight to us nowadays, bore so fundamental a character that in subsequent ages they appeared as the substructure of huge masses of superincumbent law. Coke commented upon them sentence by sentence, and even now the merest smatterer in English law must profess some knowledge of *Quia emptores* and *De donis conditionalibus*. If some American States have, while others have not, accepted these statutes, that is a difference which is not unimportant to citizens of the United States in the 20th century. Then from the early years of Edward's reign come the first "law reports" that have descended to us: the oldest of them have not yet been printed; the oldest that has been printed belongs to 1292. These are the precursors of the long series of Year Books (Edw. II.–Hen. VIII.) which runs through the residue of the middle ages. Lawyers, we perceive, are already making and preserving notes of the discussions that take place in court; French notes that will be more useful to them than the formal Latin records inscribed upon the plea rolls. From these reports we learn that there are already, as we should say, a few "leading counsel," some of whom will be retained in almost every important cause. Papal decretals had been endeavouring to withdraw the clergy from secular employment. The clerical element had been strong

among the judges of Henry III.'s reign: Bracton was an archdeacon, Pateshull a dean, Raleigh died a bishop. Their places begin to be filled by men who are not in orders, but who have pleaded the king's causes for him—his serjeants or servants at law—and beside them there are young men who are "apprentices at law," and are learning to plead. Also we begin to see men who, as "attorneys at law," are making it their business to appear on behalf of litigants. The history of the legal profession and its monopoly of legal aid is intricate, and at some points still obscure; but the influence of the canonical system is evident: the English attorney corresponds to the canonical proctor, and the English barrister to the canonical advocate. The main outlines were being drawn in Edward I.'s day; the legal profession became organic, and professional opinion became one of the main forces that moulded the law.

The study of English law fell apart from all other studies, and the impulse that had flowed from Italian jurisprudence was ebbing. We have two comprehensive text-books from Edward's reign: the one known to us as *Fleta,* the other as *Britton;* both of them, however, quarry their materials from Bracton's treatise. Also we have two little books on procedure which are attributed to Chief Justice Hengham, and a few other small tracts of an intensely practical kind. Under the cover of fables about King Alfred, the author of the *Mirror of Justices* made a bitter attack upon King Edward's judges, some of whom had fallen into deep disgrace. English legal history has hardly yet been purged of the leaven of falsehood that was introduced by this fantastic and unscrupulous pamphleteer. His enigmatical book ends that literate age which begins with Glanvill's treatise and the treasurer's dialogue. Between Edward I.'s day and Edward IV.'s hardly anything that deserves the name of book was written by an English lawyer.

The 14th and 15th Centuries.—During that time the body of statute law was growing, but not very rapidly. Acts of parliament intervened at a sufficient number of important points to generate and maintain a persuasion that no limit, or no ascertainable limit, can be set to the legislative power of king and parliament. Very few are the signs that the judges ever permitted the validity of a statute to be drawn into debate. Thus the way was being prepared for the definite assertion of parliamentary "omnicompetence" which we obtain from the Elizabethan statesman, Sir Thomas Smith, and for those theories of sovereignty which we couple with the names of Hobbes and Austin. Nevertheless, English law was being developed rather by debates in court than by open legislation. The most distinctively English of English institutions in the later middle ages are the Year Books and the Inns of Court. Year by year, term by term, lawyers were reporting cases in order that they and their fellows might know how cases had been decided. The allegation of specific precedents was indeed much rarer than it afterwards became, and no calculus of authority so definite as that which now obtains had been established in Coke's day, far less in Littleton's. Still it was by a perusal of reported cases that a man would learn the law of England. A skeleton for the law was provided, not by the Roman rubrics (such as public and private, real and personal, possessory and proprietary, contract and delict), but by the cycle of original writs that were inscribed in the chancery's *Registrum Brevium.* A new form of action could not be introduced without the authority of parliament, and the growth of the law took the shape of an explication of the true intent of ancient formulas. Times of inventive liberality alternated with times of cautious and captious conservatism. Coke could look back to Edward III.'s day as to a golden age of good pleading. The otherwise miserable time which saw the Wars of the Roses produced some famous lawyers, and some bold doctrines which broke new ground. It produced also Sir Thomas Littleton's (d. 1481) treatise on Tenures, which (though it be not, as Coke thought it, the most perfect work that ever was written in any human science) is an excellent statement of law in exquisitely simple language. Meanwhile English law was being scholastically taught. (*See* LEGAL EDUCATION.)

Chancery.—A danger threatened: the danger that a prematurely osseous system of common law would be overwhelmed by summary justice and royal equity. Even when courts for all ordinary causes had been established, a reserve of residuary justice remained with the king. Whatever lawyers and even parliaments might say, it was seen to be desirable that the king in council should with little regard for form punish offenders who could break through the meshes of a tardy procedure and should redress wrongs which corrupt and timid juries would leave unrighted. Papal edicts against heretics had made familiar to all men the notion that a judge should at times proceed *summarie et de plano et sine strepitu et figura justitiae.* And so extraordinary justice of a penal kind was done by the king's council upon misdemeanants, and extraordinary justice of a civil kind was ministered by the king's chancellor (who was the specially learned member of the council) to those who "for the love of God and in the way of charity," craved his powerful assistance. It is now well established that the chancellors started upon this course, not with any desire to introduce rules of "equity" which should supplement, or perhaps supplant, the rules of law, but for the purpose of driving the law through those accidental impediments which sometimes unfortunately beset its due course. The wrongs that the chancellor redressed were often wrongs of the simplest and most brutal kind: assaults, batteries and forcible dispossessions. However, he was warned off this field of activity by parliament; the danger to law, to lawyers, to trial by jury, was evident. But just when this was happening, a new field was being opened for him by the growing practice of conveying land to trustees. The English trust of land had ancient Germanic roots, and of late we have been learning how in far-off centuries our Lombard cousins were in effect giving themselves a power of testation by putting their lands in trust. In England, when the forms of action were crystallizing, this practice had not been common enough to obtain the protection of a writ; but many causes conspired to make it common in the 14th century; and so, with the general approval of lawyers and laity, the chancellors began to enforce by summary process against the trustee the duty that lay upon his conscience. In the next century it was clear that England had come by a new civil tribunal. Negatively, its competence was defined by the rule that when the common law offered a remedy, the chancellor was not to intervene. Positively, his power was conceived as that of doing what "good conscience" required, more especially in cases of "fraud, accident or breach of confidence." His procedure was the summary, the heresy-suppressing (not the ordinary and solemn) procedure of an ecclesiastical court; but there are few signs that he borrowed any substantive rules from legist or decretist, and many proofs that within the new field of trust he pursued the ideas of the common law. It was long, however, before lawyers made a habit of reporting his decisions. He was not supposed to be tightly bound by precedent. Adaptability was of the essence of the justice that he did.

The Tudor Age.—A time of strain and trial came with the Tudor kings. It was questionable whether the strong "governance" for which the weary nation yearned could work within the limits of a parliamentary system, or would be compatible with the preservation of the common law. We see new courts appropriating large fields of justice and proceeding *summarie et de plano;* the star chamber, the chancery, the courts of requests, of wards, of augmentations, the councils of the North and Wales; a little later we see the high commission. We see also that judicial torture which Fortescue had called the road to hell. The stream of law reports became intermittent under Henry VIII.; few judges of his or his son's reign left names that are to be remembered. In an age of humanism, alphabetically arranged "abridgments" of mediaeval cases were the best work of English lawyers: one comes to us from Anthony Fitzherbert (d. 1538), and another from Robert Broke (d. 1558). This was the time when Roman law swept like a flood over Germany. The modern historian of Germany will speak of "the Reception" (that is, the reception of Roman law), as no less important than the Renaissance and Reformation with which it is intimately connected. Very probably he will bestow hard words on a movement which disintegrated the nation and consolidated the tyranny of the princelings.

Now a project that Roman law should be "received" in England occurred to Reginald Pole (d. 1558), a humanist, and at one time a reformer, who with good fortune might have been either king of England or pope of Rome. English law, said the future cardinal and archbishop, was barbarous; Roman law was the very voice of nature pleading for "civility" and good princely governance. Pole's words were brought to the ears of his majestic cousin, and, had the course of events been somewhat other than it was, King Henry might well have decreed a reception. The rôle of English Justinian would have perfectly suited him, and there are distinct traces of the civilian's Byzantinism in the doings of the Church of England's supreme head. The academic study of the Canon law was prohibited; regius professorships of the civil law were founded; civilians were to sit as judges in the ecclesiastical courts. A little later, the protector Somerset was deeply interested in the establishment of a great school for civilians at Cambridge. Scottish law was the own sister of English law, and yet in Scotland we may see a reception of Roman jurisprudence which might have been more whole-hearted than it was, but for the drift of two British and Protestant kingdoms towards union. As it fell out, however, Henry could get what he wanted in Church and State without any decisive supersession of English by foreign law. The omnicompetence of an Act of parliament stands out the more clearly if it settles the succession to the throne, annuls royal marriages, forgives royal debts, defines religious creeds, attaints guilty or innocent nobles, or prospectively lends the force of statute to the king's proclamations. The courts of common law were suffered to work in obscurity, for jurors feared fines, and matter of State was reserved for council or Star Chamber. The Inns of Court were spared; their moots and readings did no perceptible harm, if little perceptible good.

Coke and Selden.—Yet it is no reception of alien jurisprudence that must be chronicled, but a marvellous resuscitation of English mediaeval law. We may see it already in the Commentaries of Edward Plowden (d. 1585) who reported cases at length and lovingly. Bracton's great book was put in print, and was a key to much that had been forgotten or misunderstood. Under Parker's patronage, even the Anglo-Saxon dooms were brought to light; they seemed to tell of a Church of England that had not yet been enslaved by Rome. The new national pride that animated Elizabethan England issued in boasts touching the antiquity, humanity, enlightenment of English law. Resuming the strain of Fortescue, Sir Thomas Smith, himself a civilian, wrote concerning the Commonwealth of England a book that claimed the attention of foreigners for her law and her polity. There was dignified rebuke for the French jurist who had dared to speak lightly of Littleton. And then the common law took flesh in the person of Edward Coke (1552–1634). With an enthusiastic love of English tradition, for the sake of which many offences may be forgiven him, he ranged over nearly the whole field of law, commenting, reporting, arguing, deciding—disorderly, pedantic, masterful, an incarnate national dogmatism tenacious of continuous life. Imbued with this new spirit, the lawyers fought the battle of the Constitution against James and Charles, and historical research appeared as the guardian of national liberties. That the Stuarts united against themselves three such men as Edward Coke, John Selden and William Prynne, is the measure of their folly and their failure. Words that, rightly or wrongly, were ascribed to Bracton rang in Charles's ears when he was sent to the scaffold. For the modern student of mediaeval law many of the reported cases of the Stuart time are storehouses of valuable material, since the lawyers of the 17th century were mighty hunters after records. Prynne (d. 1669), the fanatical Puritan, published ancient documents with fervid zeal, and made possible a history of parliament. Selden (d. 1654) was in all Europe among the very first to write legal history as it should be written. His book about tithes is to this day a model and a masterpiece. When this accomplished scholar had declared that he had laboured to make himself worthy to be called a common lawyer, it could no longer be said that the common lawyers were *indoctissimum genus doctissimorum hominum*. Even pliant judges, whose tenure of office depended on the king's will, were compelled to cite and discuss old precedents before they could give judgment for their master; and even at their worst moments they would not openly break with mediaeval tradition, or declare in favour of that "modern police-State" which has too often become the ideal of foreign publicists trained in Byzantine law.

The 18th Century.—The current of legal doctrine was by this time so strong and voluminous that such events as the Civil War, the Restoration and the Revolution hardly deflected the course of the stream. In retrospect, Charles II. reigns so soon as life has left his father's body, and James II. ends a lawless career by a considerate and convenient abdication. The statute book of the restored king was enriched by leaves excerpted from the acts of a lord protector; and Matthew Hale (d. 1676), who was, perhaps, the last of the great record-searching judges, sketched a map of English law which Blackstone was to colour. Then a time of self-complacency came for the law, which knew itself to be the perfection of wisdom, and any proposal for drastic legislation would have worn the garb discredited by the tyranny of the Puritan Caesar. The need for the yearly renewal of the Mutiny Act secured an annual session of parliament. The mass of the statute law made in the 18th century is enormous; but, even when we have excluded from view such acts as are technically called "private," the residuary matter bears a wonderfully empirical, partial and minutely particularizing character. In this "age of reason," as we are wont to think it, the British parliament seems rarely to rise to the dignity of a general proposition, and in our own day the legal practitioner is likely to know less about the statutes of the 18th century than he knows about the statutes of Edward I., Henry VIII. and Elizabeth. Parliament, it should be remembered, was endeavouring directly to govern the nation. There was little that resembled the permanent civil service of to-day. The choice lay between direct parliamentary government and royal "prerogative"; and lengthy statutes did much of that work of detail which would now be done by virtue of the powers that are delegated to ministers and governmental boards. Moreover, extreme and verbose particularity was required in statutes, for judges were loath to admit that the common law was capable of amendment. A vague doctrine, inherited from Coke, taught that statutes might be so unreasonable as to be null, and any political theory that seemed to derive from Hobbes would have been regarded with not unjust suspicion. But the doctrine in question never took tangible shape, and enough could be done to protect the common law by a niggardly exposition of every legislating word. It is to be remembered that some main features of English public law were attracting the admiration of enlightened Europe. When Voltaire and Montesquieu applauded, the English lawyer had cause for complacency.

The common law was by no means stagnant. Many rules which come to the front in the 18th century are hardly to be traced farther. Especially is this the case in the province of mercantile law, where the earl of Mansfield's (d. 1793) long presidency over the king's bench marked an epoch. It is too often forgotten that, until Elizabeth's reign, England was a thoroughly rustic kingdom, and that trade with England was mainly in the hands of foreigners. Also in mediaeval fairs, the assembled merchants declared their own "law merchant," which was considered to have a supernational validity. In the reports of the common law courts it is late in the day before we read of some mercantile usages which can be traced far back in the statutes of Italian cities. Even on the basis of the excessively elaborated land law—a basis which Coke's Commentary on Littleton seemed to have settled for ever—a lofty and ingenious superstructure could be reared. One after another delicate devices were invented for the accommodation of new wants within the law; but only by the assurance that the old law could not be frankly abolished can we be induced to admire the subtlety that was thus displayed. As to procedure, it had become a maze of evasive fictions, to which only a few learned men held the historical clue. By fiction the courts had stolen business from each other, and by fiction a few comparatively speedy forms of action were set to tasks for which they were not originally framed. Two fictitious persons, John Doe and Richard Roe, reigned supreme. On the other hand, that healthy and vigorous institution,

the Commission of the Peace, with a long history behind it, was giving an important share in the administration of justice to numerous country gentlemen who were thus compelled to learn some law. A like beneficial work was being done among jurors, who, having ceased to be regarded as witnesses, had become "judges of fact." No one doubted that trial by jury was the "palladium" of English liberties, and popularity awaited those who would exalt the office of the jurors and narrowly limit the powers of the judge.

Equity.—But during this age the chief addition to English jurisprudence was made by the crystallization of the chancellor's equity. In the 17th century the chancery had a narrow escape from sharing the fate that befell its twin sister the Star Chamber. Its younger sister the court of requests perished under the persistent attacks of the common lawyers. Having outlived troubles, the chancery took to orderly habits, and administered under the name of "equity" a growing group of rules, which in fact were supplemental law. Stages in this process are marked by the chancellorships of Nottingham (1673–75) and Hardwicke (1737–56). Slowly a continuous series of Equity Reports began to flow, and still more slowly an "equity bar" began to form itself. The principal outlines of equity were drawn by men who were steeped in the common law. By way of ornament a Roman maxim might be borrowed from a French or Dutch expositor, or a phrase which smacked of that "nature-rightly" school which was dominating continental Europe; but the influence exercised by Roman law upon English equity has been the subject of gross exaggeration. Parliament and the old courts being what they were, perhaps it was only in a new court that the requisite new law could be evolved. The result was not altogether satisfactory. Freed from contact with the plain man in the jury-box, the chancellors were tempted to forget how plain and rough good law should be, and to screw up the legal standard of reasonable conduct to a height hardly attainable except by those whose purses could command the constant advice of a family solicitor. A court which started with the idea of doing summary justice for the poor became a court which did a highly refined, but tardy justice, suitable only to the rich. (*See* EQUITY.)

Blackstone.—About the middle of the century William Blackstone, then a disappointed barrister, began to give lectures on English law at Oxford (1758), and soon afterwards he began to publish (1765) his *Commentaries*. Accurate enough in its history and doctrine to be an invaluable guide to professional students and a useful aid to practitioners, his book set before the unprofessional public an artistic picture of the laws of England such as had never been drawn of any similar system. No nation but the English had so eminently readable a law-book, and it must be doubtful whether any other lawyer ever did more important work than was done by the first professor of English law. Over and over again the *Commentaries* were edited, sometimes by distinguished men, and it is hardly too much to say that for nearly a century the English lawyer's main ideas of the organization and articulation of the body of English law were controlled by Blackstone. This was far from all. The Tory lawyer little thought that he was giving law to colonies that were on the eve of a great and successful rebellion. Yet so it was. In America, where books were few and lawyers had a mighty task to perform, Blackstone's facile presentment of the law of the mother country was of inestimable value. It has been said that among American lawyers the *Commentaries* "stood for the law of England," and this at a time when the American daughter of English law was rapidly growing in stature, and was preparing herself for her destined march from the Atlantic to the Pacific ocean. Excising only what seemed to savour of oligarchy, those who had defied King George retained with marvellous tenacity the law of their forefathers. Profound discussions of English mediaeval law have been heard in American courts; admirable researches into the recesses of the Year-Books have been made in American law schools; the names of the great American judges are familiar in an England which knows little indeed of foreign jurists; and the debt due for the loan of Blackstone's *Commentaries* is being fast repaid. Lectures on the common law delivered by Mr. Justice Holmes of the Supreme Court of the United States may even have begun to turn the scale against the old country. No chapter in Blackstone's book nowadays seems more antiquated than that which describes the modest territorial limits of that English law which was to spread throughout Australia and New Zealand and to follow the dominant race in India.

Bentham.—Long wars, vast economic changes and the conservatism generated by the French Revolution piled up a monstrous arrear of work for the English legislature. Meanwhile, Jeremy Bentham (d. 1832) had laboured for the overthrow of much that Blackstone had lauded. Bentham's largest projects of destruction and reconstruction took but little effect. Profoundly convinced of the fungibility and pliability of mankind, he was but too ready to draw a code for England or Spain or Russia at the shortest notice; and, scornful as he was of the past and its historic deposit, a code drawn by Bentham would have been a sorry failure. On the other hand, as a critic and derider of the system which Blackstone had complacently expounded he did excellent service. Reform, and radical reform, was indeed sadly needed throughout a system which was encumbered by noxious rubbish, the useless leavings of the middle ages: trial by battle and compurgation, deodands and benefit of clergy, John Doe and Richard Roe. It is perhaps the main fault of "judge-made law" (to use Bentham's phrase) that its destructive work can never be cleanly done. Of all vitality, and therefore of all patent harmfulness, the old rule can be deprived, but the moribund husk must remain in the system doing latent mischief. English law was full of decaying husks when Bentham attacked it, and his persistent demand for reasons could not be answered. At length a general interest in "law reform" was excited; Romilly and Brougham were inspired by Bentham, and the great changes in constitutional law which cluster round the Reform Act of 1832 were accompanied by many measures which purged the private, procedural and criminal law of much, though hardly enough, of the mediaeval dross. Some credit for rousing an interest in law, in definitions of legal terms, and in schemes of codification, is due to John Austin (d. 1859) who was regarded as the jurist of the reforming and utilitarian group. But, though he was at times an acute dissector of confused thought, he was too ignorant of the English, the Roman and every other system of law to make any considerable addition to the sum of knowledge; and when Savigny, the herald of evolution, was already in the field, the day for a "Nature-Right"—and Austin's projected "general jurisprudence" would have been a Nature-Right—was past beyond recall. The obsolescence of the map of law which Blackstone had inherited from Hale, and in which many outlines were drawn by mediaeval formulas, left intelligent English lawyers without a guide, and they were willing to listen for a while to what in their insularity they thought to be the voice of cosmopolitan science. Little came of it all. The revived study of Germanic law in Germany, which was just beginning in Austin's day, seems to be showing that the scheme of Roman jurisprudence is not the scheme into which English law will run without distortion.

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ENGLISH LITERATURE. The following discussion of the evolution of English literature is planned to give a comprehensive view, the details as to particular authors and their work being reserved for separate articles. As the precise delimitation of what may narrowly be called "English" literature, *i.e.*, in the English language, is perhaps impossible, the reader is referred to supplementary articles on the literature of Scotland, Ireland, Wales, Canada and the United States, and to such general accounts of particular forms as NOVEL; ROMANCE; VERSE, etc.

I. EARLIEST TIMES TO CHAUCER

Though there is no evidence either that the heathen English had adopted the Roman alphabet, or that they had learned to employ their native monumental script (the runes) on materials suitable for continuous writing, it is certain that in the pre-literary period at least one species of poetic art had attained a high degree of development, and that an extensive body of poetry was handed down. This unwritten poetry was the work of minstrels who found their audiences in the halls of kings and nobles. Its themes were the exploits of heroes of Germanic Europe, with which its listeners claimed kinship. Its metre was the alliterative long line, the lax rhythm of which shows that it was intended, not to be sung to regular melodies, but to be recited. Of its beauty and power we may judge from the best passages in *Beowulf* (*q.v.*); for there can be little doubt that this poem gained nothing and lost much in the process of literary redaction.

The conversion of the people to Christianity necessarily involved the decline of the minstrelsy that celebrated the glories of heathen times. Yet the descendants of Woden, even when they were devout Christians, would not easily lose all interest in the achievements of their kindred of former days. Chaucer's knowledge of "the song of Wade" is one proof among others that even so late as the 14th century the deeds of pagan heroes had not ceased to be recited in minstrel verse. The paucity of the extant remains of Old English heroic poetry is no argument to the contrary. The wonder is that any of it has survived at all. The clergy, to whom we owe the writing and the preservation of the Old English mss., would only in rare instances be keenly interested in secular poetry. We possess, in fact, portions of four narrative poems, treating of heroic legend—*Beowulf, Widsith, Finnesburh,* and *Waldere.* The second of these has no poetical merit, but great archaeological interest. It is an enumeration of the famous kings known to German tradition, put into the mouth of a minstrel, Widsith (the "far-travelled"), who claims to have been at many of their courts and to have been rewarded by them for his song. The extant fragment of *Finnesburh* is a battle piece, belonging to a story of which another part is introduced episodically in *Beowulf*. *Waldere,* of which we have two fragments, is concerned with Frankish and Burgundian traditions based on events of the 5th century; the hero is the "Waltharius" of Ekkehart's Latin epic. The English poem may possibly be rather a literary composition than a genuine example of minstrel poetry, but the portions that have survived are hardly inferior to the best passages of *Beowulf.*

It may be assumed that the minstrels who entertained the English kings and nobles with the recital of these heroic traditions would also celebrate the martial deeds of their patrons and ancestors. There may have existed an abundance of poetry commemorative of events in the conquest of Britain and the struggle with the Danes. Two examples only have survived, both belonging to the 10th century: *the Battle of Brunanburh,* and the *Battle of Maldon,* a work of greater merit but only a fragment.

The rapidity and thoroughness of the adoption of Christian civilization had an immediate effect. Augustine had landed in 597, and 40 years later was born an Englishman, Aldhelm, who in the judgment of contemporary Europe was the most accomplished scholar and the finest Latin writer of his time. In the next generation England produced in Bede (Baeda) a man who in solidity and variety of knowledge, and in literary power, had for centuries no rival. Aldhelm and Bede are known to us only from their Latin writings, though the former is recorded to have written vernacular poetry. The extant Old English literature is almost entirely Christian, for the poems that belong to an earlier period have been expurgated and given a Christian tone. English heathenism perished without leaving a record.

English Religious Poetry.—The Old English religious poetry was written, probably without exception, in the cloister, and by men who were familiar with the Bible and with Latin devotional literature. With the exception of the *Dream of the Rood,* it gives little evidence of poetic genius. Its material and thought are mainly derived from Latin sources; its expression is imitated from the native heroic poetry. Considering that a great deal of Latin verse was written by Englishmen in the 7th and succeeding centuries, and that in one or two poems the line is actually composed of an English and a Latin hemistich rhyming together, it seems strange that the Latin influence on Old English versification should have been so small. The alliterative long line is throughout the only metre employed, and although the laws of alliteration and rhythm were less rigorously obeyed in the later than in the earlier poetry, there is no trace of approximation to the structure of Latin verse. It is true that, owing to imitation of the Latin hymns of the church, rhyme came gradually to be more and more frequently used as an ornament of Old English verse; but it remained an ornament only, and never became an essential feature. It was not only in metrical respects but in imagery and diction that the Old English religious poetry remained faithful to its native models. Nearly all the religious poetry of any value seems to have been written in Northumbria during the 8th century. The vigorous poem of *Judith,* however, is certainly much later; and the *Exodus,* though early, seems to be of southern origin. For a detailed account of the Old English sacred poetry, the reader is referred to the articles on CAEDMON and CYNEWULF. The Riddles of the Exeter Book (*q.v.*) resemble the religious poetry in being the work of scholars, but they bear a deeper impress of the native English character.

The most original portion of the Old English literary poetry is the group of dramatic monologues—*The Banished Wife's Complaint, The Husband's Message, The Wanderer, The Seafarer, Deor* and *Wulf and Eadwacer.* The date of these is uncertain, though it cannot be later than the 10th century. That they are all of one period is unlikely, but they are all marked by the same peculiar pathos. It is not improbable that most of these poems relate to incidents of heroic legend, but this can be definitely affirmed only in the case of two short pieces, *Deor* and *Wulf and Eadwacer,* which have something of a lyric character, and are the only examples in Old English of strophic structure and the use of the refrain. *Wulf and Eadwacer* exhibits a further development in the same direction, the monotony of the long line metre being varied by the admission of short lines formed by the suppression of the second hemistich.

The Beginnings of Prose.—English prose may be said to have had its effective beginning in the reign of Alfred. It is true that vernacular prose of some kind was written much earlier. The English laws of Aethelberht of Kent, though it is perhaps unlikely that they were written down, as is commonly supposed, in the lifetime of Augustine (died A.D. 604), or even in that of the king (d. 616), were well known to Bede; and even in the 12th-century transcript their crude and elliptical style gives evidence of high antiquity. The early part of the Anglo-Saxon Chronicle (*q.v.*) is probably founded partly on prose annals of pre-Alfredian date. But although the amount of English prose written between the beginning of the 7th and the middle of the 9th century may have been considerable, Latin continued to be regarded as the appropriate vehicle for works of any literary pretension.

Of the works translated by Alfred and the scholars whom he employed, *St. Gregory's Pastoral Care* and his *Dialogues* are addressed to the priesthood; the other translations are all (not excepting the secular *History of Orosius*) essentially religious in purpose and spirit. In the preface to the *Pastoral Care,* in the accounts of Northern lands and peoples inserted in the *Orosius,* and in the free rendering of the *Consolation* of Boethius and of the *Soliloquies* of Augustine, Alfred appears as an original writer. Other fruits of his activity are his Laws and the beginnings of the Anglo-Saxon Chronicle. The Old English prose after Alfred is entirely of clerical authorship. Apart from the Chronicle, the bulk of this literature consists of translations from Latin and of homilies and saints' lives, the substance of which is derived from sources mostly accessible to us in their original form; it has therefore for us little importance except from the philological point of view. This remark may be applied, in the main, even to the writings of Aelfric, notwithstanding the interest which attaches to his achievement in the development of the capacities of the language for literary expression. The translation of the gospels, though executed in Aelfric's time (*c.* 1000), is by other

hands. The sermons of his younger contemporary, Archbishop Wulfstan, are marked by eloquence, and contain passages of historical value.

From the early years of the 11th century we possess an encyclopaedic manual of the science of the time—chronology, astronomy, arithmetic, metre, rhetoric and ethics—by the monk Byrhtferth, a pupil of Abbo of Fleury. The numerous works on medicine, the properties of herbs, and the like, are in the main selections from Latin treatises. Two famous works of fiction, the romance of *Apollonius of Tyre* and the *Letter of Alexander,* which in their Latin form had much influence on the later literature of Europe, were Englished in the 11th century. To the same period belongs the curious tract on *The Wonders of the East.*

French Influence.—The crowding of the monasteries by foreigners, after the Norman Conquest, arrested the development of the vernacular literature. It was not long before the boys in the monastic schools ceased to learn to read and write their native tongue, and learned instead to read and write French. The effects of this change are visible in the rapid alteration of the literary language. The artificial tradition of grammatical correctness lost its hold; the archaic vocabulary fell into disuse; and those who wrote English at all wrote as they spoke, using more and more an extemporized phonetic spelling based largely on French analogies. The 12th century is a brilliant period in the history of Anglo-Latin literature, and many works of merit were written in French (*see* ANGLO-NORMAN LITERATURE); but vernacular literature is scanty and of little originality. The *Peterborough Chronicle,* it is true, was continued till 1154, and its later parts contain admirable writing. But it is substantially correct to say that from this point until the age of Chaucer vernacular prose served no other purpose than that of popular religious edification. At the beginning of the 13th century the *Ancren Riwle* (*q.v.*), a book of counsel for nuns, shows literary genius, but the author's culture was French rather than English. In the early 14th century the writings of Richard Rolle and his school attained great popularity and exercised great influence on later religious thought, and in the development of prose style. The interest of *The Ayenbite of Inwyt* (*see* MICHEL OF NORTHGATE, DAN), an unintelligent translation (finished in 1340) from Frère Lorens's *Somme des vices et des vertus,* is exclusively philological.

This break in the continuity of literary tradition was no less complete in poetry. The verse from the latter part of the 12th century was uninfluenced by the work of Old English poets, whose diction had become unintelligible. There is no ground, however, to suppose that the succession of popular singers and reciters was interrupted. In the north-west the old recitative metre seems to have survived in oral tradition, with little more alteration than was rendered necessary by the changes in the language, until the middle of the 14th century, when it was again adopted by literary versifiers. The influence of native popular poetic tradition is clearly discernible in the earliest Middle English poems; but the authors of these poems were familiar with Latin, and probably spoke French as easily as their mother tongue. The artless verses of the hermit Godric, who died in 1170, exhibit in their metre the combined influence of native rhythm and of that of Latin hymnology. The *Proverbs of Alfred,* written about 1200, is (like the later *Proverbs of Hendyng*) a gnomic poem of the old Germanic type, and its rhythm is mainly of native origin. On the other hand, the meditation known as the *Moral Ode,* somewhat earlier in date, is in a metre derived from contemporary Latin verse. In the *Ormulum* (*see* ORM) this metre known as the septenarius appears without rhyme, and with a syllabic regularity previously without example in English verse. In the poetry of the 13th century the influence of French models is conspicuous. The many devotional lyrics, such as the *Luve Ron* of Thomas of Hales, show this influence both in their metrical form and in their mystical tenderness and fervour. The *Story of Genesis and Exodus,* of small poetic merit, derives its metre chiefly from French. In the sprightly dialogue of the *Owl and Nightingale,* about 1230, we have a "contention" of the type familiar in French and Provençal literature. The "Gallic" humour may be seen in various other writings of this period, notably in the *Land of Cockaigne,* a satire on monastic self-indulgence, and in the fabliau of *Dame Siriz,* a story of Eastern origin, told with almost Chaucerian skill. Predominantly French in metrical structure are the love poems collected in ms. Harl. 2253, written about 1320 in Herefordshire, some of which find a place in modern anthologies. It is noteworthy that they are accompanied by French lyrics very similar in style. The same ms. contains, besides some religious poetry, a number of political songs of the time of Edward II. Later, the victories of Edward III. down to the taking of Guisnes in 1352 were celebrated by the Yorkshireman Laurence Minot in alliterative verse with strophic arrangement and rhyme.

Metrical Chronicles.—At the beginning of the 13th century a new species of composition, the metrical chronicle, appears. The work of Layamon, a history (partly legendary) of Britain from the time of the mythical Brutus till after the mission of Augustine, is a free rendering of the Norman-French *Brut* of Wace, with additions from traditional sources. Echoes of its diction appear in the chronicle ascribed to Robert of Gloucester, written about 1300. This work, founded in its earlier part on the Latin historians of the 12th century, is an independent historical source for events of the writer's time. The succession of versified histories was continued by Thomas Bek of Castleford and by Robert Mannyng of Brunne. Mannyng's chronicle, finished in 1338, is a translation, in its earlier part from Wace's *Brut,* and in its later part from an Anglo-French chronicle written by Peter Langtoft.

Not far from the year 1300 (for the most part probably earlier rather than later) a vast mass of hagiological and homiletic verse was produced. To Gloucester belongs a series of Lives of Saints, metrically and linguistically resembling Robert of Gloucester's Chronicle. A similar collection was written in the north of England, as well as a large body of homilies, abounding in *exempla* or illustrative stories. The great rhyming chronicle of Scripture history entitled *Cursor Mundi* (*q.v.*) was written in the north about this time. The remaining homiletic verse of this period is too abundant to be referred to in detail; it will be enough to mention the sermons of William of Shoreham, written in strophic form. To the next generation belongs the *Pricke of Conscience* by Richard Rolle, the influence of which was not less powerful than that of the author's prose writings.

Romances, Native and Imported.—Romantic poetry did not assume a vernacular form till about 1250. In the next 100 years its development was rapid. Of the mass of metrical romances produced during this period no detailed account need here be attempted (*see* ROMANCE; ARTHURIAN LEGEND). Native English traditions form the basis of *King Horn, Guy of Warwick, Bevis of Hampton* and *Havelok,* though the stories were first put into literary form by Anglo-Norman poets. The popularity of these tales (with which may be classed the wildly fictitious *Coeur de Lion*) was soon rivalled by that of importations from France. The English rendering of *Floris and Blanchefleur* (a love-romance of Greek origin) is found in the same ms. that contains the earliest copy of *King Horn.* Before the end of the century, the French "matter of Britain" was represented by the Southern *Arthur and Merlin* and the Northern *Tristram* and *Yvaine and Gawin,* and the "matter of France" by *Roland and Vernagu* and *Otuel;* the *Alexander* was also translated, but in this instance the immediate original was Anglo-French. The Auchinleck ms., written about 1330, contains no fewer than 14 poetical romances; and there were many others in circulation. About the middle of the 14th century, the Old English alliterative long line, which for centuries had been used only in unwritten minstrel poetry, reappears. In one of the earliest poems in this revived measure, *Wynnere and Wastour* (1352); the author complains that original minstrel poetry no longer finds a welcome in the halls of great nobles, who prefer to listen to those who recite verses not of their own making. About the same date the metre began to be employed by men of letters for the translation of romance—*William of Palerne* and *Joseph of Arimathea* from the French, *Alexander* from Latin prose. The later development of alliterative poetry belongs to the age of Chaucer.

The extent and character of the literature produced during the first half of the 14th century indicate that the literary use of the native tongue was no longer a condescension to the needs of the common people. The rapid disuse of French as the medium of intercourse and the consequent substitution of English for French for school instruction, created a demand for vernacular reading. Though the literature which arose in answer to this demand consisted mainly of translations or adaptations of foreign works, it prepared the way for verse in which the genuine thought and feeling of the nation were to find expression.

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II. CHAUCER TO THE RENAISSANCE

The age of Chaucer is of peculiar interest to the student of literature, not only because of its brilliance and productiveness but also because of its apparent promise for the future. In this, as in other aspects, Chaucer (*c.* 1340–1400) is its most notable literary figure. Beginning as a student and imitator of the best French poetry of his day, he was for a time, like most of his French contemporaries, little more than a skilful maker of elegant verses. Even at this time, to be sure, he was not without close and loving observation of the living creatures of the real world, and his verses often bring us flowers dewy and fragrant and fresh of colour as they grew in the fields and gardens about London, and birds that had learned their music in the woods; but his poetry was still not easily distinguishable from that of the "courtly makers" of France. While he was still striving to master the technique of this pretty art of trifling, he became acquainted with the new poetry of Italy. It is true that much of this new poetry moved, like that of France, among the artificialities of an unreal world of romance, but it was of wider range, of fuller tone, of far greater emotional intensity, and, at its best, was the fabric, not of elegant ingenuity, but of creative human passion,—in Dante, indeed, a wonderful visionary structure in which love and hate, and pity and terror, and the forms and countenances of men were more vivid and real than in the world of real men and real passions. Less powerful and intense than the work of Dante, but more suggestive of new methods of description, narration and characterization were the choral poems of Boccaccio, whose *La Teseide* and *Il Filostrato* not only furnished to Chaucer the materials for a new type of romance, but effected an entire transformation of his aims and artistic technique.

The Progress of Chaucer.—This transformation was effected not so much through the mere superiority of the Italian models to the French as through the stimulus which the differences between the two gave to his reflections upon the processes and technique of composition, for Chaucer was not a careless, happy-go-lucky poet of divine endowment, but a conscious, reflective artist, seeking not merely for fine words and fine sentiments, but for the proper arrangement of events, the significant exponent of character, the right tone, and even the appropriate background and atmosphere—as may be seen, for example, in the transfigurations he wrought in the *Pardoner's Tale*. It is therefore in the latest and most original of the *Canterbury Tales* that his art is most admirable, most distinguished by technical excellences. In these we find so many admirable qualities that we almost forget that he had any defects. His diction is a model of picturesqueness, of simplicity, of dignity and of perfect adaptation to his theme: his versification is not only correct but musical and varied, and shows a progressive tendency towards freer and more complex melodies; his best tales are not mere repetitions of the ancient stories they retell, but new creations, transformed by his own imaginative realization of them, full of figures having the dimensions and the vivacity of real life, acting on adequate motives, and moving in an atmosphere and against a background appropriate to their characters and their actions. In the tales of the Pardoner, the Franklin, the Summoner, the Squire, he is no less notable as a consummate artist than as a poet.

Chaucer, however, was not the only writer of his day remarkable for mastery of technique. Gower, indeed, though a man of much learning and intelligence, was neither a poet of the first rank nor an artist. Despite the admirable qualities of clearness, order and occasional picturesqueness which distinguish his work, he lacked the ability which great poets have of making their words mean more than they say, and of stirring the emotions even beyond the bounds of this enhanced meaning; and there is not, perhaps, in all his voluminous work in English, French and Latin, any indication that he regarded composition as an art requiring consideration or any care beyond that of conforming to the chosen rhythm and finding suitable rhymes.

Other Poets of Genius.—There were others more richly endowed as poets and more finely developed as artists. There was the beginner of the *Piers Plowman* cycle, the author of the Prologue and first eight passus of the A-text, a man of clear and profound observation, a poet whose imagination brought before him with distinctness and reality visual images of the motley individuals and masses of men of whom he wrote, an artist who knew how to organize and direct the figures of his dream-world, the movement of his ever-unfolding vision. There was the remarkable successor of this man, the author of the B-text, an almost prophetic figure, a great poetic idealist, and, helpless though he often was in the direction of his thought, an absolute master of images and words that seize upon the heart and haunt the memory. Besides these, an unknown writer in the west midlands had, in *Gawayne and the Grene Knight*, transformed the mediaeval romance into a thing of speed and colour, of vitality and mystery, no less remarkable for its fluent definiteness of form than for the delights of hall-feast and hunt, the graceful comedy of temptation, and the lonely ride of the doomed Gawayne through the silence of the forest and the deep snow. In the same region, by its author's power of visual imagination, the Biblical paraphrase, so often a mere humdrum narrative, had been transformed, in *Patience*, into a narrative so detailed and vivid that the reader is almost ready to believe that the author himself, rather than Jonah, went down into the sea in the belly of the great fish. And there also, by some strange chance, blossomed, with perhaps only a local and temporary fragrance until its rediscovery in the 19th century, that delicate flower of mystical aspiration, *Pearl*, a wonder of elaborate art as well as of touching sentiment.

All these writings are great, not only relatively, but absolutely. There is not one of them which would not, if written in our own time, immediately mark its author as a man of very unusual ability. But the point of special concern to us at the present moment is not so much that they show remarkable poetic power, as that they possess technical merits of a very high order. And we are accustomed to believe that, although genius is a purely personal and incommunicable element, technical gains are a common possession; that after Marlowe had developed the technique of blank verse, this technique was available for all; that after Pope had mastered the heroic couplet and Gray the ode, and Poe the short story, all men could write couplets and odes and short stories of technical correctness; that, as Tennyson puts it,

"All can grow the flower now,
For all have got the seed."

But this was singularly untrue of the technical gains made by Chaucer and his great contemporaries. *Pearl* and *Patience* were apparently unknown to the 15th century, but *Gawayne* and *Piers Plowman* and Chaucer's works were known and were influential in one way or another throughout the century. *Gawayne* called into existence a large number of romances dealing with the same hero or with somewhat similar situations, some of them written in verse suggested by the remarkable verse of their model, but the resemblance, even in versification, is only superficial. *Piers Plowman* gave rise to satirical allegories written in the alliterative long line and furnished the figures and the machinery for many satires in other metres, but the technical excellence of the first

Piers Plowman poem was soon buried for centuries under the tremendous social significance of itself and its successors. And Chaucer, in spite of the fact that he was praised and imitated by many writers and definitely claimed as master by more than one, not only transmitted to them scarcely any of the technical conquests he had made, but seems also to have been almost without success in creating any change in the taste of the public that read his poems so eagerly, any demand for better literature than had been written by his predecessors.

Lydgate, Hoccleve and Hawes.—Wide and lasting Chaucer's influence undoubtedly was. Not only was all the poetry of writers who pretended to cultivation and refinement, throughout the century, in England and Scotland, either directly or indirectly imitative of his work, but even the humblest productions of unpretentious writers show at times traces of his influence. Scotland was fortunate in having writers of greater ability than England had (*see* SCOTLAND: *Literature*). In England the three chief followers of Chaucer known to us by name are Lydgate, Hoccleve (*see* OCCLEVE) and Hawes. Because of their praise of Chaucer and their supposed personal relations to him, Lydgate and Hoccleve are almost inseparable in modern discussions, but 15th century readers and writers appear not to have associated them very closely. Hoccleve was not as prolific as Lydgate, but it is difficult to understand why his work, which compares favourably in quality with Lydgate's, attracted so much less attention. The title of his greatest poem, *De regimine principum,* may have repelled readers who were not princely born, though they would have found the work full of the moral and prudential maxims and illustrative anecdotes so dear to them; but his attack upon Sir John Oldcastle as a heretic ought to have been decidedly to the taste of the orthodox upper classes, while his lamentations over his misspent youth, his tales and some of his minor poems might have interested any one. Of a less vigorous spirit than Lydgate, he was, in his mild way, more humorous and more original. Also despite his sense of personal loss in Chaucer's death and his care to transmit to posterity the likeness of his beloved master, he seems to have been less slavish than Lydgate in imitating him. His memory is full of Chaucer's phrases, he writes in verse-forms hallowed by the master's use, and he tries to give to his lines the movement of Chaucer's decasyllables, but he is comparatively free from the influence of those early allegorical works of the master which produced the dreary imitations of the 15th century.

Lydgate's productivity was enormous—how great no man can say, for, as was the case with Chaucer also, his fame caused many masterless poems to be ascribed to him, but, after making all necessary deductions, the amount of verse that has come down to us from him is astonishing. Here it may suffice to say that his translations are predominantly epic (140,000 lines), and his original compositions predominantly allegorical love poems or didactic poems. If there is anything duller than a dull epic it is a dull allegory, and Lydgate has achieved both. This is not to deny the existence of good passages in his epics and ingenuity in his allegories, but there is no pervading, persistent life in either. His epics, like almost all the narrative verse of the time, whether epic, legend, versified chronicle or metrical romance, seem designed merely to satisfy the desire of 15th century readers for information, the craving for facts—true or fictitious—the same craving that made possible the poems on alchemy, on hunting, on manners and morals, on the duties of parish priests, on the seven liberal arts. His allegories, like most allegories of the age, are ingenious rearrangements of old figures and old machinery; they are full of what had once been imagination but had become merely memory assisted by cleverness. The great fault of all his work, as of nearly all the literature of the age, is that it is merely a more or less skilful manipulation of what the author had somewhere read or heard, and not a faithful transcript of the author's own peculiar sense or conception of what he had seen or heard or read. Style, to be sure, was a thing that Lydgate and his fellows tried to supply, and some of them supplied it abundantly according to their lights. But style meant to them external decoration, classical allusions, personifications, an inverted or even dislocated order of words, and "ornate diction."

Stephen Hawes, with his allegorical treatise on the seven liberal sciences, came later than these men, only to write worse. He was a disciple of Lydgate rather than of Chaucer, and is not only lacking in the vigour and sensitiveness which Lydgate sometimes displays, but exaggerates the defects of his master. If it be a merit to have conceived the pursuit of knowledge under the form of the efforts of a knight to win the hand of his lady, it is almost the sole merit to which Hawes can lay claim. Two or three good situations, an episode of low comedy, and the epitaph of the Knight with its famous final couplet, exhaust the list of his credits. The efforts that have been made to trace through Hawes the line of Spenser's spiritual ancestry seem not well advised.

The Failure of Chaucer's Imitators.—It is obvious that the fundamental lack of all these men was imaginative power, poetic ability. But even recognizing that the followers of Chaucer were not men of genius, it seems strange that their imitation of Chaucer was what it was. They not only entirely failed to see what his merits as an artist were and how greatly superior his mature work is to his earlier in point of technique; they even preferred the earlier and imitated it almost exclusively. Furthermore, his mastery of verse seemed to them to consist solely in writing verses of approximately four or five stresses and arranging them in couplets or in stanzas of seven or eight lines. Their preference for the early allegorical work can be explained by their lack of taste and critical discernment and by the great vogue of allegorical writing in England and France. Men who are just beginning to think about the distinction between literature and ordinary writing usually feel that it consists in making literary expression differ as widely as possible from simple direct speech. For this reason some sort of artificial diction is developed and some artificial word order devised. Allegory is used as an elegant method of avoiding unpoetical plainness, and as an easy means of substituting logic for imagination. The failure to reproduce in some degree at least the melody and smoothness of Chaucer's decasyllabic verse, and the particular form which that failure took in Lydgate, are to be explained by the fact that Lydgate and his fellows never knew how Chaucer's verse sounded when properly read. We know that a misunderstanding of Chaucer's verse existed from the 16th century to the time of Thomas Tyrwhitt; it seems clear that it began even earlier, in Chaucer's own lifetime.

There are several poems of the 15th century which were long ascribed to Chaucer. Among them are:—the *Complaint of the Black Knight,* or *Complaint of a Lover's Life,* now known to be Lydgate's; the *Mother of God,* now ascribed to Hoccleve; the *Cuckoo and the Nightingale,* by Clanvowe; *La Belle Dame sans merci,* a translation from the French of Alain Chartier by Richard Ros; *Chaucer's Dream, or the Isle of Ladies;* the *Assembly of Ladies;* the *Flower and the Leaf;* and the *Court of Love.* The two poems of Lydgate and Hoccleve are as good as Chaucer's poorest work. The *Assembly of Ladies* and the *Flower and the Leaf* are perhaps better than the *Book of the Duchess,* but not so good as the *Parliament of Fowls.* The *Flower and the Leaf,* it will be remembered, was very dear to John Keats, who, like all his contemporaries, regarded it as Chaucer's. An additional interest attaches to both it and the *Assembly of Ladies,* from the fact that the author may have been a woman. These poems, like the *Court of Love,* are thoroughly conventional in material, all the figures and poetical machinery may be found in dozens of other poems in England and France, as Prof. Neilson has shown for the *Court of Love* and Marsh for the *Flower and the Leaf;* but there are a freshness of spirit and a love of beauty in them that are not common; the conventional birds and flowers are there, but they seem, like those of Chaucer's *Legend,* to have some touch of life, and the conventional companies of ladies and gentlemen ride and talk and walk with natural grace and ease. The *Court of Love* is usually ascribed to a very late date, as late even as the middle of the 16th century. If this is correct, it is a notable instance of the persistence of a Chaucerian influence.

Whatever may be true of the authorship of the *Assembly of Ladies* and the *Flower and the Leaf,* there were women writers in England in the middle ages. Juliana of Norwich wrote her *Revelations of Divine Love* before 1400. The much discussed

Dame Juliana Berners, the supposed compiler of the treatise on hunting in the *Book of St. Albans,* may be mythical, though there is no reason why a woman should not have written such a book; and a shadowy figure that disappears entirely in the sunlight is the supposed authoress of the *Nut Brown Maid,* for if language is capable of definite meaning, the last stanza declares unequivocally that the poem is the work of a man. But there is a poem warning young women against entering a nunnery which may be by a woman, and there is an interesting entry among the records of New Romney for 1463–64, "Paid to Agnes Forde for the play of the Interlude of our Lord's Passion, 6s. 8d.," which is apparently the earliest mention of a woman dramatist in England. Finally, Margaret, countess of Richmond, the mother of Henry VII., not only aided scholars and encouraged writers, but herself translated the (spurious) fourth book of St. Thomas à Kempis's *Imitatio Christi.* Another Margaret, the duchess of Burgundy, it will be remembered, encouraged Caxton in his translation and printing. Women seem, indeed, to have been especially lovers of books and patrons of writers, and Skelton, if we may believe his *Garland of Laurel,* was surrounded by a bevy of ladies comparable to a modern literary club.

Songs, Carols and Ballads.—The most original and powerful poetry of the 15th century was composed in popular forms for the ear of the common people and was apparently written without conscious artistic purpose. Three classes of productions deserve special attention—songs and carols, popular ballads and certain dramatic compositions. The songs and carols belong to a species which may have existed in England before the Norman Conquest, but which certainly was greatly modified by the musical and lyric forms of France. The best of them are the direct and simple if not entirely artless expressions of personal emotion, and even when they contain, as they sometimes do, the description of a person, a situation, or an event, they deal with these things so subjectively, confine themselves so closely to the rendering of the emotional effect upon the singer, that they lose none of their directness or simplicity. Some of them deal with secular subjects, some with religious, and some are curious and delightful blendings of religious worship and aspiration with earthly tenderness for the embodiments of helpless infancy and protecting motherhood which gave Christianity so much of its power over the affections and imagination of the middle ages. Even those which begin as mere expressions of joy in the Yuletide eating and drinking and merriment catch at moments hints of higher joys, of finer emotions, and lift singer and hearer above the noise and stir of earth.

The lyrics which describe a situation form a logical, if not a real transition to those which narrate an episode or an event. The most famous of the latter, the *Nut Brown Maid,* has often been called a ballad, and "lyrical ballad" it is in the sense established by Coleridge and Wordsworth, but its affinities are rather with the song or carol than with the folk-ballad, and, like Henryson's charming *Robin and Malkin,* it is certainly the work of a man of culture and of conscious artistic purpose and methods. Unaccompanied, as it is, by any other work of the same author, this poem, with its remarkable technical merits, is an even more astonishing literary phenomenon than the famous single sonnet of Blanco White.

The folk-ballad, like the song or carol, belongs in some form to immemorial antiquity. It can hardly be doubted that in some of the folk-ballads of the 15th century are preserved not only traditions of dateless antiquity, but formal elements and technical processes that actually are derived from communal song and dance. By the 15th century, however, communal habits and processes of composition had ceased, and the traditional elements, formulae and technique had become merely conventional aids and guides for the individual singer. Ancient as they were, conventional as, in a sense, they also were, they exercised none of the deadening, benumbing influence of ordinary conventions. At their best moments the best ballads have an almost incomparable power, and to a people sick, as we are, of the ordinary, the usual, the very trivialities and impertinences of the ballads only help to define and emphasize these best moments. In histories of English literature the ballads have been so commonly discussed in connection with their rediscovery in the 18th century, that we are apt to forget that some of the very best were demonstrably composed in the 15th and that many others of uncertain date probably belong to the same time.

Along with the genuine ballads dealing with a recent event or a traditional theme there were ballads in which earlier romances are retold in ballad style. This was doubtless inevitable in view of the increasing epic tendency of the ballad and the interest still felt in metrical romances, but it should not mislead us into regarding the genuine folk-ballad as an out-growth of the metrical romance.

Besides the ordinary epic or narrative ballad, the 15th century produced ballads in dramatic form, or, perhaps it were better to say, dramatized some of its epic ballads. How commonly this was done we do not know, but the scanty records of the period indicate that it was a widespread custom, though only three plays of this character (all concerning Robin Hood) have come down to us. These plays had, however, no further independent development, but merely furnished elements of incident and atmosphere to later plays of a more highly organized type. With these ballad plays may also be mentioned the Christmas plays (usually of St. George) and the sword-dance plays, which also flourished in the 15th century, but survive for us only as obscure elements in the masques and plays of Ben Jonson and in such modern rustic performances as Thomas Hardy has so charmingly described in *The Return of the Native.* For the contribution made by the 15th century to dramatic literature, the reader may be referred to the article Drama.

The Lack of Good Prose.—Not much good prose was written in the 15th century. It is doubtful if any one thought of prose as a possible medium of artistic expression. Chaucer apparently did not, in spite of the comparative excellence of his Preface to the *Astrolabe* and his occasional noteworthy successes with the difficulties of the philosophy of Boethius; Wycliffe is usually clumsy; and the translators of Mandeville, though they often give us passages of great charm, obviously were plain men who merely translated as best they could. There was, however, a comparatively large amount of prose written in the 15th century, mainly for religious or educational purposes, dealing with the same sorts of subjects that were dealt with in verse, and in some cases not distinguishable from the verse by any feature but the absence of rhyme. The vast body of this we must neglect; only five writers need be named: John Capgrave, Reginald Pecock, Sir John Fortescue, Caxton and Malory. Capgrave, the compiler of the first chronicle in English prose since the Conquest, wrote by preference in Latin; his English is a condescension to those who could not read Latin and has the qualities which belong to the talk of an earnest and sincere man of commonplace ability. Pecock and Fortescue are more important. Pecock (*c.* 1395–*c.* 1460) was a man of singularly acute and logical mind. He prided himself upon his dialectic skill and his faculty for discovering arguments that had been overlooked by others. His writings, therefore—or at least the *Repressor*—are excellent in general structure and arrangement, his ideas are presented clearly and simply, with few digressions or excrescences, and his sentences, though sometimes too long, are more like modern prose than any others before the age of Elizabeth. His style is lightened by frequent figures of speech, mostly illustrative, and really illustrative, of his ideas, while his intellectual ingenuity cannot fail to interest even those whom his prejudices and preconceptions repel. Fortescue, like Capgrave, wrote by preference in Latin, and, like Pecock, was philosophical and controversial. But his principal English work, the *Difference between an Absolute and a Limited Monarchy,* differs from Pecock's in being rather a pleading than a logical argument, and the geniality and glowing patriotism of its author give it a far greater human interest.

Caxton and Malory.—No new era in literary composition was marked by the activity of William Caxton as translator and publisher, though the printing-press has, of course, changed fundamentally the problem of the dissemination and preservation of culture, and thereby ultimately affected literary production

profoundly. But neither Caxton nor the writers whose works he printed produced anything new in form or spirit. His publications range over the whole field of 15th century literature, and no doubt he tried, as his quaint prefaces indicate, to direct the public taste to what was best among the works of the past, as when he printed and reprinted the *Canterbury Tales*, but among all his numerous publications not one is the herald of a new era. The only book of permanent interest as literature which he introduced to the world was the *Morte d'Arthur* of Sir Thomas Malory, and this is a compilation from older romances (*see* ARTHURIAN LEGEND). It is, to be sure, the one book of permanent literary significance produced in England in the 15th century; it glows with the warmth and beauty of the old knight's conception of chivalry and his love for the great deeds and great men of the visionary past, and it continually allures the reader by its fresh and vivid diction and by a syntax which, though sometimes faulty, has almost always a certain naïve charm.

Whatever may have been the effect of the wars and the growth of industrial life in England in withdrawing men of the best abilities from the pursuit of literature, neither these causes nor any other interfered with the activity of writers of lesser powers. The amount of writing is really astonishing, as is also its range. More than 300 separate works (exclusive of the large number still ascribed to Lydgate and of the 70 printed by Caxton) have been made accessible by the Early English Text Society and other public or private presses, and it seems probable that an equal number remains as yet unpublished. No list of these writings can be given here, but it may not be unprofitable to indicate the range of interests by noting the classes of writing represented. The classification is necessarily rough, as some writings belong to more than one type. We may note, first, love poems, allegorical and unallegorical, narrative, didactic, lyrical and quasi-lyrical; poems autobiographical and exculpatory; poems of eulogy and appeal for aid; tales of entertainment or instruction, in prose and in verse; histories ancient and modern, and brief accounts of recent historical events, in prose and in verse; prose romances and metrical romances; legends and lives of saints, in prose and in verse; poems and prose works of religious meditation, devotion and controversy; treatises of religious instruction, in prose and in verse; ethical and philosophical treatises, and ethical and prudential treatises; treatises of government, of political economy, of foreign travel, of hygiene, of surgery, of alchemy, of heraldry, of hunting and hawking and fishing, of farming, of good manners, and of cooking and carving. Prosaic and intended merely to serve practical uses as many of these were, verse is the medium of expression as often as prose. Besides this large amount and variety of English compositions, it must be remembered that much was also written in Latin, and that Latin and French works of this and other centuries were read by the educated classes.

Although the intellectual and spiritual movement which we call the Italian Renaissance was not unknown in England in the 14th and 15th centuries, it is not strange that it exercised no perceptible influence upon English literature, except in the case of Chaucer. Chaucer was the only English man of letters before the 16th century who knew Italian literature. The Italians who visited England and the Englishmen who visited Italy were interested, not in literature, but in scholarship. Such studies as were pursued by Free, Grey, Flemming, Tilly, Gunthorpe and others who went to Italy, made them better grammarians and rhetoricians, and no doubt gave them a freer, wider outlook, but upon their return to England they became immediately absorbed in administrative cares, which left them little leisure for literary composition, even if they had had any inclination to write. They prepared the way, however, for the leaders of the great intellectual awakening which began in England with Linacre, Colet, More and their fellows, and which finally culminated in the age of Spenser, Bacon, Shakespeare, Jonson, Gilbert, Harvey and Harriott.

When the middle ages ceased in England it is impossible to say definitely. Long after the new learning and culture of the Renaissance had been introduced there, long after classical and Italian models were eagerly chosen and followed, the epic and lyric models of the middle ages were admired and imitated, and the ancient forms of the drama lived side by side with the new until the time of Shakespeare himself. John Skelton, although according to Erasmus "unum Britannicarum literarum lumen ac decus," and although possessing great originality and vigour both in diction and in versification when attacking his enemies or indulging in playful rhyming, was not only a great admirer of Lydgate, but equalled even the worst of his predecessors in aureate pedantries of diction, in complicated impossibilities of syntax, and in meaningless inversions of word-order whenever he wished to write elegant and dignified literature. And not a little of the absurd diction of the middle of the 16th century is merely a continuation of the bad ideals and practices of the refined writers of the 15th.

In fine, the 15th century has, apart from its vigorous, though sometimes coarse, popular productions, little that can interest the lover of literature. Although, however, in the quality of its literary output it is decidedly inferior to the 14th century, the amount and the wide range of its productions indicate the gradual extension of the habit of reading to classes of society that were previously unlettered; and this was of great importance for the future of English literature, just as the innumerable dramatic performances throughout England were important in developing audiences for Marlowe and Shakespeare and Beaumont and Fletcher.

For bibliography *see* vol. ii. of the *Cambridge History of Literature* (1909); and Brandl's *Geschichte der mittelenglischen Literatur* (reprinted from Paul's *Grundriss der germanischen Philologie*). Interesting general discussions may be found in the larger histories of English Literature, such as Ten Brink's, Jusserand's, and (a little more antiquated) Courthope's and Morley's. (J. M. MA.)

III. ELIZABETHAN TIMES

General Influences, and Prologue to 1579.—The history of letters in England from More's *Utopia* (1516), the first Platonic vision, to Milton's *Samson Agonistes* (1671), the latest classic tragedy, is one and continuous. That is the period of the English Renaissance, in the wider sense, and it covers all and more of the literature loosely called "Elizabethan." With all its complexity and subdivisions, it has as real a unity as the age of Pericles, or that of Petrarch and Boccaccio, or the period in Germany that includes both Lessing and Heine. It is peculiar in length of span, in variety of power, and in wealth of production, though its master-works on the greater scale are relatively few. It is distinct, while never quite cut off, from the middle age preceding, and also from the classical or "Augustan" age that followed. The coming of Dryden denoted a new phase; but it was still a phase of the Renaissance; and the break that declared itself about 1660 counts as nothing beside the break with the middle ages; for this implied the whole change in art, thought and temper, which recreated the European mind. It is true that many filaments unite Renaissance and middle ages, not only in the religious and purely intellectual region, but in that of art. The matter of Geoffrey of Monmouth, the tales of Arthur and of Troilus, the old fairy folklore of the South, the topic of the *Falls of Princes,* lived on; and so did the characteristic mediaeval form, allegory and many of the old metres of the 14th century. But then these things were transformed, often out of knowledge. Shakespeare's use of the histories of Macbeth, Lear and Troilus, and Spenser's of the allegoric romance, are examples. And when the gifts of the middle ages are not transformed, as in the *Mirror for Magistrates,* they strike us as survivals from a lost world.

So vital a change took long in the working. The English Renaissance of letters only came into full flower during the last 20 years of the 16th century, later than in any Southern land; but it was all the richer for delay, and would have missed many a life-giving element could it have been driven forward sooner. If the actual process of genius is beyond analysis, we can still notice the subjects which genius receives, or chooses, to work upon, and also the vesture which it chooses for them; and we can watch some of the forces that long retard but in the end fertilize these workings of genius.

What, then, in England, were these forces? Two of them lie outside letters, namely, the political settlement, culminating in the

later reign of Elizabeth, and the religious settlement, whereby the Anglican Church grew out of the English Reformation. A third force lay within the sphere of the Renaissance itself, in the narrower meaning of the term. It was culture—the prefatory work of culture and education, which at once prepared and put off the flowering of pure genius. "Elizabethan" literature took its complexion from the circumstance that all these three forces were in operation at once. The Church began to be fully articulate, just when the national feeling was at its highest, and the tides of classical and immigrant culture were strongest. Spenser's *Faerie Queene*, Hooker's *Ecclesiastical Polity* and Shakespeare's *Henry V.* came in the same decade (1590–1600). But these three forces, political, religious and educational, were of very different duration and value. The enthusiasm of 1590–1600 was already dying down in the years 1600–10, when the great tragedies were written; and soon a wholly new set of political forces began to tell on art. The religious inspiration was mainly confined to certain important channels; and literature as a whole, from first to last, was far more secular than religious. But Renaissance culture, in its ramifications and consequences, tells all the time and over the whole field, from 1500 to 1660. It is this culture which really binds together the long and varied chronicle. Before passing to narrative, a short review of each of these elements is required.

Politics and Religion.—Down to 1579 the Tudor rule was hardly a direct inspiration to authors. The reign of Henry VII. was first duly told by Bacon, and that of Henry VIII. staged by Shakespeare and Fletcher, in the time of James I. Sir Thomas More found in Roper, and Wolsey in Cavendish, sound biographers, who are nearly the earliest in the language. The later years of Henry VIII. were full of episodes too tragically picturesque for safe handling in the lifetime of his children. The next two reigns were engrossed with the religious war; and the first 20 years of Elizabeth, if they laid the bases of an age of peace, well-being, and national self-confidence that was to prove a teeming soil for letters, were themselves poor in themes for patriotic art. The abortive treason of the northern earls was echoed only in a ringing ballad. But the voyagers, freebooters, and explorers reported their experiences as a duty, not for fame; and these, though not till the golden age, were edited by Hakluyt, and fledged the poetic fancies that took wing from the "Indian Peru" to the "still-vext Bermoothes." Yet, in default of any true historian, the queen's wise delays and diplomacies that upheld the English power, and her refusal to launch on a Protestant or a national war until occasion compelled and the country was ready, were subjects as uninspiring to poets as the burning questions of the royal marriage or the royal title. But by 1580 the nation was filled with the sense of Elizabeth's success and greatness and of its own prosperity. No shorter struggle and no less achievement could have nursed the insolent, jubilant patriotism of the years that followed; a feeling that for good reasons was peculiar to England among the nations, and created the peculiar forms of the chronicle play and poem. These were borrowed neither from antiquity nor from abroad, and were never afterwards revived. The same exultation found its way into the current forms of ode and pastoral, of masque and allegory, and into many a dedication and interlude of prose. It was so strong as to outlive the age that gave it warrant. The passion for England, the passion of England for herself, animates the bulk of Drayton's *Poly-Olbion*, which was finished so late as 1622. But the public issues were then changing, the temper was darker; and the civil struggle was to speak less in poetry than in the prose of political theory and ecclesiastical argument, until its after-explosion came in the verse of Milton.

The English Reformation, so long political rather than doctrinal or imaginative, cost much writing on all sides; but no book like Calvin's *Institution* is its trophy, at once defining the religious change for millions of later men and marking a term of departure in the national prose. Still, the debating weapons, the axes and billhooks, of vernacular English were sharpened—somewhat jaggedly—in the pamphlet battles that dwarfed the original energies of Sir Thomas More and evoked those of Tyndale and his friends. The powers of the same style were proved for descriptive economy by Starkey's Dialogue between Pole and Lupset, and for religious appeal by the blunt sound rhetoric and forthright jests in the sermons of Latimer (d. 1555). Foxe's reports of the martyrs are the type of early Protestant English (1563); but the reforming divines seldom became real men of letters even when their Puritanism, or discontent with the final Anglican settlement and its temper, began to announce itself. Their spirit, however, comes out in many a corner of poetry, in Gascoigne's *Steel Glass* as in Spenser's *Shepherd's Calendar;* and the English Reformation lived partly on its pre-natal memories of Langland as well as of Wycliffe. The fruit of the struggle, though retarded, was ample. Carrying on the work of Fisher and Cranmer, the new Church became the nursing mother of English prose, and trained it more than any single influence—trained it so well, for the purposes of sacred learning, translation and oratory, and also as a medium of poetic feeling, that in these activities England came to rival France. How late any religious writer of true rank arose may be seen by the lapse of over half a century between Henry VIII.'s Act of Supremacy and Hooker's treatise. But after Hooker the chain of eloquent divines was unbroken for 100 years.

Renaissance Culture had many stages and was fed from many streams. At the outset of the century, in the wake of Erasmus, under the teaching of Colet and his friends, there spread a sounder knowledge of the Greek and Latin tongues, of the classic texts, and so of the ancient life and mind. This period of humanism in the stricter sense was far less brilliant than in Italy and France. No very great scholar or savant arose in Britain for a long time; but neo-Latin literature, the satellite of scholarship, shone brightly in George Buchanan. But scholarship was created and secured; and in at least one, rather solitary, work of power, the *Utopia* (which remained in Latin till 1551), the fundamental process was begun which appropriates the Greek mind, not only for purposes of schooling, but as a source of new and independent thinking. In and after the middle of the century the classics were again put forward by Cheke, by Wilson in his *Art of Rhetoric* (1553), and by Ascham in his letters and in his *Schoolmaster* (1570), as the true staple of humane education, and the pattern for a simple yet lettered English. The literature of translations from the classics, in prose and verse, increased; and these works, at first plain, business-like, and uninspired, slowly rose in style and power, and at last, like the translations from modern tongues, were written by a series of masters of English, who thus introduced Plutarch and Tacitus to poets and historians. This labour of mediation was encouraged by the rapid expansion and reform of the two universities, of which almost every great master except Shakespeare was a member; and even Shakespeare had ample Latin for his purpose.

The direct impact of the classics on "Elizabethan" literature, whether through such translations or the originals, would take long to describe. But their indirect impact is far stronger, though in result the two are hard to discern. This is another point that distinguishes the English Renaissance from the Italian or the French, and makes it more complex. The knowledge of the thought, art and enthusiasms of Rome and Athens constantly came round through Italy or France, tinted and charged in the passage with something characteristic of those countries. The early playwrights read Seneca in Latin and English, but also the foreign Senecan tragedies. Spenser, when starting on his pastorals, studied the Sicilians, but also Sannazaro and Marot. Shakespeare saw heroic antiquity through Plutarch, but also, surely, through Montaigne's reading of antiquity. Few of the poets can have distinguished the original fountain of Plato from the canalized supply of the Italian Neoplatonists. The influence, however, of Cicero on the Anglican pulpit was immediate as well as constant; and so was that of the conciser Roman masters, Sallust and Tacitus, on Ben Jonson and on Bacon. Such scattered examples only intimate the existence of two great chapters of English literary history—the effects of the classics and the effects of Italy. The bibliography of 16th century translations from the Italian in the fields of political and moral speculation, poetry, fiction and the drama, is so large as itself to tell part of the story. The genius of Italy served the genius of England in three distinctive ways. It inspired the recovery, with new modulations, of a lost music and a

lost prosody. It modelled many of the chief poetic forms, which soon were developed out of recognition; such were tragedy, allegory, song, pastoral and sonnet. Thirdly, it disclosed some of the master-thoughts upon government and conduct formed both by the old and the new Mediterranean world. Machiavelli, the student of ancient Rome and modern Italy, riveted the creed of Bacon. It might be said that never has any modern people so influenced another in an equal space of time—and letters, here as ever, are only the voice, the symbol, of a whole life and culture—if we forgot the sway of French in the later 17th and 18th centuries. And the power of French was alive also in the 16th. The track of Marot, of Ronsard and the Pleiad and Desportes, of Rabelais and Calvin and Montaigne, is found in England. Journeymen like Boisteau and Belleforest handed on immortal tales. The influence is noteworthy of Spanish mannerists, above all of Guevara upon sententious prose, and of the novelists and humorists, headed by Cervantes, upon the drama. German legend is found not only in Marlowe's *Faustus*, but in the byways of play and story. It will be long before the rich and coloured tangle of these threads has been completely unravelled with due tact and science. The presence of one strand may here be mentioned, which appears in unexpected spots.

As in Greece, and as in the day of Coleridge and Shelley, the fabric of poetry and prose is shot through with philosophical ideas; a further distinction from other literatures like the Spanish of the golden age or the French of 1830. But these were not so much the ideas of the new physical science and of Bacon as of the ethical and metaphysical ferment. The wave of free talk in the circles of Marlowe, Greville and Raleigh ripples through their writings. Though the direct influence of Giordano Bruno on English writers is probably limited to a reminiscence in the *Faerie Queene* (Book vii.), he was well acquainted with Sidney and Greville, argued for the Copernican theory at Greville's house, lectured on the soul at Oxford, and published his epoch-marking Italian dialogues during his two years' stay (1583–85) in London. The debates in the earlier schools of Italy on the nature and tenure of the soul are heard in the *Nosce Teipsum* (1599) of Sir John Davies; a stoicism, "of the schools" as well as "of the blood," animates Cassius and also the French heroes of Chapman; and if the earlier drama is sown with Seneca's old maxims on sin and destiny, the later drama, at least in Shakespeare, is penetrated with the freer reading of life and conduct suggested by Montaigne. Platonism—with its *vox angelica* sometimes a little hoarse—is present from the youthful *Hymns* of Spenser to the last followers of Donne; sometimes drawn from Plato, it is oftener the Christianized doctrine codified by Ficino or Pico. It must be noted that this play of philosophic thought only becomes marked after 1580, when the preparatory tunings of English literature are over.

The period down to 1580 in the departments of prose, verse and drama was a time which left few memorials of form.

Prose to 1580.—Early modern English prose, as a medium of art, was of slow growth. For long there was alternate strife and union (ending in marriage) between the Latin, or more rhetorical, and the ancestral elements of the language, and this was true both of diction and of construction. We need to begin with the talk of actual life, as we find it in the hands of the more naïf writers, in its idiom and gusto and unshapen power, to see how style gradually declared itself. In State letters and reports, in the recorded words of Elizabeth and Mary of Scotland and public men, in travels and memoirs, in Latimer, in the rude early versions of Cicero and Boëthius, in the more unstudied speech of Ascham or Leland, the material lies. At the other extreme there are the English liturgy (1549, 1552, 1559, with the final fusion of Anglican and Puritan eloquence), and the sermons of Fisher and Cranmer,—nearly the first examples of a sinuous, musical and Ciceronian cadence. A noble pattern for saga-narrative and lyrical prose was achieved in the successive versions (1526–40–68) of the Hebrew and Greek Scriptures, where a native simple diction of short and melodious clauses are prescribed by the matter itself. Prose, in fact, down to Shakespeare's time, was largely the work of the churchmen and translators, aided by the chroniclers. About the mid-century the stories, as well as the books of conduct and maxim, drawn from Italy and France, begin to thicken. Perverted symmetry of style is found in euphuistic hacks like Pettie. Painter's *Palace of Pleasure* (1566) provided the plots of Bandello and others for the dramatists. Hoby's version (1561) of Castiglione's *Courtier*, with its command of elate and subtle English, is the most notable imported book between Berners's *Froissart* (1523–25) and North's *Plutarch* (1579). Ascham's *Schoolmaster* is the most typical English book of Renaissance culture, in its narrower sense, since *Utopia*. Holinshed's *Chronicle* (1577–87) and the work of Halle, if pre-critical, were all the fitter to minister to Shakespeare.

Verse to 1580.—The lyric impulse was fledged anew at the court of Henry VIII. The short lines and harping burdens of Sir Thomas Wyatt's songs show the revival, not only of a love-poetry more plangent than anything in English since Chaucer, but also of the long-deadened sense of metre. In Wyatt's sonnets, octaves, terzines and other Italian measures, we can watch the painful triumphant struggles of this noble old master out of the slough of formlessness in which verse had been left stranded. Wyatt's primary deed was his gradual rediscovery of the iambic decasyllabic line duly accented—the line that had been first discovered by Chaucer for England; and next came its building into sonnet and stanza. Wyatt (d. 1542) ended with perfect formal accuracy; he has the honours of victory; and Henry Howard, earl of Surrey (d. 1547), a young-hearted and more gracious but a lighter poet, carried on his labour, and caught some of Chaucer's as well as the Italian tunes. The blank verse of his two translated *Aeneids*, like all that written previous to Peele, gave little inkling of the latencies of the measure which was to become the cardinal one of English poetry. It was already the vogue in Italy for translations from the classics; and we may think of Surrey importing it like an uncut jewel and barely conscious of its value. His original poems, like those of Wyatt, waited for print till the eve of Elizabeth's reign, when they appeared, with those of followers like Grimald, in Tottel's *Miscellany* (1557), the first of many such garlands, and the outward proof of the poetical revival dating 20 years earlier. But this was a false dawn. Only one poem of authentic power, Sackville's *Induction* (1563) to that dreary patriotic venture, *A Mirror for Magistrates*, was published for 20 years. In spirit mediaeval, this picture of the gates of hell and of the kings in Bale achieves a new melody and a new intensity, and makes the coming of Spenser far less incredible. But poetry was long starved by the very ideal that nursed it—that of the all-sided, all-accomplished "courtier" or cavalier, to whom verse-making was but one of all the accomplishments that he must perfect, like fencing, or courting, or equestrian skill. Wyatt and Surrey, Sackville and Sidney (and we may add Hamlet, a true Elizabethan) are of this type. One of the first competent professional writers was George Gascoigne, whose remarks on metric, and whose blank verse satire, *The Steel Glass* (1576), save the years between Sackville and Spenser. Otherwise the gap is filled by painful rhymesters with rare flashes, such as Googe, Churchyard and Turberville.

Drama to 1580.—The English Renaissance drama, both comic and tragic, illustrates on the largest scale the characteristic power of the antique at this period—at first to reproduce itself in imitation, and then to generate something utterly different from itself, something that throws the antique to the winds. Out of the Morality, a sermon upon the certainty of death or the temptations of the soul, acted by personified qualities and supernatural creatures, had grown up, in the reign of Henry VII., the Interlude, a dialogue spoken by representative types or trades, who faintly recalled those in Chaucer's *Prologue*. These forms, which may be termed mediaeval, continued long and blended; sometimes heated, as in *Respublica*, with doctrine, and usually lightened by the comic play of a "Vice" or incarnation of sinister roguery. John Heywood was the chief maker of the pure interludes, and Bishop Bale of the Protestant medleys; his *King Johan*, a reformer's partisan tract in verse, contains the germs of the chronicle play. In the drama down to 1580 the native talent is sparse enough, but the historical interest is high. Out of a seeming welter of forms, the structure, the metres and the species that Kyd and Marlowe

found slowly emerged. Comedy was first delivered from the interlude, and fashioned in essence as we know it, by the schoolmasters. Drawing on Plautus, they constructed duly-knitted plots, divided into acts and scenes and full of homely native fun, for their pupils to present. In *Thersites* (written 1537), the oldest of these pieces, and in Udall's *Ralph Roister Doister* (1552 at latest), the best known of them, the characters are lively, and indeed are almost individuals. In others, like *Misogonus* (written 1560), the abstract element and improving purpose remain, and the source is partly neo-Latin comedy, native or foreign. Romance crept in: serious comedy, with its brilliant future, the comedy of high sentiment and averted dangers mingled still with farce, was shadowed forth in *Damon and Pithias* and in the curious play *Common Conditions;* while the domestic comedy of intrigue dawned in Gascoigne's *Supposes,* adapted from Ariosto. Thus were displaced the ranker rustic fun of *Gammer Gurton's Needle* (written *c.* 1559) and other labours of "rhyming motherwits." But there was no style, no talk, no satisfactory metre. The verse of comedy waited for Greene, and its prose for Lyly. Structure, without style, was also the main achievement of the early tragedies. The Latin plays of Buchanan, sometimes biblical in topic, rest, as to their form, upon Euripides. But early English tragedy was shapen after the Senecan plays of Italy and after Seneca himself, all of whose dramas were translated by 1581. *Gorboduc, or Ferrex and Porrex,* acted about 1561, and written by Sackville and Norton, and Hughes' *Misfortunes of Arthur* (acted 1588), are not so much plays as wraiths of plays, with their chain of slaughters and revenges, their two-dimensional personages, and their lifeless maxims which fail to sweeten the bloodshot atmosphere. The Senecan form was not barren in itself, as its sequel in France was to show: it was only barren for England. After Marlowe it was driven to the study, and was still written (possibly under the impulse of Mary countess of Pembroke) by Daniel and Greville, with much reminiscence of the French Senecans. But it left its trail on the real drama. It set the pattern of a high tragical action, often motived by revenge, swayed by large ideas of fate and retribution, and told in blank metre; and it bequeathed, besides many moral sentences, such minor points of mechanism as the Ghost, the Chorus and the inserted play. There were many hybrid forms like *Gismond of Salern,* based on foreign story, alloyed with the mere personifications of the Morality, and yet contriving, as in the case of *Promos and Cassandra* (the foundation of *Measure for Measure*), to interest Shakespeare. Thus the drama by 1580 had some of its carpentry, though not yet a true style or versification. These were only to be won by escape from the classic tutelage. The ruder chronicle play also began, and the reigns of John and Henry V. amongst others were put upon the stage.

Verse from Spenser to Donne.—Sir Philip Sidney almost shares with Edmund Spenser the honours of announcing the new verse, for part of his *Astrophel and Stella* was written, if not known in unpublished form, about 1580–81, and contains ten times the passion and poetry of *The Shepherd's Calendar* (1579). This work, of which only a few passages have the seal of Spenser's coming power, was justly acclaimed for its novelty of experiment in many styles, pastoral, satiric and triumphal, and in many measures: though it was criticized for its "rustic" and archaic diction—a "no language" that was to have more influence upon poetry than any of the real dialects of England. Spenser's desire to write high tragedy, avowed in his *October,* was not to be granted; his nine comedies are lost; and he became the chief non-dramatic poet of his time in England. Both the plaintive pessimism of Petrarch and du Bellay, with their favourite method of emblem, and the Platonic theory of the spiritual love and its heavenly begetting sank into him; and the *Hymns To Love* and *To Beauty* are possibly his earliest verses of sustained perfection and exaltation. These two strains of feeling Spenser never lost and never harmonized; the first of them recurs in his *Complaints* of 1591, above all in *The Ruins of Time,* the second in his *Amoretti* (1595) and *Colin Clout* and *Epithalamion,* which are autobiographical. These and a hundred other threads are woven into *The Faerie Queene,* an unfinished allegorical epic in honour of moral goodness, of which three books came out in 1590 and three more in 1596, while the fragment *Of Constancy* (so-called) is first found in the posthumous folio of 1609. This poem is the fullest reflex, outside the drama, of the soul and aspirations of the time. For its scenery and mechanism the *Orlando Furioso* of Ariosto furnishes the framework. In both poems tales of knightly adventure intertwine unconfused; in both the slaying of monsters, the capture of strong places, and the release of the innocent, hindered by wizard and sorcerer, or aided by magic sword and horn and mirror, constitute the quest; and in both warriors, ladies, dwarfs, dragons and figures from old mythology jostle dreamily together. To all this pomp Spenser strove to give a moral and often also a political meaning. Ariosto was not a *vates sacer;* and so Spenser took Tasso's theme of the holy war waged for the Sepulchre, and expanded it into a war between good and evil, as he saw them in the world; between chastity and lust, loyalty and detraction, England and Spain, England and Rome, Elizabeth and usurpers, Irish governor and Irish rebel, right and wrong. The title-virtues of his six extant books he affects to take from Aristotle; but Holiness, Temperance, Chastity, Justice, Friendship and Courtesy form a medley of mediaeval, puritanical and Greek ideals.

Spenser's moral sentiments, often ethereally noble, might well be contrasted, and that not always to their credit, with those more secular and naturalistic ones that rule in Shakespeare or in Bernardino Telesio and Giordano Bruno. But *The Faerie Queene* lives by its poetry; and its poetry lives independently of its creed. The idealized figures of Elizabeth, who is the Faerie Queene, and of the "magnificent" Prince Arthur, fail to bind the adventures together, and after two books the poem breaks down in structure. And indeed all through it relies on episode and pageant, on its prevailing and insuppressible loveliness of scene and tint, of phrasing and of melody, beside which the inner meaning is often an interruption. Spenser is not to be tired; in and out of his tapestry, with its "glooming light much like a shade," pace his figures on horseback, or in durance, with their clear and pictorial allegoric trappings; and they go either singly, or in his favourite masques or pageants, suggested by emblematical painting or civic procession. He is often duly praised for his lingering and liquid melodies and his gracious images, or blamed for their languor; but his ground-tone is a sombre melancholy—unlike that of Jaques—and his deepest quality as a writer is perhaps his angry power. Few of his 40,000 and more lines are unpoetical; in certainty of style, amongst English poets who have written profusely, he has no equals but Chaucer, Milton and Shelley. His "artificial" diction, drawn from middle English, from dialect or from false analogy, has always the intention and nearly always the effect of beauty; we soon feel that its absence would be unnatural, and it has taken its rank among the habitual and exquisite implements of English poetry. This equality of noble form is Spenser's strength, as dilution and diffusion of phrase, and a certain monotonous slowness of *tempo,* are beyond doubt his weaknesses. His chief technical invention, the nine-line stanza (*ababbcbcc*) was developed not from the Italian octave (*abababcc*), but by adding an alexandrine to the eight-line stave (*ababbcbc*) of Chaucer's *Monk's Tale.* It is naturally articulated twice—at the fifth line, where the turn of repeated rhyme inevitably charms, and at the ninth, which runs now to a crashing climax, now to a pensive and sighing close. In rhyming, Spenser, if not always accurate, is one of the most natural and resourceful of poets. His power over the heroic couplet or quatrain is shown in his fable, *Mother Hubbard's Tale,* and in his curious verse memoir, *Colin Clout;* both of which are medleys of satire and flattery. With formal tasks so various and so hard, it is wonderful how effortless the style of Spenser remains. His *Muiopotmos* is the lightest-handed of mock-heroics. No writer of his day except Marlowe was so faithful to the law of beauty.

Spenserians.—The mantle of Spenser fell, somewhat in shreds, upon poets of many schools until the Restoration. As though in thanks to his master Tasso, he lent to Edward Fairfax, the best translator of the *Jerusalem Delivered* (*Godfrey of Bulloigne,* 1600), some of his own ease and intricate melody. Harington,

the witty translator of Ariosto (1591) and spoilt child of the court, owed less to Spenser. The allegorical colouring was nobly caught, if sometimes barbarized, in the *Christ's Victory and Triumph* of the younger Giles Fletcher (1610), and Spenser's emblematic style was strained, even cracked, by Phineas Fletcher in *The Purple Island* (1633), an aspiring fable, gorgeous in places, of the human body and faculties. Both of these brethren clipped and marred the stanza, but they form a link between Spenser and their student Milton. The allegoric form, long-winded and broken-backed, survived late in Henry More's and Joseph Beaumont's verse disquisitions on the soul. Spenser's pastoral and allusive manner was followed by Drayton in his *Shepherd's Garland* (1593), and differently by William Browne in *Britannia's Pastorals* (1613–16), and by William Basse; while his more honeyed descriptions took on a mawkish taste in *Britain's Ida* (now known to be by Phineas Fletcher) and similar poems. His golden Platonic style was buoyantly echoed in *Orchestra* (1596), Sir John Davies' poem on the dancing spheres. He is continually traceable in 17th century verse, blending with the alien currents of Ben Jonson and of Donne. He was edited and imitated in the age of Thomson, in the age of William Morris, and constantly between.

The typical Elizabethan poet is Michael Drayton; who followed Spenser in pastoral, Daniel, Sidney, Spenser and Shakespeare in sonnet, Daniel again in chronicle and legend, and Marlowe in mythological story, and who yet remained himself. His *Endimion and Phoebe* in passages stands near *Hero and Leander;* his *England's Heroical Epistles* (1597) are in ringing rhetorical couplets; his *Odes* (1606), like the *Ballad of Agincourt* and the *Virginian Voyage,* forestall and equal Cowper's or Campbell's; his *Nymphidia* (1627) was the most popular of burlesque fairy poems; and his pastorals are full of graces and felicities. The work of Drayton that is least read and most often mentioned is his *Poly-Olbion* (1612–22), a vast and pious effort, now and then nobly repaid, to versify the scenery, legend, customs and particularities of every English county. The more recluse and pensive habit of Samuel Daniel chills his long chronicle poems; but with Chapman he is the clearest voice of Stoicism in Elizabethan letters; and his harmonious nature is perfectly expressed in a style of happy, even excellence, free alike from "fine madness" and from strain. Sonnet and epistle are his favoured forms, and in his *Musophilus* (1599) as well as in his admirable prose *Defence of Rhyme* (1602), he truly prophesies the hopes and glories of that *illustre vulgare,* the literary speech of England. All this patriotic and historic verse, like the earlier and ruder *Albion's England* (1586) of William Warner, or Fitzgeoffrey's poem upon Drake, or the outbursts of Spenser, was written during or inspired by the last 20 years of the queen's reign; and the same is true of Shakespeare's and most of the other history plays, which duly eclipsed the formal, rusty-gray chronicle poem of the type of the *Mirror for Magistrates,* though editions (1559–1610) of the latter were long repeated. Patriotic verse outside the theatre, however full of zeal, started at a disadvantage compared with love-sonnet, song, or mythic narrative, because it had no models before it in other lands, and remained therefore the more shapeless.

Sonnets.—The English love-sonnet, brought in by Wyatt and rifest between 1590 and 1600, was revived as a purely studious imitation by Watson in his *Hekatompathia* (1582), a string of translations in one of the exceptional measures that were freely entitled "sonnets." But from the first, in the hands of Sidney, whose *Astrophel and Stella* (1591) was written, as remarked above, about 1581, the sonnet was ever ready to pulse into feeling, and to flash into unborrowed beauty, embodying sometimes dramatic fancy and often living experience. These three fibres of imitation, imagination and confession are intertwisted beyond severance in many of the cycles, and now one, now another is uppermost. Incaution might read a personal diary into Thomas Lodge's *Phillis* (1593), which is often a translation from Ronsard. Literal judges have announced that Shakespeare's *Sonnets* are but his mode of taking exercise. But there is poetry in "God's plenty" almost everywhere; and few of the series fail of lovely lines or phrasing or even of perfect sonnets. This holds of Henry Constable's *Diana* (1592), of the *Parthenophil and Parthenophe* of Barnabe Barnes (1593), inebriate with poetry, and of the stray minor groups, *Alcilia, Licia, Caelia;* while the *Caelica* of Fulke Greville, Lord Brooke, in irregular form, is full of metaphysical passion struggling to be delivered. *Astrophel and Stella,* Drayton's *Idea* (1594–1619), Spenser's *Amoretti* and Shakespeare's *Sonnets* (printed 1609) are addressed to definite and probably to known persons, and are charged with true poetic rage, ecstatic or plaintive, desperate or solemn, if they are also intermingled with the mere word-play that mocks or beguiles the ebb of feeling, or with the purely plastic work that is done for solace. In most of these series, as in Daniel's paler but exquisitely-wrought *Delia* (1591–92), the form is that of the three separate quatrains with the closing couplet for emotional and melodic climax; a scheme slowly but defiantly evolved, through traceable gradations, from that stricter one of Italy, which Drummond and Milton revived, and where the crisis properly coincides with the change from octave to sestet.

The amorous mythologic tale in verse derives immediately from contemporary Italy, but in the beginning from Ovid, whose *Metamorphoses,* familiar in Golding's old version (1555–57), furnished descriptions, decorations and many tales, while his *Heroides,* of which Turberville's translation went through five editions between 1567 and 1600, provided a model for the self-anatomy of tragic or plaintive sentiment. Within ten years, between 1588 and 1598, during the early sonnet-vogue, appeared Lodge's *Scillaes Metamorphosis,* Shakespeare's *Venus and Adonis* and *Rape of Lucrece,* Marlowe's *Hero and Leander* and Drayton's *Endimion and Phoebe.* Shakespeare owed something to Lodge, and Drayton to Marlowe. All these poets describe a love-situation at length, and save in one instance they describe it from without. The exception is Marlowe, who achieves a more than Sicilian perfection; he says everything, and is equal to everything that he has to say. In *Venus and Adonis* the poet is enamoured less of love than of the tones and poses of lovers and of the beauty and gallant motion of animals, while in *The Rape of Lucrece* he is intent on the gradations of lust, shame and indignation, in which he has a spectator's interest. Virtuosity, or the delight of the executant in his own brilliant cunning, is the mark of most of these pieces.

Lyric.—If we go to the lyrics, the versified mythic tales and the sonnets of Elizabethan times for the kind of feeling that Molière's *Alceste* loved and that Burns and Shelley poured into song, we shall often come away disappointed, and think the old poetry heartless. But it is not heartless, any more than it is always impassioned or personal; it is decorative. The feeling is often that of the craftsman; it is not of the singer who spends his vital essence in song and commands an answering thrill so long as his native language is alive or understood. The arts that deal with ivories or enamelling or silver suggest themselves while we watch the delighted tinting and chasing, the sense for gesture and grouping (in *Venus and Adonis*), or the delicate beating out of rhyme in a madrigal, or the designing of a single motive, or two contrasted motives, within the panel of the sonnet. And soon it is evident how passion and emotion readily become plastic matter too, whether they be drawn from books or observation or self-scrutiny. This is above all the case in the sonnet; but it is found in the lyric as well. The result is a wonderful fertility of lyrical pattern, a wonderfully diffused power of lyrical execution, never to recur at any later time of English literature. Wyatt had to recover the very form of such verse from oblivion, and this he did in the school of translation and adaptation. Not only the decasyllabic, but the lyric, in short lines had almost died out of memory, and Wyatt brought it back. From his day to Spenser's there is not much lyric that is noteworthy, though in Gascoigne and others the impulse is seen. The introduction of Italian music, with its favourite metrical schemes, such as the madrigal, powerfully schooled and coloured lyric: in especial, the caressing double ending, regular in Italian but heavier in English, became common. The Italian poems were often translated in their own measure, line by line, and the musical setting retained. Their tunes, or other tunes, were then coupled with new and original poems; and both

appeared together in the song-books of Dowland the lutanist, of Jones and Byrd (1588), and in chief (1601–19) of Thomas Campion. The words of Campion's songs are not only supremely musical in the wider sense, but are chosen for their singing quality. Misled awhile by the heresy that rhyme was wrong, he was yet a master of lovely rhyming, as well as of a lyrical style of great range, gaily or gravely happy. But, as with most of his fellows, singing is rather his calling than his consolation. The lyrics that are sprinkled in plays and romances are the finest of this period, and perhaps, in their kind, of any period. Shakespeare is the greatest in this province also; but the power of infallible and unforgettable song is often granted to slighter, gentler playwrights like Greene and Dekker, while it is denied to men of weightier build and sterner purpose like Chapman and Jonson. The songs of Jonson are indeed at their best of absolute and antique finish; but the irrevocable dew of night or dawn seldom lies upon them as it lies on the songs of Webster or of Fletcher. The best lyrics in the plays are dramatic; they must be read in their own setting. While the action stops, they seize and dally with the dominant emotion of the scene, and yet relieve it. The songs of Lodge and Breton, of Drayton and Daniel, of Oxford and Raleigh, and the fervid brief flights of the Jesuit Southwell, show the omnipresence of the vital gift, whether among professional writers of the journalistic type, or among poets whose gift was not primarily song, or among men of action and quality or men of religion, who only wrote when they were stirred. Lullaby and valentine and compliment, and love-plaint ranging from gallantry to desperation, are all there; and the Fortunate Hour, which visits commonly only a few men in a generation, and those but now and then in their lives, is never far off. But the master of melody, Spenser, left no songs, apart from his two insuperable wedding odes. And religious lyric is rarer before the reign of James. Much of the best lyric is saved for us by the various Miscellanies, *A Handful of Pleasant Delights* (1584), the *Phoenix Nest* (1593) and Davison's *Poetical Rhapsody* (1602); while other such collections, like *England's Helicon* (1600), were chiefly garlands of verse that was already in print.

There is plenty of satiric anger and raillery in the spirit of the time, but the most genuine part of it is drawn off into drama. Except for stray passages in Spenser, Drayton and others, formal satire, though profuse, was a literary unreal thing, a pose in the manner of Persius or Juvenal, and tiresome in expression. In this kind only Donne triumphed. The attempts of Lodge and Hall and Marston and John Davies of Hereford and Guilpin and Wither are for the most part simply wearisome in different ways, and satire waited for Dryden and his age. The attempt, however, persisted throughout. Wyatt was the first and last who succeeded in the genial, natural Horatian style.

Verse from Donne to Milton.—As the age of Elizabeth receded, some changes came slowly over non-dramatic verse. In Jonson as in John Donne (1573–1631), one of the greater poets of England, and in many writers after Donne, may be traced a kind of Counter-Renaissance, or revulsion against the natural man and his claims to pleasure—a revulsion from which regret for pleasure lost is seldom far. Poetry becomes more ascetic and mystical, and this feeling takes shelter alike in the Anglican and in the Roman faith. George Herbert (*The Temple*, 1633), the most popular, quaint and pious of the school, but the least poetical; Crashaw, with his one ecstatic vision (*The Flaming Heart*) and occasional golden stanzas; Henry Vaughan, who wrote from 1646 to 1678, with his mystical landscape and magical cadences; and Thomas Traherne, his fellow-dreamer, are the best known of the religious fantastics. But, earlier than most of these are Lord Herbert of Cherbury, and Habington with his *Castara* (1634), who show the same temper, if a fitful power and felicity. Such writers form the devouter section of the famous "metaphysical" or "fantastic" school, which includes, besides Donne its founder, pure amorists like Carew (whose touch on certain rhythms has no fellow), young academic followers like Cartwright and Cleveland (in whom survives the vein of satire that also marks the school), and Abraham Cowley, who wrote from 1633 to 1678, and was perhaps the most acceptable living poet about the middle of the century. In his *Life of Cowley* Johnson tramples on the "metaphysical" poets and their vices, and he is generally right in detail. The shock of cold quaintness, which every one of them continually administers, is fatal. Johnson only erred in ignoring all their virtues and all their historical importance.

In Donne poetry became deeply intellectualized, and in temper disquisitive and introspective. The poet's emotion is played with in a cat-and-mouse fashion, and he torments it subtly. Donne's passion is so real, if so unheard-of, and his brain so finely-dividing, that he can make almost any image, even the remotest, even the commonest, poetical. His satires, his *Valentine*, his *Litany*, and his lyric or odic pieces in general, have an insolent and sudden daring which is warranted by deep-seated power and is only equalled by a few of those tragedians who are his nearest of kin. The recurring contrast of "wit" or intelligence, and "will" or desire, their struggle, their mutual illumination, their fusion as into some third and undiscovered element of human nature, are but one idiosyncrasy of Donne's intricate soul, whose progress, so far as his often dateless poems permit of its discovery, seems to have been from a paganism that is unashamed but crossed with gusts of compunction, to a mystical and otherworldly temper alloyed with covetous regrets. The *Anatomy of the World* and other ambitious pieces have the same quality amid their outrageous strangeness. In Donne and his successors the merely ingenious and ransacking intellect often came to overbalance truth and passion; and hence arose conceits and abstract verbiage, and the difficulty of finding a perfect poem, however brief, despite the omnipresence of the poetic gift. The "fantastic" school, if it contains some of the rarest sallies and passages in English, is one of the least satisfactory. Its faults only exaggerate those of Sidney, Greville and Shakespeare, who often misuse homely or technical metaphor; and English verse shared, by coincidence not by borrowing, and with variations of its own, in the general strain and torture of style that was besetting so many poets of the Latin countries. Yet these poets well earn the name of metaphysical not for their philosophic phrasing, but for the shuttle-flight of their fancy to and fro between the things of earth and the realities of spirit that lie beyond the screen of the flesh.

Between Spenser and Milton many measures of lyrical and other poetry were modified. Donne's frequent use of roughly-accentual, almost tuneless lines is unexplained and was not often followed. Rhythm in general came to be studied more for its own sake, and the study was rewarded. The lovely cordial music of Carew's amorous iambics, or of Wither's trochees, or of Crashaw's odes, or of Marvell's octosyllables, has never been regained. The formal ode set in, sometimes regularly "Pindaric" in strophe-grouping, sometimes irregularly "Pindaric" as in Cowley's experiments. Above all, the heroic couplet, of the isolated, balanced, rhetorical order, such as Spenser, Drayton, Fairfax and Sylvester, the translator (1590–1606) of Du Bartas, had often used, began to be a regular instrument of verse, and that for special purposes which soon became lastingly associated with it. The flatteries of Edmund Waller and the Ovidian translations of Sandys dispute the priority for smoothness and finish, though the fame was Waller's for two generations; but Denham's over-estimated *Cooper's Hill* (1642), Cowley's *Davideis* (1656), and even Ogilby's *Aeneid* made the path plainer for Dryden, the first sovereign of the rhetorical couplet which throve as blank verse declined. Sonnet and madrigal were the favoured measures of William Drummond of Hawthornden, a real and exquisite poet of the studio, who shows the general drift of verse towards sequestered and religious feeling. Drummond's *Poems* of 1616 and *Flowers of Zion* (1623) are full of Petrarch and Plato as well as of Christian resignation, and he kept alive the artistry of phrasing and versification in a time of indiscipline and conflicting forms. William Browne has been named as a Spenserian, but his *Britannia's Pastorals* (1613–16), with their slowly-rippling and overflowing couplets which influenced Keats, were a medley of a novel kind. George Wither may equally rank among the lighter followers of Spenser, the easy masters of lyrical narrative, and the devotional poets. But his *Shepherd's Hunting* and other pieces in

his volume of 1622 contain lovely landscapes, partly English and partly artificial, and stand far above his pious works, and still further above the dreary satires which he lived to continue after the Restoration.

Of poets yet unmentioned, Robert Herrick is the chief, with his 2,000 lyrics and epigrams, gathered in *Hesperides and Noble Numbers* (1648). His power of song and sureness of cadence are not excelled within his range of topic, which includes flowers and maidens—whom he treats as creatures of the same race—and the swift decay of both their beauties, and secular regret over this decay and his own mortality and the transience of amorous pleasure, and the virtues of his friends, and country sports and lore, and religious compunction for his own paganism. The *Hesperides* are pure Renaissance work, in natural sympathy with the Roman elegiac writings and with the Pseudo-Anacreon. Cowley is best where he is nearest Herrick, and his posy of short lyrics outlives his "epic and Pindaric art." There are many writers who last by virtue of one or two poems; Suckling by his adept playfulness, Lovelace and Montrose by a few gallant stanzas, and many a nameless poet by many a consummate cadence. It is the age of sudden flights and brief perfections. All the farther out of reach, yet never wholly despaired of or unattempted in England, was the "long poem," heroical and noble, the "phantom epic," that shadow of the ancient masterpieces, which had striven to life in Italy and France. Davenant's *Gondibert* (1651), Cowley's *Davideis* and Chamberlayne's *Pharonnida* (1659) attest the effort which Milton in 1658 resumed with triumph. These works have between them all the vices possible to epic verse, dulness and flatness, faintness and quaintness and incoherence. But there is some poetry in each of them, and in *Pharonnida* there is far more than enough poetry to save it.

Milton.—Few writers have found a flawless style of their own so early in life as John Milton (1608–74). His youthful pieces show some signs of Spenser and the Caroline fantastics; but soon his vast poetical reading ran clear and lay at the service of his talent. His vision and phrasing of natural things were already original in the *Nativity Ode,* written when he was 20; and, there also, his versification was that of a master, of a renovator. There is the pensive, figured beauty of *L'Allegro* and *Il Penseroso,* two contrasted emblematic panels, the high innocent Platonism and golden blank verse of the *Comus* (1634); the birth of long-sleeping power in the *Lycidas* (1637), with its unapproached contrivance both in evolution and detail, where the precious essences of earlier myth and pastoral seem to be distilled for an offering in honour of the tombless friend; we remark the promise, the sureness of it all amid the current schools. The historian finds in these poems, with their echoes of Plato and Sannazzaro, of Geoffrey of Monmouth and St. John, the richest and most perfect instance of the studious, decorative Renaissance style, and is not surprised to find Milton's scholars a century later in the age of Gray. The critic, while feeling that the strictly lyrical, spontaneous element is absent, is all the more baffled by the skill and enduring charm. The sonnets were written before or during Milton's long immersion (1637–58) in prose and warfare, and show the same gifts. They are not cast in the traditional form of love-cycle, but are occasional poems; in metre they revert, not always strictly but once or twice in full perfection, to the Italian scheme; and they recall not Petrarch but the spiritual elegies or patriot exaltations of Dante or Guidiccioni.

Milton also had a mediaeval side to his brain, as the *History of Britain* shows. The heroic theme, which he had resolved from his youth up to celebrate, at last, after many hesitations, proved to be the fall of man. This, for one of his creed and for the audience he desired, was the greatest theme of all. Its scene was the Ptolemaic universe with the Christian heaven and hell inserted. The time, indicated by retrospect and prophecy, was the whole of that portion of eternity, from the creation of Christ to the doomsday, of which the history was sacredly revealed. The subject and the general span of the action went back to the popular mystery play; and Milton at first planned out *Paradise Lost* as such a play, with certain elements of classic tragedy embodied. But according to the current theory the epic, not the drama, was the noblest form of verse; and, feeling where his power lay, he adopted the epic. The subject, therefore, was partly mediaeval, partly Protestant—for Milton was a true Protestant in having a variant of doctrine shared by no other mortal. But the ordering and presentment, with their overture, their interpolated episodes or narratives, their journeys between Olympus, earth and hell, invocations, set similes, battles and divine thunderbolts, are those of the classical epic. Had Milton shared the free thought as well as the scholarship of the Renaissance, the poem could never have existed. With all his range of soul and skill, he had a narrower speculative brain than any poet of equal gift; and this was well for his great and peculiar task. But whatever Milton may fail to be, his heroic writing is the permanent and absolute expression of something that in the English stock is inveterate—the Promethean self-possession of the mind in defeat, its right to solitude there, its claim to judge and deny the victor. This is the spirit of his devils, beside whom his divinities, his unfallen angels (Abdiel excepted), and even his human couple with their radiance and beauty of line, all seem shadowy. The discord between Milton's doctrine and his sympathies in *Paradise Lost* (1667) has never escaped notice. The discord between his doctrine and his culture comes out in *Paradise Regained* (1671), when he has at once to reprobate and glorify Athens, the "mother of arts." In this afterthought to the earlier epic the action is slight, the Enemy has lost spirit, and the Christ is something of a pedagogue. But there is a new charm in its even, grey desert tint, sprinkled with illuminations of gold and luxury. In *Samson Agonistes* (1671) the ethical treatment as well as the machinery is Sophoclean, and the theology not wholly Christian. But the fault of Samson is forgotten in his suffering, which is Milton's own; and thus a cross-current of sympathy is set up, which may not be much in keeping with the story, but revives the somewhat exhausted interest and heightens a few passages into a bare and inaccessible grandeur.

The essential solitude of Milton's energies is best seen in his later style and versification. When he resumed poetry about 1658, he had nothing around him to help him as an artist in heroic language. The most recent memories of the drama were also the worst; the forms of Cowley and Davenant, the would-be epic poets, were impossible. Spenser's manner was too even and fluid as a rule for such a purpose, and his power was of an alien kind. Thus Milton went back, doubtless full of Greek and Latin memories, to Marlowe, Shakespeare and others among the greater dramatists (including John Ford); and their tragic diction and measure are the half-hidden bases of his own. The product, however, is unlike anything except the imitations of itself. The incongruous elements of the *Paradise Lost* and its divided sympathies are cemented, at least superficially, by its style, perhaps the surest for dignity, character and beauty that any Germanic language has yet developed. If dull and pedantic over certain stretches, it is usually infallible. It is many styles in one, and Time has laid no hand on it. In these three later poems its variety can be seen. It is perfect in personal invocation and appeal; in the complex but unfigured rhetoric of the speeches; in narrative of all kinds; for the inlaying work of simile or scenery or pageant, where the quick, pure impressions of Milton's youth and prime—possibly kept fresher by his blindness—are felt through the sometimes conventional setting; and for soliloquy and choric speech of a might unapproachable since Dante. To these calls his blank verse responds at every point. It is the seal of Milton's artistry, as of his self-confidence, for it greatly extends, for the epical purpose, all the known powers and liberties of the metre; and yet, as has often been shown, it does so not spasmodically but within fixed technical laws or rather habits. Latterly, the underlying metrical *ictus* is at times hard to detect. But Milton remains by far the surest and greatest instrumentalist, outside the drama, on the English unrhymed line. He would, however, have scorned to be judged on his form alone. His soul and temper are not merely unique in force. Their historic and representative character ensure attention, so long as the oppositions of soul and temper in the England of Milton's time remain, as they still are, the deepest in the national life. He

is sometimes said to harmonize the Renaissance and the Puritan spirit; but he does not do this, for nothing can do it. The Puritan spirit is the deep thing in Milton; all his culture only gives immortal form to its expression. The critics have instinctively felt that this is true; and that is why their political and religious prepossessions have nearly always coloured, and perhaps must colour, every judgment passed upon him. Not otherwise can he be taken seriously, until historians are without public passions and convictions, or the strife between the hierarch and the Protestant is quenched in English civilization.

Drama, 1580–1642.—We must now go back to the drama, which lies behind Milton, and is the most individual product of all English literature. The nascent drama of genius can be found in the "University wits," who flourished between 1580 and 1595, and the chief of whom are Lyly, Peele, Greene, Kyd and Marlowe. John Lyly is the first practitioner in prose of shapely comic plot and pointed talk—the artificial but actual talk of courtly masquers who rally one another with a bright and barren finish that is second nature. *Campaspe, Sapho and Phao, Midas,* and Lyly's other comedies, mostly written from 1580 to 1591, are frail vessels, often filled with compliment, mythological allegory, or topical satire, and enamelled with pastoral interlude and flower-like song. The work of Thomas Kyd, especially *The Spanish Tragedy* (written *c.* 1585), was the most violent effort to put new wine into the old Senecan bottles, and he probably wrote the lost pre-Shakespearian *Hamlet.* He transmitted to the later drama that subject of pious but ruinous revenge, which is used by Chapman, Marston, Webster and many others; and his chief play was translated and long acted in Germany. Kyd's want of modulation is complete, but he commands a substantial skill of dramatic mechanism, and he has more than the feeling for power, just as Peele and Greene have more than the feeling for luxury or grace. To the expression of luxury Peele's often stately blank verse is well fitted, and it is by far the most correct and musical before Marlowe's, as his *Arraignment of Paris* (1584) and his *David and Bethsabe* attest. Greene did something to create the blank verse of gentle comedy, and to introduce the tone of idyll and chivalry, in his *Friar Bacon and Friar Bungay* (1594). Otherwise these writers, with Nashe and Lodge, fall into the wake of Marlowe.

Tamburlaine, in two parts (part 1, *c.* 1587), *The Life and Death of Doctor Faustus, The Jew of Malta, Edward II.* (the first chronicle play of genius), and the incomplete poem *Hero and Leander* are Christopher Marlowe's title-deeds (1564–93). He established tragedy, and inspired its master, and created for it an adequate diction and versification. His command of vibrant and heroic recitative should not obscure his power, in his greater passages (describing the descent of Helen, the passing of Mortimer and the union of Hero and Leander), to attain a kind of Greek transparency and perfection. The thirst for ideal beauty, for endless empire and for prohibited knowledge, no poet has better expressed, and in this respect Giordano Bruno is nearest him in his own time. This thirst is his own; his great cartoon-figures, gigantic rather than heroic, proclaim it for him: their type recurs through the drama, from Richard III. to Dryden's orotund heroes; but in *Faustus* and in *Edward II.* they become real, almost human beings. His constructive gift is less developed in proportion, though Goethe praised the planning-out of *Faustus.* The glory and influence of Marlowe on the side of form rest largely on his meteoric blank lines, which are varied not a little, and nobly harmonized into periods, and resonant with names to the point of splendid extravagance; and their sound is heard in Milton, whom he taught how to express the grief and despair of demons dissatisfied with their kingdom. Shakespeare did not excel Marlowe in Marlowe's own excellences, though he humanized Marlowe's Jew, launched his own blank verse on the tide of Marlowe's oratory and modulated, in *Richard II.,* his master's type of chronicle tragedy.

Shakespeare.—As the middle ages receded, the known life of man upon this earth became of sovereign interest, and of this interest the drama is the freest artistic expression. If Marlowe is the voice of the impulse to explore, the plays of Shakespeare are the amplest freight brought home by any voyager. Shakespeare is not only the greatest but the earliest English dramatist who took humanity for his province. But this he did not do from the beginning. He was at first subdued to what he worked in; and though the dry pedantic tragedy was shattered and could not touch him, the gore and rant, the impure though genuine force of Kyd do not seem at first to have repelled him, if, as is likely, he had a hand in *Titus Andronicus.* He probably served with Marlowe and others of the school at various stages in the composition of the three chronicle dramas finally entitled *Henry VI.* But besides the high-superlative style that is common to them all, there runs through them the rhymed rhetoric with which Shakespeare dallied for some time, as well as the softer flute-notes and deeper undersong that foretell his later blank verse. In *Richard III.,* though it is built on the scheme and charged with the style of Marlowe, Shakespeare first showed the intensity of his original power. But after a few years he swept out of Marlowe's orbit into his own vaster and unreturning curve. In *King John* the lyrical, epical, satirical and pathetic chords are all present, if they are scarcely harmonized. Meantime, Lyly and Greene having displaced the uncouther comedy, Shakespeare learned all they had to teach, and shaped the comedy of poetic, chivalrous fancy and good-tempered high spirits, which showed him the way of escape from his own rhetoric, and enabled him to perfect his youthful, noble and gentle blank verse. This attained its utmost fineness in *Richard II.,* and its full cordiality and beauty in the other plays that consummate this period—*A Midsummer Night's Dream, The Merchant of Venice,* and one romantic tragedy, *Romeo and Juliet.* Behind them lay the earlier and fainter romances, with their chivalry and gaiety, *The Comedy of Errors, Love's Labour's Lost* and *The Two Gentleman of Verona.* Throughout these years blank verse contended with rhyme, which Shakespeare after a while abandoned save for special purposes, as though he had exhausted its honey. The Italian Renaissance is felt in the scenery and setting of these plays. The *novella* furnishes the story, which passes in a city of the Southern type, with its absolute ruler, its fantastic by-laws on which the plot nominally turns, and its mixture of real life and marvel. The personages, at first fainter of feature and symmetrically paired, soon assume sharper outline: Richard II. and Shylock, Portia and Juliet, and Juliet's Nurse and Bottom are created. The *novella* has left the earth and taken wings: the spirit is now that of youth and Fancy (or love brooding among the shallows) with interludes of "fierce vexation," or of tragedy, or of kindly farce. And there is a visionary element, felt in the musings of Theseus upon the nature of poetry, of the dream-faculty itself; an element which is new, like the use made of fairy folklore, in the poetry of England.

Tragedy is absent in the succeeding histories (1597–99), and the comedies of wit and romance (1599–1600), in which Shakespeare perfected his style for stately, pensive or boisterous themes. Falstaff, the most popular as he is the wittiest of all imaginable comic persons, dominates, as to their prose or lower world, the two parts of *Henry IV.,* and its interlude or offshoot, *The Merry Wives of Windsor.* The play that celebrates Henry V. is less a drama than a pageant, diversified with mighty orations and cheerful humours, and filled with the love of Shakespeare for England. Here the most indigenous form of art invented by the English Renaissance reaches its climax. The Histories are peopled chiefly by men and warriors, of whom Hotspur, "dying in his excellence and flower," is perhaps more attractive than Henry of Agincourt. But in the "middle comedies," *As You Like It, Much Ado* and *Twelfth Night,* the warriors are home at court, where women rule the scene and deserve to rule it; for their wit now gives the note; and Shakespeare's prose, the medium of their talk, has a finer grace and humour than ever before, euphuism lying well in subjection behind it.

Mankind and this world have never been so sharply sifted or so sternly consoled, since Lucretius, as in Shakespeare's tragedies. The energy which created them evades, like that of the sun, our estimate. But they were not out of relation to their time, the first few years of the reign of James, with its conspiracies, its Somerset and Overbury horrors, its enigmatic and sombre figures like Raleigh, and its revulsion from Elizabethan buoyancy. In the

same decade were written the chief tragedies of Jonson, Chapman, Dekker, Marston, Tourneur; and *The White Devil,* and *A Yorkshire Tragedy,* and *The Maid's Tragedy,* and *A Woman Killed with Kindness.* But, in spite of Shakespeare's affinities with these authors at many points, *Hamlet, Macbeth, Lear, Othello,* with the three Roman plays (written at intervals and not together), and the two quasi-antique plays *Troilus and Cressida* and *Timon of Athens,* form a body of drama apart from anything else in the world. They reveal a new tragic philosophy, a new poetic style, a new dramatic technique and a new world of characters. In one way above all Shakespeare stands apart; he not only appropriates the ancient pattern of heroism, of right living and right dying, revealed by North's Plutarch; others did this also; but the intellectual movement of the time, though by no means fully reflected, is reflected in his tragedies far more than elsewhere. The new and troublous thoughts on man and conduct that were penetrating the general mind, the freedom and play of vision that Montaigne above all had stimulated, here find their fullest scope; and Florio's translation (1603) of Montaigne's *Essays,* coming out between the first and the second versions of Shakespeare's *Hamlet,* counted probably for more than any other book. The *Sonnets* (published 1609) are also full of far-wandering thoughts on truth and beauty and on good and evil. The story they reveal may be ranked with the situations of the stranger dramas like *Troilus* and *Measure for Measure.* But whether or no it is a true story, and the *Sonnets* in the main a confession, they would be at the very worst a perfect dramatic record of a great poet's suffering and friendship.

Shakespeare's last period, that of his tragi-comedies, begins about 1608 with his contributions to *Pericles, Prince of Tyre.* For unknown reasons he was moved, about the time of his retirement home, to record, as though in justice to the world, the happy turns by which tragic disaster is at times averted. *Pericles, The Winter's Tale, Cymbeline* and *The Tempest* all move, after a series of crimes, calumnies or estrangements, to some final scene of enthralling beauty, where the lost reappear and love is recovered; as though after all the faint and desperate last partings—of Lear and Cordelia, of Hamlet and Horatio—which Shakespeare had imagined, he must make retrieval with the picture of young and happy creatures whose life renews hope even in the experienced. To this end he chose the loose action and free atmosphere of the *roman d'aventure,* which had already been adapted by Beaumont and Fletcher, who may herein have furnished Shakespeare with novel and successful theatrical effects, and who certainly in turn studied his handiwork. In *The Tempest* this tragi-comic scheme is fitted to the tales brought by explorers of far isles, wild men, strange gods and airy music. Even if it be true that in Prospero's words the poet bids farewell to his magic, he took part later nevertheless in the composition of *Henry VIII.;* and not improbably also in *The Two Noble Kinsmen.* His share in two early pieces, *Arden of Feversham* (1592) and *Edward III.,* has been urged but never established, and of many other dramas he was once idly accused.

Shakespeare's throne rests on the foundation of three equal and master faculties. One is that of expression and versification; the next is the invention and presentation of human character in action; the third is the theatrical faculty. The writing of Dante may seem to us more steadily great and perfect, when we remember Shakespeare's conceits, his experiments, his haste and impatience in his long wrestle with tragic language, his not infrequent sheer infelicities. But Dante is always himself, he had not to find words for hundreds of imaginary persons. Balzac, again, may have created and exhibited as many types of mankind, but except in soul he is not a poet. Shakespeare is a supreme if not infallible poet; his verse, often of an antique simplicity or of a rich, harmonious, romantic perfection, is at other times strained and shattered with what it tries to express, and attains beauty only through discord. He is also many persons in one; in his *Sonnets* he is even, it may be thought, himself. But he had furthermore to study a personality not of his own fancying—with something in it of Caliban, of Dogberry and of Cleopatra—that of the audience in a playhouse. He belongs distinctly to the poets like Jonson and Massinger who are true to their art as practical dramatists, not to the poets like Chapman whose works chance to be in the form of plays. Shakespeare's mastery of this art is approved now by every nation. But apart from the skill that makes him eternally actable—the skill of raising, straining and relieving the suspense, and bringing it to such an ending as the theatre will tolerate—he played upon every chord in his own hearers. He frankly enlisted Jew-hatred, Pope-hatred and France-hatred; he flattered the queen, and celebrated the Union, and stormed the house with his *fanfare* over the national soldier, Henry of Agincourt, and glorified England, as in *Cymbeline,* to the last. But in deeper ways he is the chief of playwrights. Unlike another master, Ibsen, he nearly always tells us, without emphasis, by the words and behaviour of his characters, which of them we are to love and hate, and when we are to love and when to hate those whom we can neither love nor hate wholly. Yet he is not to be bribed, and deals to his characters something of the same injustice or rough justice that is found in real life. His loyalty to life, as well as to the stage, puts the crown on his felicity and his fertility, and raises him to his solitude of dramatic greatness.

Jonson.—Shakespeare's method could not be imparted, and despite reverberations in Beaumont, Fletcher, Webster and others he left no school. But his friend Ben Jonson, his nearest equal in vigour of brain, though not in poetical intuition, was the greatest of dramatic influences down to the shutting of the theatres in 1642, and his comedies found fresh disciples even after 1660. He had "the devouring eye and the portraying hand"; he could master and order the contents of a mighty if somewhat burdensome memory into an organic drama, whether the matter lay in Roman historians or before his eyes in the London streets. He had an armoury of doctrine, drawn from the *Poetics* and Horace, which moulded his creative practice. This was also partly founded on a revulsion against the plays around him, with their loose build and moral improbabilities. But in spite of his photographic and constructive power, his vision is too seldom free and genial; it is that of the satirist who thinks that his office is to improve mankind by derisively representing it. And he does this by beginning with the "humour," or abstract idiosyncrasy or quality, and clothing it with accurately minute costume and gesture, so that it may pass for a man; and indeed the result is as real as many a man, and in his best-tempered and youthful comedy *Every Man in his Humour* (acted 1598), it is very like life. In Jonson's monumental pieces, *Volpone or the Fox* (acted 1605) and *The Alchemist* (acted 1610), our laughter is arrested by the lowering and portentous atmosphere, or is loud and hard, startled by the enormous skill and energy displayed. Nor are the joy and relief of poetical comedy given for an instant by *The Silent Woman, Bartholomew Fair* (acted 1614), or *The Staple of News,* still less by topical plays like *Cynthia's Revels,* though their unfailing farce and rampant fun are less charged with contempt. The erudite tragedies, *Sejanus* (acted 1603) and *Catiline,* chiefly live by passages of high forensic power. Jonson's finer elegies, eulogies and lyrics, which are many, and his fragmentary *Sad Shepherd,* show that he also had a free and lovely talent, often smothered by doctrine and temper; and his verse, usually strong but full of knots and snags, becomes flowing and graciously finished. His prose is of the best, especially in his *Discoveries,* a series of ethical essays and critical maxims; its prevalently brief and emphatic rhythms suggesting those of Hobbes, and even, though less easy and civil and various, those of Dryden. The "sons" of Jonson, Randolph and Browne, Shadwell and Wilson, were heirs rather to his riot of "humours," his learned method and satiric aim, than to his larger style, his architectural power or his relieving graces.

Romantic Drama.—As a whole, the romantic drama (so to entitle the remaining bulk of plays down to 1642) is a vast stifled jungle, full of wild life and song, with strange growths and heady perfumes, with glades of sunshine and recesses of poisoned darkness; it is not a cleared forest, where single and splendid trees grow to shapely perfection. It has "poetry enough for anything"; passionate situations, and their eloquence; and a number, doubtless small considering its mass, of living and memorable person-

ages. Moral keeping and constructive mastery are rarer still; and too seldom through a whole drama do we see human life and hear its voices, arranged and orchestrated by the artist. But it can be truly said in defence that while structure without poetry is void (as it tended at times to be in Ben Jonson), poetry without structure is still poetry, and that the romantic drama is like nothing else in this world for variety of accent and unexpectedness of beauty. We must read it through, as Charles Lamb did, to do it justice. The diffusion of its characteristic excellences is surprising. Of its extant plays it is hardly safe to leave one unopened, if we are searchers for whatsoever is lovely or admirable. The reasons for the lack of steadfast power and artistic conscience lay partly in the conditions of the stage. Playwrights usually wrote rapidly for bread, and sold their rights. The performances of each play were few. There was no authors' copyright, and dramas were made to be seen and heard, not to be read. There was no articulate dramatic criticism, except such as we find casually in Shakespeare, and in the practice and theory of Jonson, who was deaf or hostile to some of the chief virtues of the romantic playwrights.

The wealth of dramatic production is so great that only a broad classification is here offered. George Chapman stands apart, nearest to the greatest in high austerity of sentiment and in the gracious gravity of his romantic love-comedies. But the crude melodrama of his tragedies is void of true theatrical skill. His quasi-historical French tragedies on Bussy d'Ambois and Biron and Chabot best show his gift and also his insufferable interrupting quaintness. His versions of Homer (1598–1624), honoured alike by Jonson and by Keats, are the greatest verse translations of the time, and the real work of Chapman's life. Their virtues are only partially Homer's, but the general epic nobility and the majesty of single lines, which in length are the near equivalent of the hexameter, redeem the want of Homer's limpidity and continuity and the translator's imperfect knowledge of Greek. A vein of satiric ruggedness unites Jonson and Chapman with Marston and Hall, the professors of an artificial and disgusting invective; and the same strain spoils Marston's plays, and obscures his genuine command of the language of feverish and bitter sentiment. With these writers satire and contempt of the world lie at the root both of their comedy and tragedy.

It is otherwise with most of the romantic dramatists, who may be broadly grouped as follows. (*a*) Thomas Dekker and Thomas Heywood are writers-of-all-work, the former profuse of tracts and pamphlets, the latter of treatises and compilations. They are both unrhetorical and void of pose, and divide themselves between the artless comedy of bustling, lively, English humours and pathetic, unheroic tragedy. But Dekker has splendid and poetical dreams, in *Old Fortunatus* and *The Honest Whore*, both of luxury and of tenderness; while Heywood, as in his *English Traveller* and *Woman killed with Kindness*, excels in pictures of actual, chivalrous English gentlemen and their generosities. The fertility and volubility of these writers, and their modest carelessness of fame, account for many of their imperfections. With them may be named the large crowd of professional journeymen, who did not want for power, but wrote usually in partnership together, like Munday, Chettle and Drayton, or supplied, like William Rowley, underplots of rough, lively comedy or tragedy. (*b*) Amongst dramatists of primarily tragic and sombre temper, who in their best scenes recall the creator of Angelo, Iago and Timon, must be named Thomas Middleton, John Webster, and Cyril Tourneur. Middleton has great but scattered force, and his verse has the grip and ring of the best period without a sign of the decadence. He is strong in high comedy, like *The Old Law*, that turns on some exquisite point of honour—"the moral sense of our ancestors"; in comedy that is merely graphic and vigorous; and in detached sketches of lowering wickedness and lust, like those in *The Changeling* and *Women beware Women*. He and Webster each created one unforgettable desperado, de Flores in *The Changeling* and Bosola in *The Duchess of Malfi* (whose "pity," when it came, was "nothing akin to him"). In Webster's other principal play, *Vittoria Corombona, or the White Devil*, the title-character is not less magnificent in defiant crime than Goneril or Lady Macbeth. The style of Webster, for all his mechanical horrors, distils the essences of pity and terror, of wrath and scorn, and is profoundly poetical; and his point of view seems to be blank fatalism, without Shakespeare's ever-arching rainbow of moral sympathy. Cyril Tourneur, in *The Revenger's Tragedy*, is even more of a poet than Webster; he can find the phrase for half-insane wrath and nightmare brooding, but his chaos of impieties revolts the artistic judgment. These specialists, when all is said, are great men in their dark province. (*c*) The playwrights who may be broadly called romantic, of whom Beaumont, Fletcher and Massinger are the chief, while they share in the same sombre vein, have a wider range and move more in the daylight. The three just named left a very large body of drama, tragic, comic and tragi-comic, in which their several shares can partly be discerned by metrical or other tests. Beaumont is nearest the prime, with his vein of Cervantesque mockery and his pure, beautifully-broken and cadenced verse, which is seen in his contributions to *Philaster* and *The Maid's Tragedy*. Fletcher brings us closest to the actual gaieties and humours of Jacobean life; he has a profuse comic gift and the rare instinct for natural dialogue. His verse, with its flood of vehement and expansive rhetoric, heard at its best in plays like *Bonduca*, cannot cheat us into the illusion that it is truly dramatic; but it overflows with beauty, like his silvery but monotonous versification with its hendecasyllabics arrested at the end. In Fletcher the decadence of form and feeling palpably begins. His personages often face about at critical instants and bely their natures by sudden revulsions. Wanton and cheap characters invite not only dramatic but personal sympathy, as though the author knew no better. There is too much fine writing about a chastity which is complacent rather than instinctive, and satisfied with its formal resistances and technical escapes; so that we are far from Shakespeare's heroines. These faults are present also in Philip Massinger, who offers in substantial recompense, not like Beaumont and Fletcher treasures of incessant vivacious episode and poetry and lyric interlude, but an often splendid and usually solid constructive skill, and a steady eloquence which is like a high table-land without summits. *A New Way to Pay Old Debts* is the most enduring popular comedy of the time outside Shakespeare's, and one of the best. Massinger's interweaving of impersonal or political conceptions, as in *The Bondman* and *The Roman Actor*, is often a triumph of arrangement; and though he wrote in the reign of Charles, he is saved by many noble qualities from being merely an artist of the decline. (*d*) A mass of plays, of which the authorship is unknown, uncertain or attached to a mere name, baffle classification. There are domestic tragedies, such as *Arden of Feversham;* scions of the vindictive drama, like *The Second Maiden's Tragedy;* historic or half-historic tragedies like *Nero*. There are chronicle histories, of which the last and one of the best is Ford's *Perkin Warbeck*, and melodramas of adventure such as Thomas Heywood poured forth. There are realistic citizen comedies akin to *The Merry Wives*, like Porter's refreshing *Two Angry Women of Abingdon;* there are Jonsonian comedies, vernacular farces, light intrigue-pieces like Field's and many more. Few of these, regarded as wholes, come near to perfection; few fail of some sally or scene that proves once more the unmatched diffusion of the dramatic or poetic instinct. (*e*) Outside the regular drama there are many varieties: academic plays, like *The Return from Parnassus* and *Lingua*, which are still mirthful; many pastoral plays or entertainments in the Italian style, like *The Faithful Shepherdess;* versified character-sketches, of which Day's *Parliament of Bees*, with its Theocritean grace and point, is the happiest; many masques and shows, often lyrically and scenically lovely, of which kind Jonson is the master, and Milton, in his *Comus*, the transfigurer; Senecan dramas made only to be read, like Daniel's and Fulke Greville's; and Latin comedies, like *Ignoramus*. All these species are only now being fully grouped, sifted and edited by scholars, but a number of the 600 or 700 dramas of the time remain unreprinted.

There remain two writers, John Ford and James Shirley, who kept the higher tradition alive till the Puritan ordinance crushed

the theatre in 1642. Ford is another specialist, of grave, sinister and concentrated power (reflected in his verse and diction), to whom no topic, the incest of Annabella in *'Tis Pity She's a Whore,* or the high crazed heroism of Calantha in *The Broken Heart,* is beyond the pale, if only he can dominate it; as indeed he does, without complicity, standing above his subject. Shirley, a fertile writer, has the general characteristic gifts, in a somewhat dilute but noble form, of the more romantic playwrights, and claims honour as the last of them.

Prose from 1579 to 1660.—With all the unevenness of poetry, the sense of style, of a standard, is everywhere; felicity is never far off. Prose also is full of genius, but it is more disfigured than verse by aberration and wasted power. A central, classic, durable, adaptive prose had been attained by Machiavelli, and by Amyot and Calvin, before 1550. In England it was only to become distinct after 1660. Vocabulary, sentence-structure, paragraph, idiom and rhythm were in a state of unchartered freedom, and the history of their crystallization is not yet written. But in more than compensation there is a company of prose masters, from Florio and Hooker to Milton and Clarendon, not one of whom clearly or fully anticipates the modern style, and who claim all the closer study that their special virtues have been for ever lost. They seem farther away from us than the poets around them. The verse of Shakespeare is near to us, for its tradition has persisted; his prose, the most natural and noble of his age, is far away, for its tradition has not persisted. One reason of this difference is that English prose tried to do more work than that of France and Italy; it tried the work of poetry; and it often did that better than it did the normal work of prose. This overflow of the imaginative spirit gave power and elasticity to prose, but made its task of finding equilibrium the harder. Moreover, prose in England was for long a natural growth, never much affected by critical or academic canons as in France; and when it did submit to canons, the result was often merely manner. The tendons and sinews of the language, still in its adolescent power and bewilderment, were long unset; that is, the parts of speech—noun and verb, epithet and adverb—were in freer interchange than at any period afterwards. The build, length and cadence of a complex sentence were habitually elaborate; and yet they were disorganized, so that only the ear of a master could regulate them. The law of taste and measure, perhaps through some national disability, was long unperceived. Prose, in fact, could never be sure of doing the day's work in the right fashion. The cross-currents of pedantry in the midst of simplicity, the distrust of clear plain brevity, which was apt to be affected when it came, the mimicries of foreign fashions, and the quaintness and cumbrousness of so much average writing, make it easier to classify Renaissance prose by its interests than by its styles.

The Novel.—The Elizabethan novel was always unhappily mannered, and is mostly dead. It fed the drama, which devoured it. The tales of Boccaccio, Bandello, Cinthio, Margaret of Navarre, and various other writers were purveyed in the forgotten treasuries of Painter, Pettie, Fenton and Whetstone, and many of these works or their originals filled a shelf in the playwrights' libraries. The first of famous English novels, Lyly's *Euphues* (1578), and its sequel *Euphues and his England,* are documents of form. They are commended by a certain dapper shrewdness of observation and an almost witty priggery, not by any real beauty or deep feeling. Euphuism, of which Lyly was only the patentee, not the inventor, strikes partly back to the Spaniard Guevara, and was a model for some years to many followers like Lodge and Greene. It did not merely provide Falstaff with a pattern for mock-moral diction and vegetable similes. It genuinely helped to organize the English sentence, complex or coordinate, and the talk of Portia and Rosalind shows what could be made of it. By the arch-euphuists, clauses and clusters of clauses were paired for parallel or contrast, with the beat of emphatic alliteration on the corresponding parts of speech in each constituent clause. This was a useful discipline for prose in its period of groping. Sidney's unfinished *Arcadia* (of which the earlier and relatively plainer version has recently been made accessible), despite its painful forced antitheses, is sprinkled with lovely rhythms, with pleasing formal landscapes, and even with impassioned sentiment and situation, through which the writer's eager and fretted spirit shines. Both these stories, like those of Greene and Lodge, show by their somewhat affected, edited delineation of life and their courtly tone that they were meant in chief for the eyes of ladies, who were excluded alike from the stage and from its audience. Nashe's drastic and photographic tale of masculine life, *Jack Wilton, or The Unfortunate Traveller,* stands almost alone, but some of the gap is filled by the contemporary pamphlets, sometimes vivid, often full of fierce or maudlin declamation, of Nashe himself—by far the most powerful of the group—and of Greene, Dekker and Nicholas Breton. There are also Deloney's vivid pictures of bourgeois life. Thus the English novel was a minor passing form; the leisurely and amorous romance went on in the next century, owing largely to French influence and example.

Critics and Translators.—In criticism, England may almost be counted with the minor Latin countries. Sidney, in his *Defence of Poesy* (1595, written about 1580), and Jonson in his *Discoveries,* offer a well-inspired and lofty restatement of the current answers to the current questions, but could give no account of the actual creative writing of the time. To defend the "truth" of poetry—which was identified with all inventive writing and not only with verse—poetry was saddled with the work of science and instruction. To defend its character it was treated as a delightful but deliberate bait to good behaviour, a theory at best only true of allegory and didactic verse. The real relation of tragedy to spiritual things, which is admittedly shown, however hard its definition, in Shakespeare's plays, no critic for centuries tried to fathom. One of the chief quarrels turned on metric. A few lines that Sidney and Campion wrote on what they thought the system of Latin quantity are really musical. This theory, already raised by Ascham, made a stir, at first in the group of Harvey, Sidney, Dyer and Spenser, called the "Areopagus," an informal attempt to copy the Italian academies; and it was revived on the brink of the reign of James. But Daniel's firm and eloquent *Defence of Rhyming* (1602) was not needed to persuade the poets to continue rhyming in syllabic verse. The stricter view of the nature and classification of poetry, and of the dramatic unity of action, is concisely given, partly by Jonson, partly by Bacon in his *Advancement of Learning* and *De Augmentis;* and Jonson, besides passing his famed judgments on Shakespeare and Bacon, enriched our critical vocabulary from the Roman rhetoricians. Scholastic and sensible manuals, like Webbe's *Discourse of Poetry* and the *Art of English Poesy* (1589), whose authorship is uncertain, come in the rear.

The translators count for more than the critics; the line of their great achievements from Berners' *Froissart* (1523–25) to Urquhart's *Rabelais* (1653) is never broken long; and though their lives are often obscure, their number witnesses to that far-spread diffusion of the talent for English prose, which the wealth of English poetry is apt to hide. The typical craftsman in this field, Philemon Holland, translated Livy, Pliny, Suetonius, Plutarch's *Morals* and Camden's *Britannia,* and his fount of English is of the amplest and purest. North, in his translation, made from Amyot's classic French, of Plutarch's *Lives* (1579), disclosed one of the master-works of old example; Florio, in Montaigne's *Essays* (1603), the charter of the new freedom of mental exploration; and Shelton, in *Don Quixote* (1612), the chief tragi-comic creation of Continental prose. These versions, if by no means accurate in the letter, were adequate in point of soul and style to their great originals; and the English dress of Tacitus (1591), Apuleius, Heliodorus, Commines, *Celestina* and many others, is so good and often so sumptuous a fabric, that no single class of prose authors, from the time of More to that of Dryden, excels the prose translators, unless it be the Anglican preachers. Their matter is given to them, and with it a certain standard of form, so that their natural strength and richness of phrase are controlled without being deadened. But the want of such control is seen in the many pamphleteers, who are the journalists of the time, and are often also playwrights or tale-tellers, divines or politicians. The writings, for instance, of the hectic, satiric and graphic Thomas Nashe, run at one extreme into fiction, and at the other into the virulent rag-sheets of the Marprelate controversy, which is of historical and

social but not of artistic note, being only a fragment of that vast mass of disputatious literature, which now seems grotesque, excitable or dull.

Hooker.—Richard Hooker's *Laws of Ecclesiastical Polity* (1594–97), an accepted defence of the Anglican position against Geneva and Rome, is the first theological work of note in the English tongue, and the first of note since Wycliffe written by an Englishman. It is a plea for reason as one of the safe and lawful guides to the faith; but it also speaks with admirable temper and large feeling to the ceremonial and aesthetic sense. The First Book, the scaffolding of the treatise, discusses the nature of law at large; but Hooker hardly has pure speculative power, and the language had not yet learnt to move easily in abstract trains of thought. In its elaboration of clause and period, in its delicate resonant eloquence, Hooker's style is Ciceronian; but his inversions and mazes of subordinate sentence somewhat rack the genius of English. Later divines like Jeremy Taylor had to disintegrate, since they could not wield, this admirable but over-complex eloquence. The sermons (1621–31) of Donne have the mingled strangeness and intimacy of his verse, and their subtle flame, imaginative tenacity, and hold upon the springs of awe make them unique. Though without artificial symmetry, their sentences are intricately harmonized, in strong contrast to such pellet-like clauses as those of the learned Lancelot Andrewes, who was Donne's younger contemporary and the subject of Milton's Latin epitaph.

Bacon.—With Francis Bacon (1561–1626) English philosophy began its unbroken course and took its long-delayed rank in Europe. His prose, of which he is the first high and various master in English, was shaped and coloured by his bent as orator and pleader, by his immixture in affairs, by his speculative brain, and by his use and estimate of Latin. In his conscious craftsmanship, his intellectual confidence and curiosity, his divining faith in the future of science, and his resolve to follow the leadings of nature and experience unswervingly; in his habit of storing and using up his experience, and in his wide worldly insight, crystallized in maxim, he suggests a kind of Goethe, without the poetic hand or the capacity for love and lofty suffering. He saw all nature in a map, and wished to understand and control her by outwitting the "idols," or inherent paralysing frailties of the human judgment. He planned but could not finish a great cycle of books in order to realize this conception. The *De Augmentis Scientiarum* (1623) expanded from the English *Advancement of Knowledge* (1605) draws the map; the *Novum Organum* (1620) sets out the errors of scholasticism and the methods of inductive logic; the *New Atlantis* sketches an ideally equipped and moralized scientific community. Bacon shared with the great minds of his century the notion that Latin would outlast any vernacular tongue, and committed his chief scientific writings to a Latin which is alive and splendid and his own, and which also disciplined and ennobled his English. The *Essays* (1597, 1612, 1625) are his lifelong, gradually accumulated diary of his opinions on human life and business. These famous compositions are often sadly mechanical. They are chippings and basketings of maxims and quotations, and of anecdotes, often classical, put together inductively, or rather by "simple enumeration" of the pros and cons. Still they are the honest notes of a practical observer and statesman, disenchanted—why not?—with mankind, concerned with cause and effect rather than with right and wrong, wanting the finer faith and insight into men and women, but full of reality, touched with melancholy, and redeeming some arid, small and pretentious counsels by many that are large and wise. Though sometimes betraying the workshop, Bacon's style, at its best, is infallibly expressive; like Milton's angels, it is "dilated or condensed" according to its purposes. In youth and age alike, Bacon commanded the most opposite patterns and extremes of prose—the curt maxim, balanced in antithesis or triplet, or standing solitary; the sumptuous, satisfying and brocaded period; the movements of exposition, oratory, pleading and narrative. The *History of Henry VII.* (1622), written after his fall from office, is in form as well as insight and mastery of material the one historical classic in English before Clarendon. Bacon's musical sense for the value and placing of splendid words and proper names resembles Marlowe's. But the master of mid-Renaissance prose is Shakespeare; with him it becomes the voice of finer and more impassioned spirits than Bacon's—the voice of Rosalind and Hamlet. And the eulogist of both men, Ben Jonson, must be named in their company for his senatorial weight and dignity of ethical counsel and critical maxim.

Hobbes and Browne.—As the Stuart rule declined and fell, prose became enriched from five chief sources: from philosophy, whether formal or unmethodical; from theology and preaching and political dispute; from the poetical contemplation of death; from the observation of men and manners; and from antiquarian scholarship and history. As in France, where the first three of these kinds of writings flourished, it was a time rather of individual great writers than of any admitted pattern or common ideal of prose form, although in France this pattern was always more clearly defined. The mental energy, meditative depth, and throbbing brilliant colour of the English drama passed with its decay over into prose. But Latin was still often the supplanter: the treatise of Lord Herbert of Cherbury, *De Veritate*, of note in the early history of Deism, and much of the writing of the ambidextrous Thomas Hobbes, are in Latin. In this way Latin disciplined English once more, though it often tempted men of genius away from English. The *Leviathan* (1651) with its companion books on *Human Nature* and *Liberty*, and Hobbes' explosive dialogue on the civil wars, *Behemoth* (1679), have the bitter concision of Tacitus and the clearness of a half-relief in bronze. Hobbes' speculations on the human animal, the social contract, the absolute power of the sovereign, and the subservience owed to the sovereign by the church or "Kingdom of Darkness," enraged all parties, and left their trace on the thought and controversial literature of the century. With Ben Jonson and the jurist Selden (whose English can be judged from his *Table Talk*), Hobbes anticipates the brief and clear sentence-structure of the next age, though not its social ease and amenity of form. But his grandeur is not that of a poet, and the poetical prose is the most distinctive kind of this period. It is eloquent above all on death and the vanity of human affairs; its solemn tenor prolongs the reflections of Claudio, of Fletcher's Philaster, or of Spenser's Despair. It is exemplified in Bacon's Essay *Of Death*, in the anonymous descant on the same subject once wrongly ascribed to him, in Donne's plea for suicide, in Raleigh's *History of the World*, in Drummond's *Cypress Grove* (1623), in Jeremy Taylor's sermons and *Holy Dying* (1651), and in Sir Thomas Browne's *Urn-Burial* (1658) and *Letter to a Friend*. Its usual vesture is a long purple period, freely Latinized, though Browne equally commands the form of solemn and monumental epigram. He is also free from the dejection that wraps round the other writers on the subject, and a holy quaintness and gusto relieve his ruminations. The *Religio Medici* (1642), quintessentially learned, wise and splendid, is the fullest memorial of his power. Amongst modern prose writers, De Quincey is his only true rival in musical sensibility to words.

Taylor and Burton.—Jeremy Taylor, the last great English casuist and schoolman, and one of the first pleaders for religious tolerance (in his *Liberty of Prophesying*, 1647), is above all a preacher; tender, intricate, copious, inexhaustible in image and picturesque quotation. From the classics, from the East, from the animal world, from the life of men and children, his illustrations flow, without end or measure. He is a master of the lingering cadence, which soars upward and onward on its coupled clauses, as on balanced iridescent wings, and is found long after in his scholar Ruskin. Imaginative force of another kind pervades Robert Burton's *Anatomy of Melancholy* (1621), where the humorous medium refracts and colours every ray of the recluse's far-travelled spirit. The mass of Latin citation, woven, not quilted, into Burton's style, is another proof of the vitality of the cosmopolitan language. Burton and Browne owe much to the pre-critical learning of their time, which yields up such precious savours to their fancy, that we may be thankful for the delay of more precise science and scholarship. Fancy, too, of a suddener and wittier sort, preserves some of the ample labours of Thomas Fuller, which are scattered over the years 1631–62; and the *Lives* and *Compleat Angler* (1653) of Izaak Walton are unspoilt, happy or pious pieces

of idyllic prose. No adequate note on the secular or sacred learning of the time can here be given; on Camden, with his vast erudition, historical, antiquarian and comparatively critical (*Britannia,* in Latin, 1586); or on Ussher, with his patristic and chronological learning, one of the many *savants* of the Anglican church. Other divines of the same camp pleaded, in a plainer style than Taylor, for freedom of personal judgment and against the multiplying of "vitals in religion"; the chief were Chillingworth, one of the ablest of English apologists, in his *Religion of Protestants* (1638), and John Hales of Eton. The Platonists, or rather Plotinists, of Cambridge, who form a curious digression in the history of modern philosophy, produced two writers, John Smith and Henry More, of an exalted and esoteric prose, more directly inspired by Greece than any other of the time; and their champion of erudition, Cudworth, in his *True Intellectual System,* gave some form to their doctrine.

Clarendon and Milton.—Above the vast body of pamphlets and disputatious writing that form the historian's material stands Edward Hyde, earl of Clarendon's *History of the Rebellion,* printed in 1702–04, 30 years after his death. Historical writing hitherto, but for Bacon's *Henry VII.*, had been tentative though profuse. Raleigh's vast disquisition upon all things, *The History of the World* (1614), survives by passages and poetic splendours; gallantly written second-hand works like Knolles's *History of the Turks,* and the rhetorical *History of the Long Parliament* by May, had failed to give England rank with France and Italy. Clarendon's book, one of the greatest memoirs and most vivid of portrait-galleries, spiritually unappreciative of the other side, but full of a subtle discrimination of character and political motive, brings its author into line with Retz and Saint-Simon, the watchers and recorders and sometimes the makers of contemporary history. Clarendon's *Life,* above all the picture of Falkland and his friends, is a personal record of the delightful sort in which England was thus far infertile. He is the last old master of prose, using and sustaining the long, sinuous sentence, unworkable in weaker hands. He is the last, for Milton's polemic prose, hurled from the opposite camp, was written between 1643 and 1660. Whether reviling bishops or royal privilege or indissoluble monogamy, or recalling his own youth and aims; or claiming liberty for print in *Areopagitica* (1644); in his demonic defiances, or angelic calls to arms, or his animal eruptions of spite and hatred, Milton leaves us with a sense of the motive energies that were to be transformed into *Paradise Lost* and *Samson.* His sentences are ungainly and often inharmonious, but often irresistible; he rigidly withstood the tendencies of form, in prose as in verse, that Dryden was to represent, and thus was true to his own literary dynasty.

The Authorized Version.—A special outlying position belongs to the Authorized Version (1611) of the Bible, the late fruit of the long toil that had begun with Tyndale's, and, on the side of style, with the Wycliffite translations. More scholarly than all the preceding versions which it utilized, it won its incomparable form, not so much because of the "grand style that was in the air," which would have been the worst of models, as because the style had been already tested and ennobled by generations of translators. Its effect on poetry and letters was for some time far smaller than its effect on the national life at large, but it was the greatest translation—being of a whole literature, or rather of two literatures—in an age of great translations.

Characters.—Other forms soften the transition to Restoration prose. The vast catalogue of Characters numbers hundreds of titles. Deriving from Theophrastus, who was edited by Casaubon in 1592, they are yet another Renaissance form that England shared with France. But in English hands, failing a La Bruyère —in Hall's, in Overbury's, even in those of the gay and skilful Earle (*Microcosmographie,* 1628)—the Character is a mere list of the attributes and oddities of a type or calling. It is to the Jonsonian drama of humours what the *pensée* or detached remark, practised by Bishop Hall and later by Butler and Halifax, is to the essay. These works tended long to be commonplace or didactic, as the popular *Resolves* of Owen Feltham shows. Cowley was the first essayist to come down from the desk and talk as to his equals in easy phrases of middle length. A time of dissension was not the best for this kind of peaceful, detached writing. The letters of James Howell, the autobiography of Lord Herbert of Cherbury, and the memoirs of Kenelm Digby belong rather to the older and more mannered than to the more modern form, though Howell's English is in the plainer and quicker movement.

IV. RESTORATION PERIOD

French Influence.—The Renaissance of letters in England entered on a fresh and peculiar phase in the third quarter of the century. The balance of intellectual and artistic power in Europe had completely shifted since 1580. Inspiration had died down in Italy, and its older classics were no longer a stimulus. The Spanish drama had flourished, but its influence though real was scattered and indirect. The Germanic countries were slowly emerging into literature; England they scarcely touched. But the literary empire of France began to declare itself both in Northern and Southern lands, and within half a century was assured. Under this empire the English genius partly fell, though it soon asserted its own equality, and by 1720 had so reacted upon France as more than to repay the debt. Thus between 1660 and 1700 is prepared a temporary dual control of European letters. But in Dryden's age France gave England more than she received; she gave more than she had ever given since the age of Chaucer. During Charles II.'s days Racine, Molière, La Fontaine and Bossuet ran the best of their course. Cavalier exiles like Waller, Cowley and Hobbes had come back from the winter of their discontent in Paris, and Saint-Evremond, the typical *bel esprit* and critic, settled long in England. A vast body of translations from the French is recounted, including latterly the works of the Protestant refugees printed in the free Low Countries or in England. Naturally this influence told most strongly on the social forms of verse and prose—upon comedy and satire, upon criticism and maxim and epigram, while it also affected theology and thought. And this meant the Renaissance once more, still unexhausted, only working less immediately and in fresh if narrower channels. Greek literature, Plato and Homer and the dramatists, became dimmer; the secondary forms of Latin poetry came to the fore, especially those of Juvenal and the satirists, and the *pedestris sermo,* epistolary and critical, of Horace. These had some direct influence, as Dryden's translation of them, accompanying his Virgil and Lucretius, may show. But they came commended by Boileau, their chief modernizer, and in their train was the fashion of gallant, epigrammatic and social verse. The tragedy of Corneille and Racine, developed originally from the Senecan drama, contended with the traditions of Shakespeare and Fletcher, and was reinforced by that of the correcter Jonson, in shaping the new theatre of England. The French codifiers, who were often also the distorters, of Aristotle's *Poetics* and Horace's *Ars poetica,* furnished a canonical body of criticism on the epic and the drama, to which Dryden is half a disciple and half a rebel. All this implied at once a loss of the larger and fuller inspirations of poetry, a decadence in its great and primary forms, epic, lyric and tragic, and a disposition, in default of such creative power, to turn and take stock of past production. In England, therefore, it is the age of secondary verse and of nascent, often searching criticism.

Rise of Science.—The same critical spirit was also whetted in the fields of science and speculation, which the war and the Puritan rule had not encouraged. The activities of the newly-founded Royal Society told directly upon literature, and counted powerfully in the organization of a clear, uniform prose—the "close, naked, natural way of speaking," which the historian of the Society, Sprat, cites as part of its programme. And the style of Sprat, as of scientific masters like Newton and Ray the botanist, itself attests the change. A time of profound and peaceful and fruitful scientific labour began; the whole of Newton's *Principia* appeared in 1687; the dream of Bacon came nearer, and England was less isolated from the international work of knowledge. The spirit of method and observation and induction spread over the whole field of thought and was typified in John Locke, whose *Essay concerning Human Understanding* came out in English in 1690, and who applied the same deeply sagacious

and cautious calculus to education and religion and the "conduct of the understanding." But his works, though their often mellow and dignified style has been ignorantly underrated, also show the change in philosophic writing since Hobbes. The old grandeur and pugnacity are gone; the imaginative play of science, or quasi-science, on the literature of reflection is gone; the eccentrics, the fantasts, the dreamers are gone, or only survive in curious transitional writers like Joseph Glanvil (*Scepsis scientifica,* 1665) or Thomas Burnet (*Sacred Theory of the Earth,* 1684). This change was in part a conscious and an angry change, as is clear from the attacks made in Samuel Butler's *Hudibras* (1663–68) upon scholastic verbiage, astrology, fanatical sects and their disputes, upon poetic "heroic" enthusiasm and intellectual whim.

Before the Restoration men of letters, with signal exceptions like Milton and Marvell, had been Cavalier, courtly and Anglican in their sympathies. The Civil War had scattered them away from the capital, which, despite Milton's dream in *Areopagitica* of its humming and surging energies, had ceased to be, what it now again became, the natural haunt and Rialto of authors. The taste of the new king and court served to rally them. Charles II. relished *Hudibras,* used and pensioned Dryden, sat under Barrow and South and heard them with appreciation, countenanced science, visited comedies, and held his own in talk by mother-wit. Letters became the pastime, and therefore one of the more serious pursuits, of men of quality, who soon excelled in song and light scarifying verse and comedy, and took their own tragedies and criticisms gravely. Poetry under such auspices became gallant and social, and also personal and partisan; and satire was soon its most vital form, with the accessories of compliment, rhymed popular argumentation and elegy. The social and conversational instinct was the master-influence in prose. It produced a subtle but fundamental change in the attitude of author to reader. Prose came nearer to living speech, it became more civil and natural and persuasive, and this not least in the pulpit. The sense of ennui, or boredom, which seemed unknown in the earlier part of the century, became strongly developed, and prose was much improved by the fear of provoking it. In all these ways the Restoration accompanied and quickened a speedier and greater change in letters than any political event in English history since the reign of Alfred, when prose itself was created.

Prose and Criticism.—The formal change in prose can thus be assigned to no one writer, for the good reason that it presupposes a change of spoken style lying deeper than any personal influence. If we begin with the writing that is nearest living talk—the letters of Otway or Lady Rachel Russell, or the diary of Pepys (1659–69)—that supreme disclosure of our mother-earth —or the evidence in a State trial, or the dialogue in the more natural comedies; if we then work upwards through some of the plainer kinds of authorship, like the less slangy of L'Estrange's pamphlets, or Burnet's *History of My Own Time,* a solid Whig memoir of historical value, until we reach really admirable or lasting prose like Dryden's *Preface* to his *Fables* (1700), or the maxims of Halifax;—if we do this, we are aware, amid all varieties, survivals and reversions, of a strong and rapid drift towards the style that we call modern. And one sign of this movement is the revulsion against any over-saturating of the working, daily language, and even of the language of appeal and eloquence, with the Latin element. In Barrow and Glanvil, descendants of Taylor and Browne, many Latinized words remain, which were soon expelled from style like foreign bodies from an organism. As in the mid-16th and the mid-18th century, the process is visible by which the Latin vocabulary and Latin complication of sentence first gathers strength, and then, though not without leaving its traces, is forced to ebb. The instinct of the best writers secured this result, and secured it for good and all. In Dryden's diction there is a nearly perfect balance and harmony of learned and native constituents, and a sensitive tact in Gallicizing; in his build of sentence there is the same balance between curtness or bareness and complexity or ungainly lengthiness. For ceremony and compliment he keeps a rolling period, for invective a short sharp stroke without the gloves. And he not only uses in general a sentence of moderate scale, inclining to brevity, but he finds out its harmonies; he is a seeming-careless but an absolute master of rhythm. In delusive ease he is unexcelled; and we only regret that he could not have written prose oftener instead of plays. We should thus, however, have lost their prefaces, in which the bulk and the best of Dryden's criticisms appear. From the *Essay of Dramatic Poesy* (1668) down to the *Preface to Fables* (1700) runs a series of essays: *On the Grounds of Criticism in Tragedy, On Heroic Plays, On Translated Verse, On Satire* and many more; which form the first connected body of criticisms in the language, and are nobly written always. Dryden's prose is literature as it stands, and yet is talk, and yet again is mysteriously better than talk. The critical writings of John Dennis are but a sincere application of the rules and canons that were now becoming conventional; Rymer, though not so despicable as Macaulay said, is still more depressing than Dennis; and for any critic at once so free, so generous and so sure as Dryden we wait in vain for a century.

Three or four names are usually associated with Dryden's in the work of reforming or modifying prose: Sprat, Tillotson, Sir William Temple, and George Savile, marquis of Halifax; but the honours rest with Halifax. Sprat, though clear and easy, has little range; Tillotson, though lucid, orderly, and a very popular preacher, has little distinction; Temple, the elegant essayist, has a kind of barren gloss and fine literary manners, but very little to say. The political tracts, essays and maxims of Halifax are the most typically modern prose between Dryden and Swift, and are nearer than anything else to the best French writing of the same order, in their finality of epigram, their neatness and mannerliness and sharpness. The *Character of a Trimmer* and *Advice to a Daughter* are the best examples.

Religious Literature, Anglican and Puritan, is the chief remaining department to be named. The strong, eloquent and coloured preaching of Isaac Barrow, the mathematician, who died in 1677, is a survival of the larger and older manner of the church. In its balance of logic, learning and emotion, in its command alike of Latin splendour and native force, it deserves a recognition it has lost. Another athlete of the pulpit, Robert South, who is so often praised for his wit that his force is forgotten, continues the lineage, while Tillotson and the elder Sherlock show the tendency to the smoother and more level prose. But the revulsion against strangeness and fancy and magnificence went too far; it made for a temporary bareness and meanness and disharmony, which had to be checked by Addison, Bolingbroke and Berkeley. From what Addison saved our daily written English, may be seen in the vigorous slangy hackwork of Roger L'Estrange, the translator and pamphleteer, in the news-sheets of Dunton, and in the satires of Tom Brown. These writers were debasing the coinage with their street journalism.

Another and far nobler variety of vernacular prose is found in the Puritans. Baxter and Howe, Fox and Bunyan, had the English Bible behind them, which gave them the best of their inspiration, though the first two of them were also erudite men. Richard Baxter, an immensely fertile writer, is best remembered by those of his own fold for his *Saint's Everlasting Rest* (1650) and his autobiography, John Howe for his evangelical apologia *The Living Temple of God* (1675), Fox for his *Journal* and its mixture of quaintness and rapturous mysticism. John Bunyan, the least instructed of them all, is their only born artist. His creed and point of view were those of half the nation—the half that was usually inarticulate in literature, or spoke without style or genius. His reading, consisting not only of the Bible, but of the popular allegories of giants, pilgrims and adventure, was also that of his class. *The Pilgrim's Progress,* of which the first part appeared in 1678, the second in 1684, is the happy flowering sport amidst a growth of barren plants of the same tribe. The *Progess* is a dream, more vivid to its author than most men's waking memories to themselves; the emblem and the thing signified are merged at every point, so that Christian's journey is not so much an allegory with a key as a spiritual vision of this earth and our neighbours. *Grace Abounding,* Bunyan's diary of his own voyage to salvation, *The Holy War,* an overloaded fable of the fall and recovery of mankind, and *The Life and*

Death of Mr. Badman, a novel telling of the triumphal earthly progress of a scoundrelly tradesman, are among Bunyan's other contributions to literature. His union of spiritual intensity, sharp humorous vision, and power of simple speech consummately chosen, mark his work off alike from his own inarticulate public and from all other literary performance of his time.

Transitional Verse.—The transition from the older to the newer poetry was not abrupt. Old themes and tunes were slowly disused, others previously of lesser mark rose into favour, and a few quite fresh ones were introduced. The poems of John Oldham and Andrew Marvell belong to both periods. Both of them begin with fantasy and elegy, and end with satires, which indeed are rather documents than works of art. The monody of Oldham on his friend Morwent is poorly exchanged for the *Satires on the Jesuits* (1681), and the lovely metaphysical verses of Marvell on gardens and orchards and the spiritual love sadly give place to his *Last Instructions to a Painter* (1669). In his *Horatian Ode* Marvell had nobly and impartially applied his earlier style to national affairs; but the time proved too strong for this delightful poet. Another and a stranger satire had soon greeted the Restoration, the *Hudibras* (1663–78) of Samuel Butler, with its companion pieces. The returned wanderers delighted in this horribly agile, boisterous and fierce attack on the popular party and its religions, and its wrangles and its manners. Profoundly eccentric and tiresomely allusive in his form, and working in the short rhyming couplets thenceforth called "Hudibrastics," Butler founded a small and peculiar but long-lived school of satire. The other verse of the time is largely satire of a different tone and metre; but the earlier kind of finished and gallant lyric persisted through the reign of Charles II. The songs of John Wilmot, earl of Rochester, are usually malicious, sometimes passionate; they have a music and a splendid self-abandonment such as we never meet again till Burns. Sedley and Dorset and Aphra Behn and Dryden are the rightful heirs of Carew and Lovelace, those infallible masters of short rhythms; and this secret also was lost for a century afterwards.

Dryden.—In poetry, in prose, and to some extent in drama, John Dryden, the creature of his time, is the master of its expression. He began with panegyric verse, first on Cromwell and then on Charles, which is full of fine things and false writing. The *Annus Mirabilis* (1667) is the chief example, celebrating the Plague, the Fire and the naval victory, in the quatrains for which Davenant's pompous *Gondibert* had shown the way. The *Essay on Dramatic Poesy* (1668), a dialogue on the rivalries of blank verse with rhyme, and of the Elizabethan drama with the French, is perfect modern prose; and to this perfection Dryden attained at a bound, while he attained his poetical style more gradually. He practised his couplet in panegyric, in heroic tragedy, and in dramatic prologue and epilogue for 20 years before it was consummate. Till 1680 he supported himself chiefly by his plays, which have not lived so long as their critical prefaces, already mentioned. His diction and versification came to their full power in his satires, rhymed arguments, dedications and translations. *Absalom and Achitophel* (part 1, 1681; part 2, with Nahum Tate, 1682), as well as *The Medal* and *Mac Flecknoe,* marked a new birth of English satire, placing it at once on a level with that of any ancient or modern country. The mixture of deadly good temper, Olympian unfairness, and rhetorical and metrical skill in each of these poems has never been repeated. The presentment of Achitophel, earl of Shaftesbury, in his relations with Absalom Walters and Charles the minstrel-king of Judah, as well as the portraits of Shimei and Barzillai and Jotham, the eminent Whigs and Tories, and of the poets Og and Doeg, are things whose vividness age has never discoloured. Dryden's Protestant arguings in *Religio Laici* (1682) and his equally sincere Papistical arguings in *The Hind and the Panther* (1687) are just as skilful. His translations of Virgil and parts of Lucretius, of Chaucer and Boccaccio (*Fables*, 1700), set the seal on his command of his favourite couplet for the higher kinds of appeal and oratory. His *Ode* on Anne Killigrew, and his popular but coarser *Alexander's Feast,* have a more lyric harmony; and his songs, inserted in his plays, reflect the change of fashion by their metrical adeptness and often thoroughgoing wantonness. The epithet of "glorious," in its older sense of a certain conscious and warranted pride of place, not in that of boastful or pretentious, suits Dryden well. Not only did he leave a model and a point of departure for Pope, but his influence recurs in Churchill, in Gray, in Johnson and in Crabbe, where he is seen counteracting, with his large, wholesome and sincere bluntness, the acidity of Pope. Dryden was counted near Shakespeare and Milton until the romantic revival renewed the sense of proportion; but the same sense now demands his acknowledgment as the English poet who is nearest to their frontiers of all those who are exiled from their kingdom.

Restoration Drama.—Restoration and Revolution tragedy is nearly all abortive; it is now hard to read it for pleasure. But it has lofty flights, and its historic interest is high. Two of its species, the rhymed heroic play and the rehandling of Shakespeare in blank verse, were also brought to their utmost by Dryden, though in both he had many companions. The heroic tragedies were a hybrid offspring of the heroic romance and French tragedy; and though *The Conquest of Granada* (1669–70) and *Tyrannic Love* would be very open to satire in Dryden's own vein, they are at least generously absurd. Their intention is never ignoble, if often impossible. After a time Dryden went back to Shakespeare, after a fashion already set by Sir William Davenant, the connecting link with the older tragedy and the inaugurator of the new. They "revived" Shakespeare; they vamped him in a style that did not wholly perish till after the time of Garrick. *The Tempest, Troilus and Cressida,* and *Antony and Cleopatra* were thus handled by Dryden; and the last of these, as converted by him into *All for Love* (1678) is loftier and stronger than any of his original plays, its blank verse renewing the ties of Restoration poetry with the great age. The heroic plays, written in one or other metre, lived long, and expired in the burlesques of Fielding and Sheridan. *The Rehearsal* (1671), a gracious piece of fooling partly aimed at Dryden by Buckingham and his friends, did not suffice to kill its victims. Thomas Otway and Nathaniel Lee, both of whom generally used blank verse, are the other tragic writers of note, children indeed of the extreme old age of the drama. Otway's long-acted *Venice Preserved* (1682) has an almost Shakespearian skill in melodrama, a wonderful tide of passionate language, and a blunt and bold delineation of character; but Otway's inferior style and verse could only be admired in an age like his own. Lee is far more of a poet, though less of a dramatist, and he wasted a certain talent in noise and fury.

Restoration comedy at first followed Jonson, whom it was easy to try and imitate; Shadwell and Wilson, whose works are a museum for the social antiquary, photographed the humours of the town. Dryden's many comedies often show his more boisterous and blatant, rarely his finer qualities. Like all playwrights of the time he pillages from the French, and vulgarizes Molière without stint or shame. A truer light comedy began with Sir George Etherege, who mirrored in his fops the gaiety and insolence of the world he knew. The society depicted by William Wycherley, the one comic dramatist of power between Massinger and Congreve, at first seems hardly human; but his energy is skilful and faithful as well as brutal; he excels in the graphic reckless exhibition of outward humours and bustle; he scavenges in the most callous good spirits and with careful cynicism. *The Plain Dealer* (1677), a skilful transplantation, as well as a depravation of Molière's *Le Misanthrope,* is his best piece: he writes in prose, and his prose is excellent, modern and lifelike.

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See also DRAMA; SONNET; RENAISSANCE. (O. E.)

V. THE 18TH CENTURY

In the reign of Anne (1702–14) the social changes which had begun with the Restoration of 1660 made themselves definitely felt. Books began to penetrate among all classes of society. The period is consequently one of differentiation and expansion. As the practice of reading becomes more and more universal, English writers lose much of their old idiosyncrasy, intensity and obscurity. As in politics and religion, so in letters, there is a great development of nationality. Commercial considerations too for the first time become important. Provincial feeling exercises a diminishing sway, and literature becomes increasingly metropolitan or suburban. With the multiplication of moulds, the refinement of prose polish, and the development of breadth, variety and ease, it was natural enough, having regard to the part that the country played in the world's affairs, that English literature should make its début in western Europe. The strong national savour seemed to stimulate the foreign appetite, and as represented by Swift, Pope, Defoe, Young, Goldsmith, Richardson, Sterne and Ossian, if we exclude Byron and Scott, the 18th century may be deemed the cosmopolitan age, *par excellence*, of English Letters.

It is pre-eminently an age of prose, and although verbal expression is seldom represented at its highest power, we shall find nearly every variety of English prose brilliantly illustrated during this period: the aristocratic style of Bolingbroke, Addison and Berkeley; the gentlemanly style of Fielding; the keen and logical controversy of Butler, Middleton, Smith and Bentham; the rhythmic and balanced if occasionally involved style of Johnson and his admirers; the limpid and flowing manner of Hume and Mackintosh; the light, easy and witty flow of Walpole; the divine chit-chat of Cowper; the colour of Gray and Berkeley; the organ roll of Burke; the lucid realism of Swift and Defoe, the sly familiarity of Sterne; the dance music and wax candles of Sheridan; the stateliness of Gibbon; the air and ripple of Goldsmith; the dramatic dialogue of Boswell—these and other characteristics can be illustrated in 18th-century prose as probably nowhere else.

Addison, Swift and Defoe.—At the outset of the new century the two chief architects of public opinion were John Locke and Joseph Addison. When he died at High Laver in Oct. 1704 at the age of 72, Locke had, perhaps, done more than any man of the previous century to prepare the way for the new era. Social duty and social responsibility were his two watchwords. The key to both he discerned in the *Human Understanding*—"no province of knowledge can be regarded as independent of reason." But the great modernist of the time was Joseph Addison (1672–1719). It was he who first left the 17th century, with its formal obsequiousness, definitely behind. He did for English culture what Rambouillet did for that of France, and it is hardly an exaggeration to call the half-century before the great fame of the English novel, the half century of the *Spectator*.

Addison's mind was fertilized by intercourse with the more original genius of Swift and with the more inventive mind of Steele. It was Richard Steele (1672–1729) in the *Tatler* of 1709–10 who first realized that the specific which that urbane age both needed and desired was no longer copious preaching and rigorous declamation, but little doses of good sense, good taste and good-humoured morality, disguised beneath an easy and fashionable style. Nothing could have suited Addison better than the opportunity afforded him of contributing an occasional essay or roundabout paper in praise of virtue or dispraise of stupidity and bad form to his friend's periodical. When the *Spectator* succeeded the *Tatler* in March 1711, Addison took a more active share in shaping the chief characters (with the immortal baronet, Sir Roger, at their head) who were to make up the "Spectator club"; and, better even than before, he saw his way, perhaps, to reinforcing his copious friend with his own more frugal but more refined endowment. Such a privileged talent came into play at precisely the right moment to circulate through the coffee houses and to convey a large measure of French ease and elegance into the texture of English prose. Addison became a personage of the utmost consideration, and the essay as he left it became an almost indispensable accomplishment to the complete gentlemen of that age.

The other side, both in life and politics, was taken by Jonathan Swift (1667–1745), who preferred to represent man on his unsocial side. He sneered at most things, but not at his own order, and he came to defend the church and the country squirearchy against the conventicle and Capel court. To undermine the complacent entrenchments of the Whig capitalists at war with France no sap proved so effectual as his pen. Literary influence was then exercised in politics mainly by pamphlets, and Swift was the greatest of pamphleteers. In the *Journal to Stella* he has left us a portrait of himself in turn currying favour, spoiled, petted and humiliated by the party leaders of the Tories from 1710–13. He had always been bitter in his satire, and when the Hanoverians came in and he was treated as a suspect, he showed the very genius of savagery in his mockery of all mankind (*Gulliver's Travels*, 1726). In wit, logic, energy, pith, sardonic playfulness, resourcefulness and Saxon simplicity, his prose has never been equalled. The choicest English then, it is the choicest English still. Dr. John Arbuthnot (1667–1735) may be described as an understudy of Swift on the whimsical side only, whose malignity, in a nature otherwise most kindly, was circumscribed strictly by the limits of political persiflage. Bernard Mandeville (1670–1733), unorthodox as he was in every respect, discovered a little of Swift's pessimism in his assault (in *The Fable of the Bees* of 1723) on the genteel optimism of the *Characteristics* of Lord Shaftesbury. Neither the matter nor the manner of the brilliant Tory chieftain Henry St. John, Viscount Bolingbroke (1678–1751), appears to us now as being of the highest significance; but, although Bolingbroke's ideas were second-hand, his work has historical importance. His essays on "History" and on "a Patriot King" both disturb a soil well prepared, and set up a reaction against such evil tendencies as a narrowing conception of history and a factious and partisan conception of politics.

The new trade of writing was represented most perfectly by Daniel Defoe (1660–1731). From reporting sensations and chronicling *faits divers*, Defoe worked his way almost insensibly to the Spanish tale of the picaresque pattern. *Robinson Crusoe* was a true story expanded on these lines, and written under stress of circumstance when its author was just upon 60. What Defoe excelled in was plain, straightforward story-telling, in understanding and appraising the curiosity of the ordinary man, and in possessing just the literary stroke that would enable him most effectually to satisfy it. He was the first and cleverest of all descriptive reporters, for he knew better than any successor how and where to throw in those details which give an air of verisimilitude to a narrative—the little naïvetés as of a plain man who is not telling a tale for effect, but striving after his own manner to give the plain unvarnished truth. Defoe contributes story, Addison character, Fielding the life-atmosphere, Richardson and Sterne the sentiment, and we have the 18th-century novel complete.

Poetry.—To the passion and imagination essential to the most inspired kinds of poetry Alexander Pope (1688–1744) can lay small claim, even in his best work like the *Satires* and *Epistles*. Yet in lucid, terse and pungent phrase, and in mastery of his metrical instrument, he has rarely if ever been surpassed. His classical fancy, his elegant turn for periphrasis and his venomous sting alike made him the idol of that urbane age. His style was the apotheosis of wit, point, lucidity and technical correctness. Pope was the first Englishman to make poetry pay (apart from

patronage). He was flattered by imitation to an extent which threatened to throw the school of poetry which he represented into permanent discredit. The second-rate wore his badge. But although the cult of Pope was the established religion of poetic taste from 1714 to 1798, there were always nonconformists. The poetic revolt, indeed, was far more versatile than the religious revival of the century. The *Winter* (1726) of James Thomson may be regarded as inaugurating a new era in English poetry. Lady Winchilsea, John Philips, author of *Cyder*, and John Dyer, whose *Grongar Hill* was published a few months before *Winter*, had pleaded by their work for a truthful and unaffected, and at the same time a romantic treatment of nature in poetry; but the ideal of artificiality and of a frigid poetic diction by which English poetry had been dominated since the days of Waller and Cowley was first effectively challenged by Thomson. At the time when the Popean couplet was at the height of its vogue he deliberately put it aside in favour of blank verse. And he it was who transmitted the sentiment of natural beauty not merely to imitators, but also to Collins, to Gray and to Cowper, and so indirectly to the lyrical bards of 1798. By the same hands and those of Shenstone experiments were being made in the stanza of *The Faerie Queene;* a little later, through Bishop Percy, the cultivation of the old English and Scottish ballad literature became popular. Dissatisfaction with the limitations of "Augustan" poetry was similarly responsible for the revived interest in Shakespeare and Chaucer.

To pretend then that the poetic heart of the 18th century was Popean to the core would be extravagant. There were a number of poets in the second and third quarters of the century who strove to reinstate imagination upon its throne, and to substitute the singing voice for the rhetorical recitative of the heroic couplet. Within two years of the death of Pope, in 1746, William Collins was content to *sing* (not say) what he had in him. A more important if less original figure in that movement was Thomas Gray, a man of the widest curiosities of his time, in whom every attribute of the poet to which scholarship, taste and refinement are contributory may be found to the full, but in whom the strong creative energy is deficient—despite the fact that he wrote a string of "divine truisms" in his *Elegy*, which has given to multitudes more of the exquisite pleasure of poetry than any other single piece in the English language. The imaginative originality of Christopher Smart's *Song to David,* written in Bedlam, has won slower but authoritative recognition. Shenstone and Percy, Capell, the Wartons and eventually Chatterton, continued to mine in the shafts which Gray had been the first to sink.

The Novel.—The development of the individual and of a well-to-do urban middle class, which was rapidly multiplying its area of leisure, brought into existence a curious and self-conscious society, hungry for pleasure and new sensations, anxious to be told about themselves, willing in some cases even to learn civilization from their betters. The disrepute into which the drama had fallen since Jeremy Collier's attack on it directed this society by an almost inevitable course into the flowery paths of fiction. The De Coverley papers in the *Spectator* want nothing but a love-thread to convert them into a serial novel of a high order. The supreme importance of the sentimental interest had already been discovered in France by Madame de la Fayette, the Marquise de Tencin, Marivaux and the Abbé Prevost. Samuel Richardson (1689–1762), therefore, when he produced the first two modern novels of European fame in *Pamela* (1740) and *Clarissa* (1748), inherited far more than he invented. There had been Richardsonians before Richardson. *Pamela* is nevertheless a pioneer work in its adroit use of the epistolary method and in its revelation of the latent romance in the outwardly commonplace life of a maid-servant. In *Clarissa* Richardson rises to a greater height as an anatomist of the female heart and creates in his heroine one of the master-figures of literature. The long drawn out English novel of love analysis and moral sentiment (as opposed to the romance of adventure) has in Richardson its first successful charioteer.

The novel in England gained prodigiously by the shock of opposition between the ideals of Richardson and Henry Fielding (1707–54), his rival and parodist. Fielding is, to be brief, the antithesis of Richardson, and represents the opposite pole of English character. He is the Cavalier, Richardson the Roundhead; he is the gentleman, Richardson the tradesman; he represents church and county, Richardson chapel and borough. There was no poetry in Fielding; but there was practically every other ingredient of a great prose writer—taste, culture, order, vivacity, humour, penetrating irony and vivid, pervading common sense and it is Fielding's masterpiece *Tom Jones* (1749) that we must regard if not as the fundament at least as the head of the corner in English prose fiction. Before *Tom Jones* appeared, the success of the novel had drawn a new competitor into the field in Tobias Smollett, the descendant of a good western lowland family who had knocked about the world and seen more of its hurlyburly than Fielding himself. The genius which struggles through novels such as *Roderick Random* and *Ferdinand Count Fathom* was nearly submerged under the hard conditions of a general writer during the third quarter of the 18th century, and it speaks volumes for Smollett's powers of recuperation that he survived to write two such masterpieces of sardonic and humorous observation as his *Travels* and *Humphry Clinker.*

The fourth master of the English novel was Laurence Sterne. Though they owed a good deal to *Don Quixote* and the French novelists, Fielding and Smollett were essentially observers of life in the quick. Sterne brought a self-conscious style, a bookish apparatus and a deliberate eccentricity into fiction. *Tristram Shandy*, produced successively in nine small volumes between 1760 and 1764, is the pretended history of a personage who is not born (before the fourth volume) and hardly ever appears, carried on in an eccentric rigmarole of old and new, original and borrowed humour, arranged in a style well known to students of the later Valois humorists as *fatrasie.* Sterne invented a kind of tremolo style of his own, with the aid of which, in conjunction with the most unblushingly indecorous innuendoes, and with a conspicuous genius for humorous portraiture, trembling upon the verge of the pathetic, he succeeded in winning a new domain for the art of fiction.

Johnson and Goldsmith.—Apart from the novelists, the middle period of the 18th century is rich in prose writers: these include Dr. Johnson, Oliver Goldsmith, Lord Chesterfield and Horace Walpole. The last three were all influenced by the sovereign lucidity of the best French style of the day. Chesterfield and Walpole were both writers of aristocratic experience and of European knowledge and sentiment. Johnson alone was a distinctively English thinker and stylist. His knowledge of the world, outside England, was derived from books, he was a good deal of a scholar, an earnest moralist, and something of a divine; his style reaches back to Browne, Taylor, Barrow and South, though the later influence of Addison and Bolingbroke is also apparent. Johnson himself was fond of the essay, the satire in verse and the moral tale (*Rasselas*); but he lacked the creative imagination indispensable for such work and excelled chiefly as biographer and critic. In his criticism he upholds authority. We go to his critical works (*Lives of the Poets* and *Essay on Shakespeare*) less for their conclusions than for their shrewd comments on life, and for an application to literary problems of a caustic common sense. Johnson's character and conversation, his knowledge and memory were still more remarkable than his ideas or his writings, admirable though the best of these were; the exceptional traits which met in his person and made that age regard him as a nonpareil have found in James Boswell a delineator unrivalled in patience, dexterity and dramatic insight. The result has been a portrait of a man of letters more alive at the present time than that which any other age or nation has bequeathed to us. In most of his ideas Johnson was a generation behind the typical academic critics of his date, Joseph and Thomas Warton, who championed against his authority what the doctor regarded as the finicking notions of Gray. Both of the Wartons were enthusiastic for Spenser and the older poetry; they were saturated with Milton whom they placed far above the correct Mr. Pope, they wrote sonnets (thereby provoking Johnson's ire) and attempted to revive mediaeval and Celtic lore in every direction. Johnson's one attempt at a novel or tale was *Rasselas,* a long

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BRITISH MEN OF LETTERS

1. Geoffrey Chaucer (*c.* 1340–1400). 2. John Dryden (1631–1700). 3. Edmund Spenser (*c.* 1552–99). 4. Charles Dickens (1812–70). 5. William Makepeace Thackeray (1811–63). 6. Sir Walter Scott (1771–1832). 7. William Wordsworth (1770–1850). 8. Dr. Samuel Johnson (1709–84). 9. Thomas Carlyle (1795–1881). 10. Charles Lamb (1775–1834). 11. H. G. Wells (1866–). 12. Thomas Hardy (1840–1928)

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BRITISH POETS

1. John Milton (1608–74)
2. Alexander Pope (1688–1744)
3. Lord Byron (1788–1824)
4. Robert Burns (1759–96)
5. Samuel Taylor Coleridge (1772–1834)
6. John Keats (1795–1821)
7. Alfred Lord Tennyson (1809–92)
8. Percy Bysshe Shelley (1792–1822)
9. Algernon Charles Swinburne (1837–1909)

"Rambler" essay upon the vanity of human hope and ambition, something after the manner of the oriental tales of which Voltaire had caught the idea from Swift and Montesquieu.

The very quality of charm that Johnson lacked was possessed in its fullest perfection by Oliver Goldsmith, whose style is the supreme expression of 18th-century clearness and easy graceful fluency. Much of Goldsmith's material, whether as playwright, story teller or essayist, is commonplace. But, whenever Goldsmith writes about human life, he seems to pay it a compliment; his playful and delicate touch could transform every thought that he handled into something radiant with sunlight and fragrant with the perfume of youth. Goldsmith's plots are Irish, his critical theories are French with a light top dressing of Johnson and Reynolds or Burke, while his prose style is an idealization of Addison. His versatility was great, and, in this and in other respects, he and Johnson are constantly reminding us that they were professional authors writing against time for money.

Letters and Memoirs.—Much of the best prose work of this period, from 1740 to 1780, was done under very different conditions. The increase of travel, of intercourse between the nobility of Europe, and of a sense of solidarity, self-consciousness, leisure and connoisseurship among that section of English society known as the governing class could hardly fail to produce an increasing crop of those elaborate collections of letters and memoirs which had already attained their apogee in France with Mme. de Sévigné and the Duc de Saint-Simon. England was not to remain far behind, for in 1718 began the *Letters* of Lady Mary Wortley Montagu; ten years more saw the commencement of Lord Hervey's *Memoirs of the Reign of George II.;* and Lord Chesterfield and Lord Orford (better known as Horace Walpole) both began their inimitable series of *Letters* about 1740. The *Memoirs* of the man-about-town and adventurer, William Hickey, and the *Diary* of the Oxfordshire country parson, James Woodforde, have only recently been made available. These writings, none of them written ostensibly for the press, serve to show the enormous strides that English prose was making as a medium of vivacious description. Chesterfield, whose theme is manners and social amenity, deliberately seeks a form of expression appropriate to his text —the perfection of tact, neatness, good order and *savoir faire.* After his grandfather, the marquess of Halifax, Lord Chesterfield, the synonym in the vulgar world for a heartless exquisite, is in reality the first fine gentlemen and epicurean in the best sense in English polite literature. Both Chesterfield and Walpole were conspicuous as raconteurs in an age of witty talkers, of whose talk R. B. Sheridan, in *The School for Scandal* (1777), served up a *suprême.* The most brilliant comedy of the century, the theatrical output of which is dealt with under DRAMA and the individual playwrights, represents the sparkle of this brilliant crowd: it reveals no hearts, but it shows us every trick of phrase, every eccentricity of manner and every foible of thought. The most mundane of the letter writers, the most frivolous, and also the most pungent, is Horace Walpole, whose writings are an epitome of the history and biography of the Georgian era. Yet, in some ways, he was a corrective to the self-complacency of his generation, a vast dilettante, lover of "Gothic," of curios and antiques, of costly printing, of old illuminations and stained glass. In his short miracle-novel, *The Castle of Otranto,* he set a fashion for mystery and terror in fiction, for mediaeval legend, *diablerie,* mystery, horror, antique furniture and Gothic jargon, which led directly by the route of Anne Radcliffe, Maturin, *Vathek, St. Leon* and *Frankenstein,* to *Queenhoo Hall,* to *Waverley* and even to Hugo and Poe.

Meanwhile the area of the Memoir was widening rapidly in the hands of Fanny, daughter of the worldly-wise and fashionable musician, Dr. Burney, author of a novel (*Evelina*), written before she was well out of her teens; not too kind a satirist of her former patroness, Mrs. Thrale (afterwards Piozzi), the least tiresome of the new group of scribbling sibyls, blue stockings, lady dilettanti and Della Cruscans. Both, as portraitists and purveyors of *Johnsoniana,* were far surpassed by the inimitable Boswell.

Historians.—It is surprising how many types of literary productions with which we are now familiar were first moulded into definite and classical form during the Johnsonian period. In addition to the novel one need only mention the economic treatise, as exemplified in the admirable symmetry of *The Wealth of Nations,* the diary of a faithful observer of nature such as Gilbert White, the *Fifteen Discourses* (1769–91), in which Sir Joshua Reynolds endeavours for the first time to expound for England a philosophy of Art, the historico-philosophical tableau as exemplified by Robertson and Gibbon, the light political parody of which the poetry of *The Rolliad* and *Anti-Jacobin* afford so many excellent models; and, going to the other extreme, the ponderous archaeological or topographical monograph, as exemplified in Stuart and Revett's *Antiquities of Athens,* in Robert Wood's colossal *Ruins of Palmyra* (1753), or the monumental *History of Leicestershire* by John Nichols.

It was not until the third quarter of the 18th century that English literature freed itself from the imputation of lagging hopelessly behind France, Italy and Germany in the serious work of historical reconstruction. Hume published the first volume of his *History of England* in 1754. Robertson's *History of Scotland* saw the light in 1759 and his *Charles V.* in 1769; Gibbon's *Decline and Fall of the Roman Empire* came in 1776. Hume was, perhaps, the first modernist in history; he attempted to give his work a modern interest and, Scot though he was, a modern style. Wm. Robertson was, perhaps, the first man to adapt the polished periphrases of the pulpit to historical generalization. The gifts of compromise which he had learned as Moderator of the General Assembly he brought to bear upon his historical studies, and a language so unfamiliar to his lips as academic English he wrote with so much the more care that the greatest connoisseurs of the day were enthusiastic about "Robertson's wonderful style." Even more portentous in its superhuman dignity was the style of Edward Gibbon, who combined with the unspiritual optimism of Hume and Robertson a far more concentrated devotion to his subject, an industry more monumental, a greater co-ordinative vigour, and a malice which, even in the 18th century, rendered him the least credulous man of his age. Of all histories, therefore, based upon the transmitted evidence of other ages rather than on the personal observation of the writer's own, Gibbon's *Decline and Fall* has hitherto best maintained its reputation.

The increasing transparency of texture in the working English prose of this period is shown in the writings of theologians such as Butler and Paley, and of thinkers such as Berkeley and Hume, who, by prolonging and extending Berkeley's contention that matter was an abstraction, had shown that mind would have to be considered an abstraction, too. Butler and Paley are merely two of the biggest and most characteristic apologists of that day, both great stylists, though it must be allowed that their lucid good sense excites almost more doubt than it stills, and both very successful in repelling the enemy in controversy, though their very success accentuates the faults of that unspiritual age in which churchmen were so far more concerned about the title deeds than about the living portion of the church's estate. Free thought was already beginning to sap their defences in various directions, and in Tom Paine, Priestley, Price, Godwin and Mackintosh they found more formidable adversaries than in the earlier deists. The greatest champion, however, of continuity and conservation, both in church and State, against the new schools of latitudinarians and radicals, the great eulogist of the unwritten constitution, and the most perfect master of emotional prose in this period, prose in which the harmony of sense and sound is attained to an extent hardly ever seen outside supreme poetry, was Edmund Burke, one of the most commanding intellects in the whole range of political letters—a striking contrast in this respect to Junius, whose mechanical and journalistic talent for invective had a quite ephemeral value.

Return to Nature.—While Voltaire and Pope were at their height, the world began to realize that the Augustan age, in its zeal for rationality, civism and trim parterres, had neglected the wild freshness of an age when literature was a wild flower that grew on the common. Rousseau laid the axe to the root of this over-sophistication of life; Goldsmith, half understanding, echoed

some of his ideas in *The Deserted Village*. Back from books to men was now the prescription. Within a few years of Pope's death we find Gray, Warton, Hurd, Webb and other disciples of the new age denying to Pope the highest kind of poetic excellence, and exalting imagination and fancy into a sphere far above the Augustan qualities of correct taste and good judgment. In the revolt from Augustanism we find an explanation of the enthusiasm that welcomed the sham Ossianic poems of James Macpherson in 1760 and Percy's real treasures of 1765 (*Reliques of Ancient Poetry*); the new enthusiasm for Chaucer; the "black letter" school of Ritson, Tyrrwhitt, George Ellis, Steevens, Ireland and Malone; above all, the spurious 15th-century poems poured forth in 1768–69 with such gusto of archaic imagination by a prodigy not quite 17 years of age. Chatterton's precocious fantasy cast a wonderful spell upon the romantic imagination of other times. It does not prepare us for the change that was coming over the poetic spirit of the last two decades of the century, but it at least helps us to explain it. The great masters of verse in Britain during this period were the three very disparate figures of William Cowper, William Blake and Robert Burns. Cowper was not a poet of vivid and rapturous visions. There is always something of the rusticating city-scholar about his humour. The greater part, nearly all his best poetry is of the occasional order. In all the arts that raise the best occasional poetry to the level of greatness Cowper is supreme. In phrase-moulding, verbal gymnastic and prosodical marquetry he has scarcely a rival, and the fruits of his poetic industry are enshrined in the filigree of a most delicate fancy and a highly cultivated intelligence, purified and thrice refined in the fire of mental affliction. His work expresses the rapid civilization of his time, its humanitarian feeling and growing sensitiveness to natural beauty, home comfort, the claims of animals and the charms of light literature. William Blake had no immediate literary descendants, for he worked alone, and Lamb was practically alone in recognizing what he wrote as poetry. But he was by far the most original of the reactionaries who preceded the Romantic Revival, and he caught far more of the Elizabethan air in his lyric verse than any one else before Coleridge. The *Songs of Innocence* and *Songs of Experience*, in 1789 and 1794, sing themselves, and have a bird-like spontaneity that has been the despair of all song-writers from that day to this. After 1800 he winged his flight farther and farther into strange and unknown regions. In the finest of these earlier lyrics, which owe so little to his contemporaries, the ripple of the stream of romance that began to gush forth in 1798 is distinctly heard. But the first poetic genius of the century was unmistakably Robert Burns. In song and satire alike Burns is racy, in the highest degree, of the poets of North Britain, who had kept alive the old native poetic tradition, had provided the strolling fiddlers with merry and wanton staves, and had perpetuated the daintiest shreds of national music, the broadest colloquialisms, and the warmest hues of patriotic or local sentiment. Burns immortalizes these old staves by means of his keener vision, his more fiery spirit, his stronger passion and his richer volume of sound. His eye is unerring, his humour of the ripest, his wit both fine and abundant. In him the return of the 18th century to nature is perfected.

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VI. THE ROMANTIC PERIOD

The early part of the 19th century is generally known as the Romantic Period, a period which opened, actually, in the year 1798, when Wordsworth and Coleridge published their *Lyrical Ballads*, in which they made a conscious and successful attempt to break away, both in subject and style, from the tradition of the 18th century. The period ended in the early '30s, by which time nearly all its chief figures had quitted the stage. During these thirty-and-odd years, which saw the long Napoleonic wars, the subsequent restoration, then the stir of Liberal thought all over Europe, years of political and social ferment, some of the greatest literature in the language was produced. As usual, however, it was only in certain departments of literature that the age excelled. These were poetry, chiefly lyrical, and miscellaneous prose. It failed in the drama, although nearly all its major writers made at least one attempt to conquer the theatre. It produced no history that can be compared with Gibbon's *Decline and Fall*, and no biography as good as Boswell's *Johnson*. Its fiction, in spite of Scott and Jane Austen, both supreme masters in their own kind, is inferior to that of the succeeding age, the Victorian. But in poetry and miscellaneous prose, criticism and the essay, this Romantic Period is triumphant. Moreover, it is an age unusually rich in men of letters who are also fascinating as personalities. Scott, Lamb, Byron, Keats, Shelley—to name no other—have each had scores of volumes written round them; and no period in literature since that of Shakespeare has had more enthusiastic students.

The Era of Individualism.—These thirty years are sometimes called the "Romantic Revolt," a name that could be given with more justice to the Romantic movement in France that came later. It is rather misleading when applied to the English period because it suggests the existence of some definite literary authority and something like an organized rebellion against its canons. What actually happened was something vaguer and more complicated. We shall not attempt to define "Romantic," and there is not space in which even to indicate all the forces at work, the hundred and one factors, ranging from the re-discovery of mediaeval ballads to the influence of the French revolution. All that we can do is to find some common denominator of all the major writers of the age, something that not only links Wordsworth and Shelley, Lamb and Byron, but also points to the difference between them and the writers of the previous century. It is not easy. No political or religious belief, no common system of philosophy, no theory of literature, will help us. If, however, we remember that the 19th century itself was an era of individualism, we stumble upon a common denominator. What distinguishes the literature of this Romantic Period is its intense individualism. In the 18th century, an author was essentially a member of a community, a good citizen writing for other good citizens; his appeal was always to common sense, general knowledge; if he described a landscape he took care to give it features that a hundred landscapes have in common; if he expressed feelings, they were only the feelings that it is customary to express in society. The result was a literature that is sensible, social, generalized. When it was weak, it was dull, savourless. The Romantics broke with this tradition. Their first duty, they considered, was to express themselves. Their appeal was always to what transcended common sense. They would become universal in that appeal not by smoothing away all individual characteristics but by reaching the very heart of individuality. They held that to express one's own most intimate thoughts and feelings was really to express everybody. Thus it comes about that these Romantic poets, for all their wonders and crazy flights of fancy, are actually more realistic than the poets in the English classical tradition. It is they who give us "the streaks on the tulip," simply because they are aiming at the individual thing. And when they are at their weakest, they arrive at sheer eccentricity. Their danger always is that they may become mawkishly egoistic or barbarically anti-social.

The Poetic Revolution and Wordsworth.—In poetry this individualism resulted at once in an enlargement of subject matter, a new variety in prosody, a substitution of the best ordinary

speech for the conventional poetical language of the previous age, and a widening and deepening of emotion. In their *Lyrical Ballads,* Wordsworth and Coleridge deliberately aimed at this poetic revolution. Wordsworth's poetical career, unlike that of most of his contemporaries, was a long one, but nearly all his best work was written between 1797 and 1820. He is undoubtedly the most massive poet of his time, though it is not in his two long poems, *The Excursion* and *The Prelude,* semi-narrative, semi-philosophical poems in blank verse, that he is at his supreme height, but in his short reflective lyrics and sonnets and one or two rather longer poems, such as *Tintern Abbey* and *Intimations of Immortality.* This last is perhaps his masterpiece, a blaze of poetic genius. Wordsworth can be duller than any other English poet of similar stature. He is essentially a poet of great moments. Probably he would not object to being so described, for it was his practice to lie in wait for such moments. In his own Lake country, solitary, he would brood over the face of nature, remote from the common bustle of life, until at last the wide sky and the mountains and the bare trees and the very grass were lit up from within, were the vesture of some radiant spirit. He was not a pantheist. He did not see nature as God but only as the sign and symbol of God. All his greatest poems are intimations of immortality. These ecstatic moments of mystical communion he could express in lines that seem extraordinarily simple in structure and language but have a haunting beauty quite unlike that of any other poet. He is especially fond of auditory images and is a master of cadence.

Coleridge.—Coleridge's reputation as a poet hangs chiefly upon three poems, *The Ancient Mariner, Kubla Khan* and *Christabel,* and two of these are unfinished. The imagination at work in these little masterpieces is unique. *The Ancient Mariner* is the most astonishing narrative poem in the language; the exquisitely lovely verses unfold an unforgettable pageant of marvels and horrors. *Kubla Khan* is a fragment of pure romance; it would be hard to find in the same number of lines elsewhere the same curious power of evocation; it is at once as vague and mysterious and yet charged with meaning as a piece of music. Coleridge is the most magical of all our poets. What he has left us is merely the work of a few early years. He took to opium and was then incapable of sustained effort. But he became as great a critic as he was a poet. Indeed, he is perhaps our greatest critic, in spite of his turgid prose style, his second-hand metaphysics and the fragmentary nature of his work. He had enormous reading, a most subtle intellect, and an eye and an ear unusually sensitive to style. In his Lectures on Shakespeare, the more critical chapters of his *Biographia Literaria,* and the odd notes and fragments of lectures on books and authors since collected into various volumes, these gifts are fully displayed. It was he more than any other man who was responsible for the new interpretative mode of criticism, which replaced the judicial method of the previous century. To that century, he was always somewhat unjust, and in reaction against its characteristic judgments, he was always in danger of running to uncritical extremes in his appreciation of the older Romantic writers, from Shakespeare downwards. His was easily the greatest influence of the time. Even Scott and Byron, to say nothing of Wordsworth, Shelley, Keats, Lamb and Hazlitt, were influenced by him. Notwithstanding his comparative failure to achieve sustained work, Coleridge must always be considered one of the greatest figures of his age.

This can no longer be said of the remaining member of this trio of "Lake Poets," Robert Southey, who in his own time was regarded as their equal. Even those fellow poets, such as Byron and Shelley, who most bitterly resented Southey's defection from the Liberal cause would be astonished if they could learn how his reputation as a poet has declined. Southey's epics, notably *Thalaba* and *The Curse of Kehama,* seem now so many monuments of wasted effort and futile ambition. He was, however, a most industrious man and learned prose man too, writing an excellent style, and at least one volume of his, the *Life of Nelson,* has kept its place. Time has dealt a little more tenderly with the picturesque narrative poems of Sir Walter Scott, whose *Lady of the Lake* and the rest are still enjoyed by young readers; but it is as the author of one or two magnificent lyrics, such as *Proud Maisie,* that Scott keeps his place as a poet. Beside him may be set his fellow-countryman, James Hogg (The Ettrick Shepherd), who has never quite had full justice done him. And there are three other poets who for years were regarded as the foremost men of their time but have since dwindled into the authors of a few acceptable lyrics. These are Samuel Rogers (the least important), Thomas Campbell and Tom Moore.

Byron and Shelley.—Between these older men and the three younger poets, Byron, Shelley and Keats, who all died before they reached maturity, may be set the figure of a man who was greater as an influence than strictly as a writer. This was Leigh Hunt, who produced some pleasant verses, some good light essays and some really excellent criticism. His greatest work, however, was done as the inspiring friend of the younger poets, especially Shelley and Keats. Byron was not deeply influenced by any contemporary writer. Oddly enough, Byron, who became a European figure of Romance, was not at heart a Romantic poet at all, a fact that is now recognized. His most lasting work, apart from one or two poignant lyrics, has been in verse of a satirically descriptive order, found at its best in his *Don Juan,* in which his really strong masculine intellect, his witty impertinence and his rhetorical gusto have full scope. He was—and still remains—a symbolic figure of romantic rebellion, though he himself would have been the first to laugh at most of his fervent admirers.

Byron is steadily being overshadowed, however, by a more authentic figure of romantic rebellion. His friend and junior, Percy Bysshe Shelley, has long been recognized as the greater poet, and he is now taking the place that Byron once had, at home and abroad, as a symbolic figure. He was only thirty when he perished in the sea, and it is impossible to imagine what would have become of him had he lived to a ripe old age, for he is the poet of enthusiastic and revolutionary youth. Coming early under the influence of William Godwin (who wrote some novels of merit), Shelley became a philosophical anarchist of a type not uncommon in the later 18th century. He was the Ariel of all such dry Prosperos as Godwin. He is pre-eminently the poet of some future Golden Age, unearthly in its loveliness and innocence. His lyrics (and he is always lyrical, even in his longer poems) have a matchless swiftness and grace and opalescent colouring; they are all vague music and perfume and shifting lights; and neither their beautiful melancholy nor their ecstasies are quite of this world. Indeed, the chief fault of Shelley's poetry is its lack of all ordinary human feeling and its remoteness from common interests. A further weakness is a certain mushiness of phrase, and there are signs that his vocabulary never quite recovered from the influence of the absurd philosophical romances he read (and wrote) so eagerly in early youth. But he was a lyrical genius and a figure of poetry and eager revolt that, at certain ages and always for some readers, completely captures the imagination.

The Genius of Keats.—The last of these young poets died even before he reached his prime, at the age of twenty-six. This was John Keats, who is represented by an early narrative poem, full of faults, the fragment of an epic, *Hyperion,* and a small number of sonnets, odes and short narrative poems. But these are astonishing in their quality; they have a rich sensuousness, a carven beauty of phrase and the everpresent suggestion of a wide brooding imagination, that set their author among the masters of English poetry. When we consider these poems and put beside them their author's letters (full of good writing, high spirits, sense and flashes of unusual wisdom), and then remember not merely his early death but the whole evil circumstances of his life, we can only conclude that English literature lost in him a very great genius, the potential master of almost any form of the art. His actual performance was astonishing, but his promise was nothing less than a wonder.

This period brought about almost as great a change in prose as it did in poetry, a fact that is frequently overlooked. That intense individualism, already mentioned, is as evident in the chief prose writers as it is in the poets. The essay was no longer some-

thing that might have been written by a committee of sensible men, it was as personal and intimate as talk. So, too, criticism became frankly personal, and the only standard was the critic's own likes and dislikes. These Romantic prose writers expressed themselves first of all, and even their criticism was a chapter of autobiography. One result of this was a change in prose style. The 18th century prose style had been antithetical, balanced, impersonal. This standard style was by no means abandoned altogether (it exists to this day) and most of the quarterly reviewers used it, but all the more important prose writers (with the exception of Walter Savage Landor, who in his massive prose *Imaginary Conversations*, as in his exquisite epigrammatic verses, aimed at a classical balance, dignity and brevity of phrase) turned away from it to styles more personal, more highly coloured and musical, nearer to poetry. The most ambitious of all these prose colourists and musicians was Thomas De Quincey, who produced one masterpiece of autobiography and day-dream and elaborately notated prose, in his *Confessions of an English Opium-Eater*, and then gently subsided into being a writer of learned and ingenious articles for the magazines.

The Great Essayists.—The two greatest essayists of the time are Lamb and Hazlitt. Charles Lamb was a considerable critic; he was an exquisite essayist and one of the best letter-writers in the language; but he was greatest of all simply as a personality. In him that intense individualism seems to run into eccentricity, almost into madness, yet there is in him everywhere, in the midst of his wild dark humour, a sweet sanity, a wisdom of the spirit. Above all the great, the picturesque, the fascinating personalities of his time, he is the best-loved. His friend, William Hazlitt, whose reputation is equally balanced between the personal essay and criticism, was a very different person, wanting in humour and tenderness, a difficult friend, a ferocious enemy. He had a good strong intellect and a fine taste, and no man did more in calling attention to what was true and beautiful and in communicating a zest for good writing.

The official criticism of the period, that which was associated with the quarterlies, falls a long way behind the scattered notes of Coleridge and Lamb and the headlong essays of Hazlitt. It suffered from two defects, first, that it was influenced by political and social considerations; secondly, that it never quite escaped from the 18th century, was rooted in an outworn tradition, and did not understand what was going on in literature. The Whig *Edinburgh Review* was the first of the quarterlies, and its editor, Francis Jeffrey, with whom were associated Sydney Smith (a great wit) and Brougham, was a man of real ability, but neither he nor his colleagues ever understood what the major writers of their time were trying to do. The Tory rival of the *Edinburgh*, the *Quarterly Review*, was even more unsympathetic. Its first editor was William Gifford, a somewhat ferocious scholar; and later it was edited by John Gibson Lockhart, Scott's son-in-law, who suffered from a supercilious cleverness but set it aside to write a really masterly *Life of Scott*, the best biography the age produced. Lockhart had earlier been associated with *Blackwood's Magazine*, in which John Wilson (Christopher North) roared and cudgelled and rhapsodized, especially in the series of dialogues afterwards published as *Noctes Ambrosianae*, which contain some entertaining criticism, some even more entertaining character sketches and some uproarious high spirits. For some time *Blackwood's* had a rival in the *London Magazine*, which did not live long but nevertheless succeeded perhaps in bringing out more masterpieces than any other magazine before or since. But the greatest journalist of his time and one of the best writers of plain solid prose was William Cobbett, whose *Rural Rides* still remains one of the best pictures of the English countryside we have.

In history and philosophy, especially when they are regarded as departments of literature, this period was decidedly inferior to the one that went before and the one that came after. It has no Hume, no Gibbon, no Carlyle, not even a Macaulay. Hallam, Mitford, Roscoe, Mackintosh, these are its figures, respectable enough but a long way from the front rank. And though Malthus, Bentham and James Mill may be sufficiently important thinkers, their respective works are far removed from literature.

Jane Austen and Scott.—In fiction, as we have already seen, the period would make a very poor show indeed if it were not for two outstanding figures. During the opening years of the century, there is a curious lull in fiction, perhaps due in part to the great popularity of the narrative poem. But two kinds were being essayed, and both of them found their masters. (We must not overlook, however, that satirist of the philosophers and the romantics, Thomas Love Peacock, whose chief contributions were to fiction and whose novels are unique in their blend of intellectual high spirits and ironic comment.) The earlier to mature was the novel of ordinary domestic life and manners, depending for its appeal on the close observation of the writer and his (though it was nearly always her) power of making quite ordinary people entertaining as characters. Fanny Burney, Maria Edgeworth, Susan Ferrier, all these ladies made some progress in this delicate art, but it was Jane Austen who brought it as near to perfection as it seems possible to bring it. Nothing could seem more unpromising than her material, the uneventful lives of dull, well-fed people in quiet corners of England, but by the enchantment of her art, her sense of character, her bland irony, her exquisite powers of organization and presentation, she has given us half-a-dozen novels that have aroused the enthusiasm of every succeeding generation of readers. She is our most finished artist in fiction.

The other kind was the historical novel. A delighted discovery of the past marks the whole age, but it was left to Sir Walter Scott, already practised in poetic narration, steeped in the lore of his own Border country, experienced in men and affairs, to make this discovery the servant of fiction. This he did in the great series of romances that began with *Waverley* in 1814 and captured not only the British Isles but all Europe. The weaknesses of Scott, who wrote too much and too quickly, are a marked carelessness not merely in style but in actual narration, and a certain limitation in his thought. But these are far outweighed by his massive virtues, the way in which he combines the personal and historical interests, the generous breadth and fine rush of his narrative and his solid sense of character. Other writers, working over similar ground, have improved upon his work in this particular or that, but as an all-round narrator of historical romance he has never been excelled. The age honoured him both as a writer and a man, and now he still honours the age, rich as it was in arresting figures and triumphant masterpieces.

(J. B. Pr.)

VII. VICTORIAN PERIOD OF THE 19TH CENTURY

Introduction.—During the Romantic Revival the pendulum had swung from revolt to reaction, from rapturous hope to despair. The revolutionary ardour of the youthful Wordsworth and Coleridge had deadened into the rigidity of *The Ecclesiastical Sonnets* or sunk into the spiritual lassitude of the "Ode to Dejection." Shelley's metaphysical and Byron's political visions of a world regenerated by freedom had been quenched in the waves of the bay of Spezzia and the swamps of Missolonghi. The generation that had endured the disastrous aftermath of the Napoleonic wars could never recapture the intoxication of the Revolutionary dawn. Yet it could not find permanent satisfaction in the humorous irony of Peacock or in the communion with beauty of Keats. It began, therefore, a new forward movement. Its conception of progress was no longer the taking of Heaven by storm, but gradual, orderly advance. The Reform Bill of 1832 was a renewed pledge of faith in slowly working political machinery, instead of catastrophic upheaval, as the means of social betterment. In the scientific sphere geological discovery accustomed men to the idea of gradual transformation, and prepared the way for the evolutionary doctrines that have closed for ever the vision of humanity attaining perfection at a bound. As the ascent of man was shown to be by stages, the importance of education in furthering his development was realized as never before.

Such were the conditions in which the literature arose that is known by the name of the young queen who in 1837 succeeded to the throne of Elizabeth and Anne. Each of these has also given

her name to a literary epoch. The Tudor queen was herself the cynosure of the poets and playwrights of her day; Anne was no magnetic personality, but her court and Capital were the focus of the Augustan wits. When Victoria came to the throne, literature had learned neither to look for inspiration to a sovereign nor to concentrate its gaze upon the charmed circle of the town. Yet it was not for nothing that from 1837 to 1900 a woman was the centre of social and, in a sense, political life. Feminine activities were thereby stimulated in all fields, including that of literature. And it made for that reticence in the treatment of sexual problems which, whether considered a merit or a defect, was, till its later phases, distinctive of the Victorian period.

That period is more remarkable for the high level of its attainment in very varied branches of literature than for absolute pre-eminence in one. The Elizabethan age primarily spells Drama; the Augustan, Satire; the Romantic Revival, Poetry. The Novel may claim to be the most representative Victorian type. Yet does either *Pickwick* or *Vanity Fair* count for as much as Newman's *Apologia* or Darwin's *Origin of Species?* It was in fields outside of pure literature, not only in science and theology, but history, law, and economics, that the age produced much of its most notable work. These are, however, primarily the concern of others than the historian of literature.

POETRY

Tennyson.—In the highest sphere of letters, poetry, the Victorian achievement is linked with, and yet distinct from, that of the preceding age. When the young Cambridge prizeman, Alfred Tennyson, published his first volumes of verse in 1832 and 1833 an unfriendly critic accused him of "out-babying Wordsworth and out-glittering Keats." He had not Wordsworth's sense of the mystical union of Nature and man, but excelled him in exactness of observation and description. He was not absorbed, like Keats, in pure beauty, but practised a more fastidious and scholarly art. From the first even in his lovely reshaping of classical stories, and more explicitly in such poems as "The Palace of Art" and "The Two Voices," there is an undercurrent of *malaise*. In *In Memoriam* (1850) the sudden death of a deeply loved friend raised the fundamental questions of the age when religion and science were beginning their conflict. Even if the poet's solution may seem inadequate to-day, the stanzas in their exquisitely apt metre are imperishable cameos of mid-Victorian life in the rectory and the hall. And if the lapse of years has made *The Princess* (1847), in its treatment of woman's sphere, a museum-piece it lives by the beauty of its songs. In the *Idylls of the King* (1859–85) Tennyson allegorized King Arthur as the soul of man at war with the senses. Such a conception could not be successfully combined with that of Arthur in his human relationships, especially as the husband of Guinevere. The poet is to blame for the incongruity. But it is unjust on that account not to recognize the spiritual insight in the handling of the central theme or the narrative beauty of individual *Idylls* and episodes. The "reaction against Tennyson" of which the *Idylls of the King* has borne the brunt, has spent much of its force; his place is secure as the representative poet of his age.

The Brownings.—Strongly contrasted, except in fundamental convictions, is Robert Browning, educated outside the traditional pale, and except for an early debt to the "sun-treader" Shelley, curiously dissociated from the poets of the Romantic Revival. He throws back to Donne and the "metaphysical" school in subtlety of thought and pregnancy of style. He is preoccupied with the inner life of the individual, his motives and aspirations. After a period of experiment in dramatic and semi-dramatic forms he found the monologue to be his fittest instrument and made use of it in *Men and Women* (1855), *Dramatis Personae* (1864) and elsewhere. The speakers range from an Arab physician and a Greek "tyrant" to Renaissance painters and thence to moderns like "Bishop Blougram" and "Sludge the Medium." With his cosmopolitan interests and knowledge of the arts Browning could always furnish an appropriate setting. But he rings the changes on the same leading motives—earthly life as a probation, high failure worth more than low success. Behind his "men and women" looms the interpreting personality of their creator. The method reaches its climax in *The Ring and the Book* (1868–69) where it is used to illuminate from the lips of criminal, victim, priest, the pope and others all of brutality and beauty that lies behind the bare facts of an Italian murder case. The frequently uncouth and grotesque phrasing serves, as a rule, a dramatic purpose. Anapaestic and dactylic rhythms suited him best for poems in stanza forms, but it is in passages of blank verse of strangely individual fascination that he achieved his rarest metrical effects.

Browning's fame grew more slowly than that of his wife but has now overshadowed it. Her poetic art has weaknesses—sentimentality, facile fluency, and slovenly technique—which are in particular disfavour to-day. But in her so-called *Sonnets from the Portuguese,* written during her courtship, the intensity of her passion swept sentimentality away, and the curb of the sonnet-form checked the too easy flow of her verse. In short lyric outbursts, "Cowper's Grave" and "The Cry of the Children," she struck a peculiarly tender note. She had not the genius for narrative, and *Aurora Leigh* (1856), a blank-verse novel, has long outlived its immediate success.

Matthew Arnold.—Mrs. Browning's study of Greek literature had taught her nothing of Greek restraint. Far otherwise was it with the young Oxford graduate, Matthew Arnold, who in 1849 made his first poetic venture. Yet the ardent classicist was in his depths a modern. None felt more acutely than he the shifting of the traditional religious and intellectual landmarks. His is the cry of one, "Wandering between two worlds, one dead, the other powerless to be born." For relief he goes to the calm and serenity of Greek art, and to the healing touch of Nature. All these elements are blended in *The Scholar Gipsy* and *Thyrsis* where the genius of Greek pastoral elegy gathers in her hands flowers from the Oxford fields, and hears the troubled sound of piping from other than Dorian flutes. Nowhere was that piping more troubled than in the verse of Arnold's Rugby and Balliol friend, A. H. Clough. *Thyrsis* and such of his own lyrics as "Qua Cursum Ventus" will do more for his immortality than his introspective hexameter poems, *The Bothie* and *Amours de Voyage.*

The Pre-Raphaelite Poets.—While Arnold and Clough were confronting the challenging issues of their own day, a group of young poets and artists were turning their gaze backward to the middle ages. Linked in the pre-Raphaelite Brotherhood they issued in 1850 the short-lived *Germ* where they advocated sincerity in art and poetry and sought to renew the mystical fervour of the age of the primitives. To D. G. Rossetti, of Italian parentage, love in *The Blessed Damozel* is a transcendental ecstasy as it was to Dante and his circle of whom he became the interpreter to Victorian England. Later in the eerie romance of early Scottish history and legend he found material for *The King's Tragedy* and *Sister Helen.* In his sonnet-sequence, *The House of Life,* in which each sonnet is "a moment's monument," his mystical conception of love was blended with a sensuous warmth unfamiliar to the North and misunderstood by the profane. To his sister Christina love was known in its unearthly and devotional aspects, and it found in her sonnets, *Monna Innominata,* and her lyrics that exquisitely simple and heartfelt expression which was the ideal of the pre-Raphaelites but which they did not all attain.

The *Germ* had its successor in *The Oxford and Cambridge Magazine* (1856) chiefly inspired by William Morris. For him and his friends as for the Rossettis, the middle ages were full of enchantment. But it was to feudal France and legendary Britain that they were drawn. In *The Defence of Guenevere* and other Arthurian poems Morris did not, like Tennyson, spiritualize episodes from the cycle, but got deep into the heart of mediaeval passion. Here, and in such feathery lyrics as "Two Red Roses across the Moon" he struck his most original notes. His growing devotion to Chaucer led him to emulate *The Canterbury Tales* in a long series of narrative poems, *Jason, The Earthly Paradise* (1868–70), and (as Icelandic saga more and more captivated him) *Sigurd the Volsung* (1877). Morris has the story-teller's art, and felicities of detail are everywhere, but the poems in their somewhat mannered simplicity have a derivative air.

Swinburne.—In *Poems and Ballads* (1866) A. C. Swinburne accentuated the sensuousness of *The House of Life* into frank voluptuousness. Unlike his Balliol forerunner, Matthew Arnold, he had drawn from Greek literature a creed of hedonistic nihilism which thrilled through "Dolores" and "Laus Veneris." It was given an intoxicating quality by the new singer's almost magical mastery over word and rhythm. In *Atalanta in Calydon* the same astonishing virtuosity gave renewed life to an ancient story, and to the dialogue and choruses of Greek tragedy. Swinburne's prolific later output of lyric, drama, and narrative verse displayed no widening of imaginative vision, and virtuosity tended to become a mechanical device. But through the "voluptuous garden-closes" there was ever the purifying virtue of the elemental forces he loved—the sun and stars, the winds, and, above all, the sea.

As Swinburne had put to new use the machinery of Greek drama so did Edward FitzGerald that of Spanish in his versions, not merely translations, of Calderon's plays. Still more free was the handling of his original in his adaptation (1859–68) of the *Rubáiyát* of the Persian poet, Omar Khayyám. In 100 stanzas of novel and arresting rhythm he gives flawless expression to the creed of *carpe diem.* No other Victorian poet was so felicitously to hold the East in fee. But Sir A. Lyall's *Verses Written in India* gave a fine edge to the contrast between native and English life and thought. Sir Edwin Arnold's sympathetic interpretation in facile blank-verse of Buddha's career in *The Light of Asia* (1879) had a wide vogue.

Coventry Patmore.—The Roman Catholic poetic tradition revived by Christina Rossetti was carried on by Coventry Patmore who, after his earlier illumination of the domesticities in *The Angel in the House* (1854–56), displayed in the Odes of *The Unknown Eros* (1877) a strangely different temper and diction reminiscent of the metaphysical school. Alice Meynell had much of the range and quality of Christina Rossetti with more conscious and deliberate art. It was due in part to her and her *entourage* that Francis Thompson was enabled to gain an ear for the intricate harmonies and mystical imagery of *The Hound of Heaven* and its companion poems.

The shipwreck of his fortunes from which Thompson was saved befell two men whose poetic interpretation of life was diametrically opposed to his. James Thomson (B.V.) could, however, give voice to other moods than the stark pessimism of *The City of Dreadful Night* (1874). John Davidson in his *Fleet Street Eclogues* and *Ballads* (1893–97) blended verbal crudities and rebellious temper with genuine imagination and power. But personal misfortune is less of a tragedy in the poetic career than the downfall of too meteoric a reputation. Such has been the fate of J. M. Tupper, whose *Proverbial Philosophy* had an ephemeral vogue; of Lewis Morris with his modern applications of Greek legends in the *Epic of Hades;* and of Stephen Phillips whose plays in verse, over-rated when brought on the stage, have more merit than is now allowed.

Anglo-Irish Poets.—There was a feeble rustle from English history and scenes in the verse of Alfred Austin. In strong contrast was the inspiration from the legends and annals of Ireland that breathed full and free through the lyrics of W. B. Yeats. Master of that exquisitely simple and liquid speech which is the secret of Anglo-Irish genius, he has "spread his dreams under our feet" and carried us to the enchanted haunts of the Gael. The mysticism of G. W. Russell (A.E.) looks inward to the Ireland in the heart, while James Stephens gives voice to the humorous realism which is its complement in the Celtic "make-up." Moira O'Neill has shown that Ulster too has its *Songs of the Glens of Antrim.* Herbert Trench had a style more highly wrought than that of his brethren of the Pale, and the top of his achievement was with other themes than theirs. The inherited Celtic strain worked more potently in the genius of the English-born George Meredith, though blended with an intellectual apprehension of man's kinship with earth and his upward evolution. From the poems dominated by this conception Meredith ranges through the dewy freshness of *Love in a Valley,* the tragic intensity of *Modern Love* (1862) and the apocalyptic vision of the *Odes in Contribution to the Song of French History* (1898).

Local Poetry.—The poetry of local association which culminates in the Irish literary movement can point to other achievements in more specialized spheres. William Barnes made music on the Doric lute of the Dorset dialect. T. E. Brown chanted *Foc'sle Yarns* in an Anglo-Manx recitative. The soft accent of Devon sings through the "Drake's Drum" of Sir Henry Newbolt, though elsewhere it is in a pure strain of the King's English that he tells of the deeds of the King's Englishmen on sea and shore. The more consciously imperial muse of Rudyard Kipling has enlisted the argot of the Indian barrack-room and compound, but it dispenses with this when it takes the loftier range of the "Recessional" or of the panegyric on the Sussex of Wilfrid and to-day. In A. E. Housman's *Shropshire Lad* (1896) the local setting is of less account than the sombre impress and the gem-like finish of his art.

Religious poetry has had its chief voices in John Keble, carrying on the Anglican tradition of George Herbert, with a new Wordsworthian note; and in J. H. Newman, a greater master, except for some inspired hymns, in prose than in verse. The lighter sides of life have had numerous interpreters in a series of highly accomplished craftsmen in verse. R. H. Barham, C. S. Calverley, Edward Lear, J. K. Stephen, Austin Dobson, and W. S. Gilbert are not merely wits but adepts, in their various styles, in verbal and metrical technique. And it is a kindred virtuosity, applied in a loftier sphere, that helps to give distinction to the poetry of Robert Bridges, who is himself a student of the metrical art. His technical accomplishment and a surface austerity have tended to mask the underlying spontaneity and tenderness of the best of his lyric verse. He wears the Laureate's wreath worthily, but not, like Tennyson, with popular acclaim.

Drama.—In the considerable field of drama the Victorian period till its closing years marks an almost complete divorce between literature and the stage. In the year of the Queen's accession the publication of Browning's *Strafford* and R. H. Horne's *Death of Marlowe* showed that poetic drama was not dead, but it was Lytton's theatrically effective *Richelieu* and *The Lady of Lyons* (1838) that won favour on the boards. J. Westland's verse-tragedies had a short life; Swinburne's were not intended for the stage. The genius of Henry Irving illumined the tawdry but pathetic *Charles I.* (1871) of W. G. Wills, and afterwards found finer material in Tennyson's plays, especially *Becket.*

Melodrama was more to the taste of the early Victorians, as provided by J. B. Buckstone and Dion Boucicault. The latter's *Corsican Brothers* had a prolonged vogue, but his gifts of dialogue and humour show to more advantage in his Irish dramas *The Colleen Bawn* and *The Shaughraun,* while his earlier *London Assurance* (1841), in a vein of higher comedy, has life in it yet. So too has the most famous of the many farces of the time, J. M. Morton's *Box and Cox* (1847). This cannot be said of J. R. Planché's burlesques, or even of Tom Taylor's deftly constructed plays like *Still Waters Run Deep* (1855) or *'Twixt Axe and Crown* (1870).

In T. W. Robertson's *Society* (1865), followed by *Ours, Caste,* and *School,* the voice of nature is again heard amidst theatrical artifice and conventionality, and, in spite of all changes, still sounds in these comedies to-day. The cheaper sentiment of H. J. Byron's successful *Uncle Dick's Darling* and *Our Boys* (1875) has lost its appeal. W. S. Gilbert showed in his verse-plays, beginning with *The Palace of Truth* (1870) hints of the genius for topsy-turvy logic that was to be fully revealed in his comic opera *libretti.* In the 1890's the witty dialogue of Oscar Wilde's artificial comedies and the high craftsmanship of the earlier plays of Sir. A. W. Pinero and H. A. Jones begin that dramatic renaissance which, stimulated by the influence of Ibsen, has revolutionized the outlook and methods of the English stage.

THE NOVEL

Character.—In the other main field of creative literature, the novel, the Victorian age, in spite of its limitation of outlook, had closer links with the 18th century than with Scott or Jane Austen. W. M. Thackeray, as his *English Humourists* proves,

was a close student of that century and his conception of the novel was akin to that of Fielding, as the "comic epic in prose." Thus in the broad sweep of their scheme and the variety of their characterization, *Vanity Fair, Pendennis,* and *The Newcomes* (1848–55) descend from *Tom Jones.* In other ways Thackeray carries on the Fielding tradition. His favourite targets are hypocrisy and affectation; he makes confidants of his readers; his English, less virile but more modulated than that of Fielding, is fastidious and pure. But he lacks Fielding's buoyant animalism and his devastating irony. With all Thackeray's command of mockery and pathos and charm, he had not the supremely creative gift; even Becky Sharp is not completely flesh-and-blood. Hence his historical imagination, working in a sympathetic medium, has produced in Henry Esmond and Beatrix figures that are more real to us than the Osbornes and the Crawleys who have faded with the social changes of two generations. But the keenly-observed idiosyncrasies of a Barry Lyndon and a Blanche Amory and "The Campaigner" will be repeated, in different guises, from age to age.

Dickens.—If Thackeray is a lesser Fielding, Dickens is a highly magnified Smollett. Some of the sailor folk with whom Smollett had been thrown were transformed by him into eccentrics of idea and speech. By Dickens the whole world was seen under such a transformation. G. K. Chesterton has said that Mr. Pickwick is a fairy. In this sense all the most typical Dickens characters (1837–70) Sam Weller, Mr. Micawber, Uriah Heep, Mrs. Gamp, are fairies, good or bad. They never existed or could exist on solid earth, and they have therefore the indestructible life of the supernatural. More than any other Englishman since Shakespeare, Dickens was a magician who could call spirits from the vasty deep. He was of course much else. He was a Cockney of the Cockneys; a humanitarian reformer with his zeal sharpened by his own early privations; a sentimentalist; and at his worst, a writer of very bad English. And in *The Tale of Two Cities* and *Barnaby Rudge* he could take on the mantle of the historical novelist. But in essence he is the modern Prospero.

The Brontë Sisters.—While the kaleidescopic fantasy of Dickens was at work in London, on the northern moors the Brontë sisters were infusing into English fiction the passionate intensity of their lonely and introspective lives. In *Jane Eyre* (1847) and *Villette* (1853), whether the setting be that of a Yorkshire hall, with a harrowing secret, or a Brussels boarding-school, with a too magnetic "professor," the tumult of the heart of Jane and of Lucy Snowe is a revelation of Charlotte's own emotional experiences. Emily, with a less realistic grip but with fiercer imagination transfigures the tale of terror into the masterpiece of *Wuthering Heights* (1847), red-hot with passion and dark with Rembrandtesque gloom. Mrs. Gaskell, the biographer of the Brontës, sets her own tales against the background of industrial Lancashire, but her delicate observation is at its fine flower in the little Cheshire idyll of *Cranford* (1853).

George Eliot.—George Eliot (Mary Anne Evans) pictured from the first in *Scenes from Clerical Life* (1858) the domestic tragedies that lay behind the placid beauty of her native Warwickshire. In *Adam Bede* (1859) and *The Mill on the Floss* (1860) it is in the same setting that the chief personages work out their destinies according to her determinist creed. But her creative power shows its richest fruit in the humours of Mrs. Poyser and the Tulliver aunts. *Middlemarch* (1871–72) carries on the Warwickshire series with some loss of freshness but with enhanced analytical power. *Silas Marner* is a masterly miniature. But in political, historical, and racial fiction (*Felix Holt, Romola, Daniel Deronda*), her genius became submerged under alien loads.

George Eliot's title, *Scenes from Clerical Life,* might have been used by Anthony Trollope to cover the Barsetshire novels from *The Warden* and *Barchester Towers* to *The Last Chronicle of Barset* (1851–67). Himself a civil servant, without clerical associations, he succeeded by some intuitive gift in the nicely discriminated delineation of ecclesiastical types from the bishop and his stronger half, Mrs. Proudie, downwards. He was scarcely less successful with the other "county" sets, nor did he fail when he tried his hand on the political novel. But here he had been anticipated by a master, who knew every turn of the game. Benjamin Disraeli after experimenting on other lines turned in *Coningsby* (1844) and *Sybil* (1845) to "the condition of the people" question and in *Tancred* (1847) to the wider problem of racial destiny. The flamboyancy of the style matches the glow of social aspiration which has its foil in the satiric edge of the professional portraits—Rigby, Tadpole and Taper.

The Humanitarian Novel.—It was the practical reforming zeal of a parson with Chartist sympathies, that inspired Charles Kingsley in *Yeast* (1848) and *Alton Locke* (1850), while in *Hypatia* and *Westward Ho* he revives the clash of conflicting moral and religious ideals in 1st century Egypt and Elizabethan England. Charles Reade showed a similar union of historical imagination and propagandist zeal, with more lurid intensity, in *The Cloister and the Hearth* (1861) and *It's Never too late to Mend* (1853). His humanitarian interest in convict prison reform was mingled in Lord Lytton's *Paul Clifford* (1839) and kindred tales with a sentimental glorification of criminals. This sentimental alloy runs through Lytton's prolific output of social and domestic novels, studies in the occult and historical romances, of which the most purely imaginative, *The Last Days of Pompeii,* has worn best. Crime and mystery pre-occupied Wilkie Collins in *The Woman in White* and other *tours de force* of ingenious construction. Mrs. Henry Wood and Miss Braddon both shared this power of telling a well-knit and arresting tale. "Ouida" (Louise de la Ramée), though she had a sense of beauty and of pathos, gave to the more flamboyant elements in the Lytton type of romance an exotic flavour that touched burlesque.

It needs an effort to realize that Charles Lever's novels are of the same Anglo-Irish origin as the poems of Yeats and "A. E." But the gaily irresponsible episodes of Cork and Dublin garrison life in *Charles O'Malley* are an other than poetic avenue of escape from the everyday world. Among other regional novels R. D. Blackmore's *Lorna Doone* (1869) is pre-eminent less as a historical romance than as compact of Devon dialect, scenes, and characters. George Macdonald and William Black continued from different angles the delineation of Scottish types and scenes before the more minute realism of the "Kailyard" school of Sir J. M. Barrie, S. R. Crockett and Ian MacLaren. The romantic genius of R. L. Stevenson looked backward in *Kidnapped* (1886) and its successors to the Scotland of the Jacobite era, or roamed through uncharted regions in *Treasure Island* (1883) and *Dr. Jekyll and Mr. Hyde* (1886). If the high artifice of his style sometimes overloaded his longer tales, he is a master of the short story. Here too is Rudyard Kipling's chosen field. In *Plain Tales from the Hills* (1887) and similar collections, and on a broader canvas in *Kim* he has exhibited with searching realism Anglo-Indian and native life in their manifold facets. In the *Jungle Books* (1894–95) he has explored a fascinating region close to, but outside of, human ken. But even Mowgli's experiences are ordinary compared with the adventures of the Alice of Lewis Carroll (C. L. Dodgson) *in Wonderland* (1866) or *Through the Looking-Glass,* where the March Hare and the Queen of Hearts are "forms more real than living man."

The born apostle of romance can find it anywhere. George Borrow, agent of the Bible Society, wove episodes from his travels, together with experiences among gypsies, prize-fighters and vagabonds of the road, into a magnetic blend of autobiography and fiction in *The Bible in Spain, Lavengro* and *The Romany Rye* (1843–57). More devotional minds than his have turned the novel to semi-religious use. Elizabeth Sewell's *Amy Herbert* and Charlotte M. Yonge's *The Heir of Redclyffe* were in the Anglo-Catholic tradition which later in the century made a magnetic appeal through J. H. Shorthouse's mystical and semi-historic *John Inglesant* (1881). A more characteristically Victorian ideal was exhibited in Dinah Mulock's *John Halifax, Gentleman;* and Thomas Hughes in *Tom Brown's Schooldays* enshrined the practical gospel of muscular Christianity. Mrs. Oliphant in *Salem Chapel* and M. Hale White in *The Autobiography of Mark Rutherford* pictured the rebellion of fine spirits against narrow provincial pietism. Mrs. Humphry Ward dealt with a more purely intellectual crisis in *Robert Elsmere,* where an Anglican parson loses his

faith in the Christian creed. It was in stark revolt from all Victorian religious and domestic influences that Samuel Butler penned the vitriolic *Way of all Flesh;* and it was the bitterness of one bred outside these influences that wrung from George Gissing such studies in pessimistic realism as *Born in Exile.*

Hardy and Meredith.—But a pessimism that is mainly the outcome of personal experience seems insignificant beside the spirit of philosophic fatalism that broods over the Wessex novels of Thomas Hardy. Throughout the quarter of a century of production from *Under the Greenwood Tree* (1872) and *A Pair of Blue Eyes* (1873) to *Tess of the D'Urbervilles* (1891) and *Jude the Obscure* (1894), Hardy maintains the same sense of the kinship of man and nature, the same ironic conception of the working out of human destinies. But the rustic humours and the pastoral setting give more relief to the earlier tales; in the later the tragic evolution is more relentless and austere. George Meredith also, during the well-nigh 40 years that lie between *The Ordeal of Richard Feverel* (1859) and *The Amazing Marriage* (1895) took as his starting-point the kinship between man and nature. But his individual men and women are not shown in the toils of circumstance; they are all working out their own fates as members of a civilized society, in which the relations of the sexes are of predominant importance. Because Meredith's world is outwardly akin to Thackeray's we realize the gulf between his brilliant, vivid heroines and their pallid forerunners. But in the elliptical pregnancy of his style he came near to breaking the mould of the narrative art that Thackeray had handed on from the 18th century masters of fiction and had stamped with his own individuality.

History, Biography and Essay.—It was by his mastery of this narrative art that T. B. Macaulay gave to his *Essays* and to his unfinished *History of England* (1849–61) the attraction of a novel. His Whig sympathies doubtless led to some distortion of perspective and to propagandist selection from his vast store of memorized material. But if truth sometimes escapes between his antitheses, this is the concern of history, and it does not affect the lucidity of his style or his descriptive genius. His nephew and biographer, Sir George Trevelyan, carried on with less rhetorical art his tradition in politics and letters. A more austerely Radical outlook, affected partly by French influences, characterizes Lord Morley's studies of Burke, Voltaire and Rousseau.

Carlyle.—Thomas Carlyle was not only, like Macaulay, an essayist and historian but also a semi-philosopher. *Sartor Resartus* (1833–34) is, under a thin veil, a spiritual autobiography in which Calvinistic morality and Kantian idealism are predominant elements. In his lectures on *Heroes* (1840), Carlyle gave his most genial interpretation, through a galaxy of examples, of the hero-worship which took more challenging form in the biographies of Cromwell and Frederick the Great, and became aggressive in the later political pamphlets. In his *French Revolution* (1837) we read history by the lightning-flashes of a style of jagged beauty that sometimes blinds us to the arduous toil that went to the making of the work.

J. A. Froude, Carlyle's biographer, shared his propagandist views which coloured his presentation of Tudor history set forth in flexible and melodious prose. From the opposite angle, but with something of the same picturesque power, J. R. Green in his *Short History* traced the fortunes of the English people. The fervour of Sir John Seeley's belief in the imperial destinies of that people lent a glow to his *Expansion of England,* as did Goldwin Smith's exactly opposite views to *The Empire* and other separatist writings. Sir W. Napier and A. W. Kinglake bring energy, sometimes controversial, and glow into the sphere of the military historian.

Of the more purely scientific historians, building upon documentary or legal bases, only the more prominent names can be mentioned—H. T. Buckle, Henry Hallam, George Grote, Sir F. Palgrave, E. A. Freeman, William Stubbs, S. R. Gardiner, Mandell Creighton, F. W. Maitland, Sir Henry Maine, W. E. Lecky, A. V. Dicey, James Bryce and Lord Acton. The style of most of these has the virtue of aptness to the subject-matter, and with some it can rise on occasion to eloquence, but truth not art is their quest. So too with the writers on economic and philosophical subjects, though J. S. Mill stands by himself. The classic simplicity and purity of his style in his *Principles of Political Economy* (1847), *Liberty* and his *Autobiography* (1873) will always give them a place in literature however views may change. And this is true for different reasons of a later philosopher of a different school, F. H. Bradley. The literary quality, though not absent, is more subdued in the writings of Walter Bagehot, Leslie Stephen, James Martineau, F. D. Maurice and T. H. Green. The scientific enquirers had no direct concern with letters. But some of the phrases in which the doctrine of evolution was set forth by Charles Darwin himself, or by Herbert Spencer and T. H. Huxley, "the survival of the fittest," "the struggle for existence," "adaptation to environment," had an arresting imaginative quality. Huxley in especial had the secret of a style perfectly tempered for argument and exposition, and, when he desired, matchless for invective.

Ruskin.—Among the writers of imaginative prose John Ruskin stands conspicuous by the volume and variety of his work. But the more he changes the more he is the same; national and individual welfare is throughout his concern. In *Modern Painters* (1843–60) a defence of Turner grew into an exposition of the true principles of beauty in nature and in art; *The Seven Lamps* and *Stones of Venice* interpreted to a commercialized age the spiritual message of Gothic architecture. The same message, applied to another sphere, is set forth in his writings on political economy beginning with *Unto this Last* (1862) and in his letters on social subjects in *Time and Tide* and *Fors Clavigera.* His style has a similar unity in diversity. The purple elaboration of *Modern Painters* is replaced in *Unto this Last* by limpid simplicity, but the alliteration and the balanced cadence and the biblical echoes remain.

William Morris in his lectures and visionary tales blended, like Ruskin, artistic and social "hopes and fears." But Walter Pater in his studies of the Renaissance art was seen in detachment from extraneous influences as a revelation of sensations and emotions in all their intensity.

By the grace and delicate precision of the style in his autobiographical *Apologia* (1869) and other controversial writings Cardinal Newman takes a foremost place among Victorian masters of prose. Matthew Arnold, from the opposite pole of thought, eulogized Newman's prose as "of the centre." His own highest qualities were not shown in his treatises on religious and political subjects, though he popularized such catchwords as "Sweetness and Light." But in *Essays in Criticism* (1855) and his Oxford lectures he applied felicitously, though with an occasional lapse, a canon of appreciation based upon international standards, with the touchstone of "the grand style." W. E. Henley, George Saintsbury, R. H. Hutton, Edward Dowden, A. C. Bradley, Sir W. Raleigh, Sir Sidney Lee and Sir Edmund Gosse are other prominent names in the sphere of critical appreciation or literary biography. R. L. Stevenson, Andrew Lang, Oscar Wilde and A. B. Walkley are more notable as essayists with a personal note. And at the opposite end of the scale mention may be made of the great co-operative undertakings which were begun during the period, the *Oxford New English Dictionary,* the *Dictionary of National Biography* and the *Victorian County Histories.* They at least are certain to give it an enduring remembrance.

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VIII. THE MODERN PERIOD

It must remain for a remoter posterity to pass judgment upon the English literature of 1911–26; to decide which (if any) of the authors then living were really great; to discern with certitude the trends and the characteristic colour of the age. Among those who lived through the period, it was a common opinion that it was not an age "of giants"; that the poets were not as great as Browning or Tennyson, nor any of the novelists as eminent as Dickens, Thackeray or Fielding. That opinion, as yet, can only be tentative; in the ultimate, reputations are decided by the permanent, as contrasted with the topical, appeal to the human mind and heart; and it may be that to posterity all the writers of the age will seem to have qualities and a tone in common which were not evident to themselves.

If there is foundation for the general view that there is a defect of passion in the most recent English literature and a lack of major achievements, the reasons must certainly be found in the state of thought and of what passes for thought. Men's views about the universe, the purpose of life and the nature and destiny of the soul, must profoundly influence their works of art, as well as their other actions, however frequent may be the antinomy between their proclaimed theories and their obscure but obstinate impulses. There can be no doubt that the period under review was, at least in what are called "intellectual circles," a period of confusion, of conflict, of doubt manifesting itself here in energetic pessimism, here in fatigue and apathy, here in blind hedonism, here in a desperate search for new creeds, sometimes brutally pagan. "Why should I?" was the dominant note, accompanied by a subtler "Why shouldn't I?"; and often neither awaited an answer.

FICTION

Politics, popularized science, psycho-analysis and the results of their wide study are powerfully present in a large proportion of the most intelligent modern novels, and the novel, grown polymorphous, is the characteristic medium of the age. Just as the Pre-Raphaelites segregated themselves behind the arras in flight from the smoke of the first industrial age, so certain modern novelists have declined to be affected by the smoke of modern controversy. Amongst novelists, since Meredith and Stevenson died, Joseph Conrad and George Moore were signal examples of the kind of artist who can build a raft for himself and escape from the topical welter. Conrad had his religion and his morality, "a few simple maxims," a code of honour and fidelity. He did not shrink from the major problems either; he was perennially occupied with the difficulties of conduct, the mystery of evil, the veil over the face of Destiny. Yet, as an artist, he did not primarily set out as a sublimated journalist, to mingle art with conversion and subversion, to add his word to the babel of tongues discussing property, sex, the multiple self and spiritualism. His views were manifest and set; so were his doubts; he wrote to record what he saw of magnificence, even in the form and visage of tempest and terror, in the most beautiful language he could find. Of Conrad's last works, *The Rover* (1923) was a prelude to the posthumous *Suspense* (1925), the torso of what might have been a great book, set in the Mediterranean, with Napoleon in Elba a shadow imminent over the action. He died in 1924, a Pole by birth, a seaman by training, who had achieved miracles in a tongue not his own.

George Moore, in his latest years, modified his manner and took new materials. His Irish trilogy, *Hail and Farewell* (1911–14), might be classed, by some of the friends whose words and deeds it records, with "fiction"; at least it does indicate his aims. Politics and religion may be and are touched on here, but they are raw material for art, for witty, graceful and tuneful writing; and the desire to create a finely shaped and phrased work is never subordinate to a desire to inform the reader. In *The Brook Kerith* (1916) and *Héloïse and Abélard* (1921), Moore took historical events and settings and made of them stories like tapestries in the evenness of their flow and the carefulness of their execution.

Apart from these, the outstanding novelists of their generation were H. G. Wells, John Galsworthy and Arnold Bennett. Ultimately, Wells is not likely to be thought of primarily as a novelist, and he himself has stated that he has dedicated himself to journalism rather than art. He was the Rousseau, as Shaw was the Voltaire, of his time. As a workman and a poet in prose, he never excelled his early short stories and "scientific romances," in which extreme assumptions led up to ingenious and seemingly inevitable chains of consequence. Nor did any of his later novels, in which sexual romance, contemporary politics, satire and Utopian preaching are mingled, betray quite the same care or contain quite such fine sustained passages of description as *Tono-Bungay* (1909). But *Mr. Britling Sees it Through* (1916) was a remarkable record of the effect of the War upon one man's mind, and *The Undying Fire* (1919) a very striking and successful modernization of the arguments canvassed in the Book of Job and *In Memoriam*. He was tireless as a tractarian and amongst the most astonishing by-products of his great energy and zeal was an *Outline of History* (1919–20), unique among such compilations for the raciness of its narration and the ingenuity of its summary of all the world's annals since the ball of fire first began to cool.

The reforming, or at least the protesting, bias was strong also in the novels of John Galsworthy. *The Forsyte Saga* (1922), with its sequel *Swan-Song* (1928), a collection of novels early and late, about one respectable family, was the crown of all his work. For all his air of detachment Galsworthy could not help presenting the respectable and complacent incompletely; more humour might have led to more truth; so even might a less acutely sensitive humanitarianism. But the achievement of his presentation of the mere *moeurs* of South Kensington and of country houses cannot be denied; and his writing at its best, if uniformly quiet, is extremely good.

In Arnold Bennett the propagandist instinct was much weaker, though the reporting proclivity was strong. He was never slipshod and dull, but in some of his books the chief interest lay in brilliant journalistic descriptions of superficial aspects of "West-End life," some were light-hearted farces, and the best were long-meditated and profoundly "understanding" stories about real human beings, stories in which all his talents were brought into play, but all kept subordinate to his genius. The chief of his later books, a worthy successor to *Clayhanger* (1910) and *The Old Wives' Tale* (1908), was *Riceyman Steps* (1923).

Among the younger novelists, Hugh Walpole (*Wintersmoon*, 1928, was his best book), Compton Mackenzie, Rose Macaulay, E. M. Delafield, Sheila Kaye-Smith, Francis Brett-Young, Virginia Woolf and Margaret Kennedy were widely read. D. H. Lawrence, brooding like many of them over the mysteries of sex and expounding vaguely prophetic things, showed great descriptive power and a gift for sentences like lightnings. Walter de la Mare in *Memoirs of a Midget* (1921) wrote a long modern fairy tale, like a poet's wood, full of flowers and insects, with a candle-light window at the end of a path and the constellations glittering in the dark sky overhead. H. Belloc's *The Four Men* (1912) was remarkable for its Sussex walks, its gay dialogue and its songs. E. M. Forster's *A Passage to India* (1924) was the most notable book of a maturing and slowly-working novelist, a book in which the artist brooded over the whole surface of Indian and Anglo-Indian life, showing the general through the particular. David Garnett's *Lady into Fox* (1923) and Hugh de Selincourt's *The Cricket Match* (1925) were short books beautifully composed. Among short-story writers W. W. Jacobs lost none of his old cunning and Katherine Mansfield, cut off in her youth, came, in *Bliss* and *The Garden Party*, nearer to Tchekhov, the remarkable and most celebrated founder of the art of the short-story in Russia, than any other of his many disciples. May Sinclair, J. D. Beresford, E. F. Benson, Leo Myers, R. H. Mottram, Aldous Huxley, P. G. Wodehouse, Frank Swinnerton, C. E. Montague (d. 1928) and many other names might be added to the list of the novelists, who, during the period, produced novels competent or more than competent.

It is by no means inconceivable that in later retrospect the years of the World War and the years immediately preceding and following will be held in literature to be remarkable chiefly for their poetry. There may have been few long poems of great note, but a very large volume of good lyric poetry by a very large number of

writers was produced.

One of the most extraordinary phenomena of the period was the continued fertility of the older poets. When nearly 80, the Poet Laureate, Robert Bridges, produced a new volume of poems, *October and Other Poems* (1920), a collection which showed no waning of his technical powers, experimental curiosity and gift of observation, and (more unusual still) no slacking of his emotional ardour. Perhaps the finest of all our landscape poets, and certainly one of the most careful and cunning artists who has ever worked with English words and English rhythms, he stands out conspicuously also by virtue of his perennial freshness and energy.

As Dr. Bridges at Oxford, so Thomas Hardy (1840–1928) at Dorchester continued to command the astonished admiration of his juniors. Hardy, turning to verse in his old age after a long, and nobly productive, servitude to the novel, followed up *The Dynasts* and his three earlier volumes of lyric and narrative poems with a series of volumes beginning with *Satires of Circumstance* (1914) and culminating in *Human Shows* (1925). Grim little tragedies, tender memories of the beloved dead and Wessex scenes long vanished, hard clear etchings of landscape, sea and shingle, down and puddled lane, bare tree and shivering bird; many of these written in extreme old age, surpassed the best of Hardy's previous work. These poems were marked by a great and seemingly spontaneous gift of metrical invention, a power of emotion which enabled the poet to incorporate the most unmanageable words in the movement of his music, and a quick sensitiveness, a capacity for suffering and pure joy, rare in the old.

Another prolific veteran was C. M. Doughty (d. 1926), author of *Travels in Arabia Deserta* (1888), one of the greatest books of the kind in any language, who followed up his *Dawn in Britain* (1906), with a series of long poems. *The Clouds* (1912), *The Cliffs* (1909), *The Titans* (1916) and *Mansoul* (1920), epical dramas and dramatic epics in which archaism and topicality, naïveté and sublimity are strangely mingled, are interspersed with massive passages in which the imagination ranges over all time.

Sir William Watson published one volume during, and one after, the War in which, whilst not equalling his major achievements, he showed that his talents for pithy yet magniloquent statement and for the careful polishing of verse remained unimpaired. Maurice Hewlett (d. 1923) devoted his last years mainly to poetry. His *Song of the Plow* (1916), perhaps the finest of all his works and certainly one of the few memorable long poems of the period, was a racy, vigorous, picturesque summary of English history from the point of view of "Hodge." Laurence Binyon, of the other poets of that generation, perhaps wrote the most impressive volume of War poetry, *The Four Years* (1919), in which the meditations and agonies and exaltations of the humanitarian and the patriot in face of the great calamity are expressed with power and dignity.

Noble poetry inspired by the War was also among the last work of Herbert Trench (d. 1923) and Alice Meynell (d. 1922), Mrs. Meynell's little book *A Father of Women* (1917) displaying rigid restraint, perfection of workmanship and concentrated emotion. A similar frugality was manifest in A. E. Housman's *Last Poems* (1922), its author's first collection of poems since *A Shropshire Lad* (1896), of a generation before. A few of the new poems surpassed the finest of the old for beauty and imagery and cadence, and the book was received with enthusiasm by the larger public and with reverent admiration by fellow artists. Gilbert Murray continued to add to his beautiful translations from Euripides. One volume, which contained some excellent epigrams and some spirited poems of the War, was all that the period added to the poetical works of Rudyard Kipling.

There remain a large number of poets whose reputations were not fully established in 1911, or who emerged during or after the War. The most notable progress among the former was made by Walter de la Mare, whose early books were followed by *The Listeners* (1912), *Peacock Pie* (1913) and others, including a two-volume collection in 1920. This poet usually inhabits provinces which he has made his own: woods haunted by fairies, midnight gardens and heaths haunted by ghosts, desolate shores haunted by memory. The exquisite melody and felicity of his most typical work would give him a high place among English poets; yet what is called the "major" note is not absent from his work.

The slow, vivid, sunlit style of T. Sturge Moore was again seen at its best in *The Sea is Kind* (1914); G. K. Chesterton, with "Lepanto," the songs in *The Flying Inn* (1914) and a few comic poems intensified his readers' regret that he should find so little time for verse; Hilaire Belloc added a few beautiful lyrics, notably "Tarantella," to the small body of his serious verse; and W. H. Davies almost annually delighted his admirers with a little collection of nature lyrics. Alfred Noyes, with the two first volumes of *The Torch Bearers* (1922–25), opened an ambitious epic of human intellectual development.

In 1911 there broke upon the world John Masefield's *The Everlasting Mercy*, a sensational story of conversion written in vigorous octosyllabics. It had, as lively narrative work usually has, a great success; and the author followed it up with a series of long poems on rural and marine tragedies. *Dauber* (1913) was probably the best of them, but there were good things in all. Of his shorter poems "Biography," a series of vivid pictures from memory and "August 1914," were notable.

Several of the best poets of their generation died in the War. Rupert Brooke (d. 1915), by virtue of his beauty, radiant personality and talents, became, when his *1914 and Other Poems* (1915) were published, the general symbol of youth that went into the furnace. His maturer work showed grace, wit, intellectual curiosity and a growing perception of the chief goods of life.

James Elroy Flecker (d. 1915) died of consumption at Davos, cut off from home by a ring of battle-grounds. His *Collected Poems* (1916) show that he had outgrown early affectation and uncertainty, achieved a style, pictorial and euphonious, of his own, and secured his grasp upon his deepest loves and most personal dreams. The East, which fascinated and repelled him, inspired many of his best things; it was also the source of his posthumous drama *Hassan* (1922), produced at His Majesty's theatre, London, in 1923. Wilfred Owen, killed in 1918, was unknown in life. His *Poems* (1920) were very interesting for their technical use of assonance; but his technical genius, however remarkable, was less so than the magnitude of his vision and the ardour of his spirit. Charles H. Sorley (d. 1915) was another boy who was killed on the verge of greatness; and Julian Grenfell (d. 1915), professional soldier and fine boxer, went to his death with the finest song of the War on his lips, "Into Battle" (1915).

Edward Thomas (d. 1917) had had a strange career. Before 1914 he was known as a voluminous writer and journalist whose hack work was scattered with fine descriptions of nature, but whom no one thought of as a poet. Under the stimulus of the American poet, Robert Frost, he turned, in his last two fertile years, to the making of poetry, nature poetry unique in its kind. Exact observation and record of landscape could go no farther than this; but his *Poems* (1920) would not be as fine as they are were it not for their faltering music and the positive, if quiet and melancholy, personality which suffuses them all.

Siegfried Sassoon, Robert Graves and Robert Nichols all came into notice during the War as writers of powerful and "realistic" poems describing it. Surviving, they all developed interestingly. Ralph Hodgson (*Poems*, 1917) was always a poet of slender production, but his "Song of Honour," "The Bull" and "Eve" are among the best-loved poems of the time. Edmund Blunden, mainly a recorder of rural scenes in the tradition of Morland and Constable, showed a very individual talent, and John Freeman must be singled out for the beauty of his rhythms, his spiritual strength and his landscape[1]; D. H. Lawrence (especially *Birds, Beasts and Flowers*, 1923) for his graphic power and apprehension of the crude forces of nature. Amongst others who, in few poems or many, have beautifully registered moments and moods, have

[1]Blunden and Freeman were awarded the Hawthornden prize, founded by Miss Alice Warrender in 1919 for imaginative work by young writers, the other recipients during the period being Edward Shanks, Romer Wilson, David Garnett, R. H. Mottram, Sean O'Casey, V. Sackville-West and Henry Williamson.

dreamed or reflected, are Lascelles Abercrombie, Gordon Bottomley, A. Y. Campbell, John Drinkwater, Edward Davison, Humbert Wolfe, Frank Kendon, Harold Monro, Edward Shanks, W. J. Turner, Dorothy Wellesley, Victoria Sackville-West.

The Irish poetical movement (*see* IRISH LITERATURE) begun in the previous generation by "AE" (George Russell) and W. B. Yeats, showed signs of exhaustion. "AE" wrote little; Yeats in his later poems escaped from "the Celtic twilight," abandoned the Celtic myths and discarded the languorous manner of his early triumphs for a hard, bare style in which, used for describing the outer world and the inner, he wrote poems often obscure but always full of thought, which many held to be his finest. Thomas Macdonagh and Joseph Plunkett, who died after the Easter Week rebellion of 1916, had written good lyrics; Joseph Campbell, Seumas O'Sullivan and a few others did as much; but the most notable "new" poet of the period was James Stephens, author of the delightful prose fantasy *The Crock of Gold* (1912).

BELLES-LETTRES

Criticism.—The publication of works of pure scholarship, and new editions with critical apparatus, was seriously affected by the expenses of production during the War and post-War period. Nevertheless, a considerable number of important standard editions, especially through the university presses, were published, notably Prof. Grierson's *Donne* (1912), the first volumes of C. H. Herford's and Percy Simpson's *Ben Jonson* (1925), some volumes of the *Cambridge Shakespeare* (a new text embodying the results of the bibliographical researches of A. W. Pollard and J. Dover Wilson [1920]), P. W. Chapman's exhaustive Jane Austen (1923) and T. Earle Welby's pioneering edition of Landor in process of publication in 1928. *The Cambridge History of English Literature* (1907–16) was brought to a conclusion and Prof. Oliver Elton published his massive *Survey of Modern English Literature* (1912 and 1920). Prof. Caroline Spurgeon's *Five Hundred Years of Chaucer Criticism and Allusion* (1925), in three volumes, was an outstanding example of the specialized literary research work which is largely superseding the older kind of academic criticism. Miss Helen Waddell's *The Wandering Scholars* (1927) was a delightfully discursive recreation of mediaeval life.

Among critical studies of a less encyclopaedic kind, the most substantial were done by the older men, notably Sir Edmund Gosse (d. 1928) and George Saintsbury. Sir Edmund Gosse, enjoying an Indian summer, produced numerous volumes of collected papers in which he illuminated authors and movements, ancient and modern, English and foreign, incorporating anecdote and personal sidelights with incomparable ease and grace, and delighting his readers by the suppleness, wit and pictorial brightness of his clear and idiomatic style. The most important of his later publications was *The Life of Algernon Charles Swinburne* (1917), a model of brilliant portraiture, compact narrative and sane criticism. George Saintsbury, who retired from his Edinburgh professorship in 1915, completed his edition of the *Minor Caroline Poets* (1905–21), added a *History of English Prose Rhythm* (1912), *A History of the French Novel* (1917–19) and *The Peace of the Augustans* (1916) to the prodigious pile of his historical works; and made delightful use of his vast erudition and full-stored memory in several miscellanies including two about wine. At Oxford Sir Walter Raleigh and at Cambridge Sir Arthur Quiller-Couch lectured brilliantly and published the best of their lectures. Standard lives of Keats and Byron were produced by Sir Sidney Colvin and Ethel Colburn Mayne; and theoretical treatises of a high order were Percy Lubbock's *The Craft of Fiction* (1921), E. M. Forster's *Aspects of the Novel* (1928), Christopher Hussey's *The Picturesque* (1928), and Geoffrey Scott's *The Architecture of Humanism* (1914). The death of Arthur Clutton-Brock, in 1924, prematurely removed one of the most luminous and sensible of the literary journalists who abounded in the period. Others who did good critical work were Edward Garnett, a notable discoverer of talent, John Freeman, Lascelles Abercrombie, Harold Nicolson, Gerald Gould, R. Ellis Roberts, Arthur McDowall, Robert Lynd, T. Sturge Moore, J. B. Priestley, Osbert Burdett, Lytton Strachey, Edward Shanks, Maurice Baring, Virginia Woolf; and, among critics of the drama, A. B. Walkley and Desmond MacCarthy.

Miscellaneous Literature.—The essay flourished in the period, but mainly in a modern form. The old leisurely manner was practised with perfect success by Max Beerbohm in *Seven Men* (1919), *And Even Now* (1920) and other collections. A caricaturist and parodist of genius, Beerbohm wrote with an awareness that made him extremely careful to secure the last degree of accuracy and flavour in his language, to arrange the cadence of his sentences, to exhaust his subject as it presented itself to his mind, the mind of a humorous, witty and tender connoisseur of life and particularly of highly civilized urban life. Alice Meynell also wrote essays on the major scale, profound in thought, exquisite in phrasing, austere in temper yet iridescent in hue, which posterity cannot neglect. The typical modern essayist of the time wrote regularly every week to fill a column in a daily newspaper, or a page in a weekly: the remarkable thing is the merit of much of the writing done under these limitations of time and space by such men as G. K. Chesterton, Hilaire Belloc, E. V. Lucas and Robert Lynd, and, in his last years, Maurice Hewlett.

Vivid and powerful sketches of travel were written by R. B. Cunninghame Graham and H. M. Tomlinson; Francis Brett-Young, in *Marching on Tanga* (1919), wrote a narrative prose poem on the Africa he saw during the War. With Henry Williamson in *Tarka the Otter* (1928) appeared (although the prose was rather congested) a true successor to Jefferies and Hudson. Works difficult to group are the *Earlham* (1922) of Percy Lubbock, a picture of childhood's memories of a place and people; L. Pearsall Smith's *Trivia* (1902–18), brief prose compositions full of wit, candour and pictures, and Sacheverell Sitwell's *All Summer in A Day* (1926), an enchanting piece of retrospection. *The Puppet Show of Memory* (1922) by Maurice Baring, one of the most versatile writers of his time, was an autobiographical work of great charm and interest, conspicuous among recent memoirs for its good manners. Max Beerbohm's *A Christmas Garland* (1912) was a masterly volume of parodies of modern prose writers. Among other parodists, Sir Owen Seaman having resigned the art, E. V. Knox (Evoe) was conspicuous; his work in *Punch*, together with that, both in prose and in verse, of A. P. Herbert, was a mainstay of the chief English humorous journal.

Historical works, deserving the appellation of literature, were few in the period. G. M. Trevelyan completed his Garibaldian trilogy, H. Belloc published in several volumes a controversial but suggestive *History of England*, and Philip Guedalla wrote an amusing book about Napoleon III., *The Second Empire* (1922). Sir John M. Fortescue's *History of the British Army*, concluded in 1920, more than 20 years after its inception, was a massive work written in excellent English. The most interesting work in biography was not to be found in the two or three volume political biographies, such as G. E. Buckle's continuation of W. F. Monypenny's *Disraeli*, and Lord Ronaldshay's *Lord Curzon*, excellent though several of these were, as in such works as Lytton Strachey's *Eminent Victorians* (1918) and *Queen Victoria* (1921), works tinged with irony and partial perhaps, but seminal books, because of their brevity, their concentration of the essentials of a great mass of material, the excellence of their portraiture and the impeccability of their epigrammatic and coloured prose.

DRAMATIC LITERATURE

The theatrical literature of the period under consideration is surveyed elsewhere (*see* DRAMA), but some reference may be permitted here to certain works which were widely read as well as acted. In 1911 the "realistic" movement in the drama, largely influenced by Ibsen, was in full swing. The word did not necessarily imply any approximation to reality, though it was meant to do so. What it really implied was the substitution of a novel set of conventions for a set of which people had grown tired. West-End drawing-rooms were replaced by the homes of suburban clerks; rosy sentimentalism was replaced by cynicism, a prophetic

pessimism or a detached irony of presentation; speeches gave way to silences or pregnant ejaculations; "social problems" broke in upon a theatre which had ignored them.

The born dramatist could work within this convention as within another, assuming the fashionable trappings, but relying, as he must, for his effect upon the audience, on his ability to excite and amuse them by surprise, to charm them by the presentation of "humours," to exalt them with passion and courage, to "purge" them rather than depress by the display of failure and pain; and, where a play of this school succeeded, it was not because it was arguing for prison reform, votes for women, better housing or better drains. The restrictions, however, could not endure; humanity craves in the theatre for more splendid language than it ever uses and more splendid scenes than it habitually lives among; and the end of the period saw ample signs of a return to the stage of poetry and eloquence, vivid colour and symbolism, to the universal and the particular as contrasted with the mere mundane and temporal generalization which obscures individual character without connoting anything eternal.

Chief among living British dramatists, Bernard Shaw was perennially active, moved with the times and remained obstinately himself. His method in his early plays recalled now Sheridan, now Ibsen; the wit, the paradox, the irony, the odd "angle on life" were his own. Of his last 11 plays, long and short, the most interesting were the last three: *Heartbreak House* (1919), *Back to Methuselah* (1921) and *Saint Joan* (1924). In the first picture of social fecklessness, the influence of Tchekhov and the Russians was evident; in *Saint Joan*, notable for the great trial scene of Jeanne d'Arc and the detachment with which both sides of the argument were presented, Shaw wrote a chronicle play. *Back to Methuselah*, a cycle taking five nights to play, was all his own; a prodigiously ambitious play, which opens with Adam, Eve and the Serpent in the Garden and ends with human beings "as far as thought can reach," who live beautifully and very long and are born, mature, out of eggs. The earlier and later scenes contained fine, even poetical, passages; the middle was marred by political topicality.

Sir James Barrie in *Dear Brutus* (1917), *Mary Rose* (1920) and seven short plays continued to charm a large public with his peculiar vein of humour, sentiment and fantasy, and John Galsworthy, with *The Skin Game* (1920) and *Loyalties* (1922), also did effective work in his established manner. A greater development was noticeable in the work of W. Somerset Maugham, whose long series of witty social comedies culminated (1923) in *Our Betters*, the most effective, if the bitterest, of them all. Henry Arthur Jones and Sir Arthur Pinero, the dominant dramatists of the previous period, did little to modify their reputations; and H. Granville-Barker, who had shown great promise with *The Voysey Inheritance* (1909), was largely preoccupied first with production and then with editing Shakespeare. Arnold Bennett's *The Great Adventure* (1913) was a delightful comedy; the comedies of A. A. Milne also had distinction. G. K. Chesterton's solitary dramatic work *Magic* (1913) was agreeably individual in manner.

The effort to restore "poetic drama" to the stage from the "closet" was increasingly noticeable. Flecker's *Hassan* (1922) was written before the War; Rupert Brooke was making his first dramatic experiments when the War broke out. A series of verse plays by Gordon Bottomley, the best, perhaps, being *The Riding to Lithend* (1909) and *King Lear's Wife* (1915), though retaining traces of the "reading play" had considerable dramatic power; Herbert Trench's *Napoleon* (1919) was on the verge of greatness; and there was grace and charm in Clifford Bax's *Midsummer Madness* (1923), a ballad opera to which C. Armstrong Gibbs wrote music. Other dramatists conspicuous in the period were Noel Coward, Clemence Dane, John Drinkwater, St. John Ervine, "Ian Hay," John Masefield, Alfred Sutro and Israel Zangwill.

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(J. C. SQ.)

ENGLISHRY, the process by which William the Conqueror protected the lives of his Normans. If a stranger was found slain, and the slayer was not produced in court, he was presumed to be a Norman, and the hundred was fined accordingly, unless it could be proved that he was English. Englishry, if established, excused the hundred. It is said that Cnut protected his Danes in a similar manner. Englishry was abolished in 1340.

See Pollock and Maitland, *Hist. Eng. Law*, vol. i. 67.

ENGLISH-SPEAKING WORLD: ORIGINS, EXPANSION, RELATIONS AND PROSPECT. The following pages divide into nine sections:—I. Origins up to 1606: the island, its breeds and the language. II. First expansion in the 17th century: Puritanism and Sea-Power. III. 1674–1782: Making and breaking of the Old Empire. IV. After 1782: Britain's vitality. V. Ireland's increase, disaster and exodus overseas. VI. 1790–1928: Growth and transformation of the United States. VII. A general view of English-speaking life. VIII. "Towards 300,000,000": the future and its problems. IX. Conditions of Moral unity and parallel action: the "Key of the World."

I. ORIGINS UP TO 1606: THE ISLAND, THE BREED AND THE LANGUAGE

When Shakespeare and the Authorized Bible revealed the incomparable resources of expression attained by one modern language, its speakers were still but a small handful of the human family; and nearly all local to a peculiar nook of ground. Nothing augured the destinies of their tongue. Then, it was used by little more than 5,000,000 persons altogether. To-day, multiplied forty-fold in a short period of historic time, it is the principal world-language; already familiarly spoken by about 200,000,000 people and sure of large increase. Then, though its seafaring epic had just begun, it was still confined almost entirely to one island broken off narrowly from the continental mass of Europe. Now, this language, and this only, has been carried through all the oceans and spread round the globe. The results have appeared in our day as a paramount force of world-history. With political and social diversities of every kind, widely-separated communities have speech and literature in common; their general conceptions of freedom and law and ethics are the same. The relations of this vast array of lands and peoples are of unsurpassable moment.

"Language" and "Race."—The growth of the English-speaking world is more often marvelled at than understood as a process of historical geography. At no phase can it be explained by dwelling in the older way, with almost exclusive emphasis upon the "Anglo-Saxon idea." From that standpoint only, the biggest developments and the future problems cannot be realized at all. Language and race may be two very different elements in combination. There is no such thing known as a "pure" unmixed breed. Every great language covers more or less a variety of racial origins. This is a principal key to modern historical work. None the less is England the mother of nations—a "little England," indeed, but a mighty mother.

Formation of the Nucleus.—There were ages when not even the island was. Ancient waters hid its foundations: "here where the long street roars hath been the stillness of the central sea." Through another age after the island rose and first was peopled,

no England was. No more than an unknown westward continent was yet named America. Primitive races whose languages have left no sign, though some anthropologists believe that they survive largely in the physical substratum of the insular breed, lived there, before history dawned, for a longer period than any later occupants. The Celts came, conquered, mixed. They made "Britain." The Romans followed and remained for four hundred years—a period nearly as long as from Columbus to this day—building their solid quays, their gated cities, their linking highways; leaving some of the mixed blood of their legions in the veins of the natives. They went. Already some of the racial factors still entering everywhere into our subject were formed before there was any trace of English in England.

The rudiments of our modern world-tongue had not reached the country destined to receive and transform them. Then from the fifth to the tenth centuries, "English-speaking expansion" began as a new colonization of the island—like a miniature America—by north European tribes. By successive waves the Germanic and Norse invaders—Angles, Saxons, Jutes, and later Scandinavians—swept in and changed utterly the breed and speech of the larger part of the land which had been Britain; while, in the latter centuries of this period, the swoops and settlements of the Vikings came round to Ireland and though in the end less successful there had a far-reaching influence on its future. The terms "England" and "English" do not come into use for a long time. First, towards A.D. 1000 under the Danish domination, they seem to have implied as against the new invaders, a common consciousness of the Anglo-Saxons formerly at feud with one another. Secondly, and very soon (A.D. 1066) from the Norman conquest onwards, "English" took in the Danes as well, against the new masters. For a generation or two, by distinction, the Normans of the ruling caste even though born in England called themselves "French." This caste itself sprang from no pure Norman aristocracy as supposed in centuries afterwards by the vanity of their real and fictitious descendants, but mainly from a medley of adventurers syndicated for profit and drawn to the Duke's banner by his wide advertisement of expected spoil. William's host was a Joint Stock company in armour. The consequences are in the life and language of America to-day no less than in the substance and soul of the original islands.

Late Creation of English: the Newest Modern Language.—Though "English" had been a name in use for a couple of generations before the Battle of Hastings, as yet the tongue we mean by it was not. It was gradually, wonderfully shaped, in the next five centuries from the Conquest to Elizabeth. Chaucer shows change and enrichment advanced more than mid-way. Words from the French swell the vocabulary. This digestive habit easily leads under the Renaissance to ample assimilation of Latin forms. Thus we acquired the present inheritance of all the English-speaking and English-writing communities—a medium capable of magnificence, power, subtlety, but of all homeliness, humour, tenderness; full of practical force. It kept a great simplicity in inmost nerve and character, and controlling elements. For all the splendour, you have mostly words of one syllable in:

> "Is this the face that launched a thousand ships
> And sunk the topless towers of Ilion."

Bunyan writes line after line in words of one syllable. But Shakespeare suggests in one sentence the whole range and blending and depth of tone, of this orchestra:

> ". . . not poppy nor mandragora,
> Nor all the drowsy syrups of the East,
> Shall ever medicine thee to that sweet sleep
> Thou owest yesterday. . . ."

Burke breathes eternal regret: "What shadows we are and what shadows we pursue." Wordsworth spiritualizes a loveliness of imagination:—

> "The light that never was on sea or land,
> The consecration and the poet's dream."

And an Abraham Lincoln creates the Gettysburg speech where the eloquence of a prose, brief, pure and immortal, remains even after the World War the utterance in modern centuries most worthy of great nations remembering their dead. But the book of books, the English-speakers carried with them when they began to spread overseas was the Bible in the Authorized Version, chief treasury of the language containing all the qualities remarked upon above, and others of its own:

> "I will praise thee; for I am fearfully and wonderfully made: marvellous are thy works."

Note that since Alfred's day the immense growth by verbal immigration of the language itself while yet local only, was like a premonition of the subsequent expansion and assimilativeness of the race. Another thing was preparative. The English themselves were of mixed Germanic-Celtic blood representing racial elements as different at first as say Swede and Slav in the present white population of the United States. As Sir Walter Scott puts it, Scottish Lowlanders for long regarded Gaelic Highlanders much as Pennsylvanian settlers used to regard Cherokees.

The First Five Millions; and the Larger Rivals.—Thus much for things as they had come to be when the great dispersion began. Estimates of the population of England at the time of the Conquest vary and are all very uncertain. The likeliest number in 1066 is given as about 1,500,000. There is no more certainty about whether the rate of increase afterwards in the middle ages was fairly good or very slow. There seems no doubt that the Black Death (1348–50) meant a heavy throwback though the chronicles exaggerate. Whether one third of the people disappeared or but one tenth (the lowest reckoning) we do not know. But it is probable that in the century and a half between the great pestilence and the height of the Elizabethan period the population doubled itself and increased as much in prosperity. It is thought to have numbered, however, only about 5,000,000—in Scotland at the same time there may have been not much more than half a million of English speakers and in Ireland less than 100,000—when Queen Elizabeth died in 1603.

What were the chances of the insular five millions in the coming struggle of nations in the 17th century for sea-power and colonies? To almost any foreign eye at that time, the chances would not seem considerable. The power of Spain though somewhat past its zenith seemed immense in both hemispheres. The French were already about 16,000,000 strong, over three times as numerous as the English and increasing faster. The Dutch were going far ahead, as for long they were to continue, in maritime and mercantile progress. The English until rather recently had not even begun to be in the forefront of navigation and world-adventure though the discovery of America was destined in the very end to have greater consequences for them and their posterity than for all other nations put together. When Shakespeare went to school there had been nothing to compare with the achievements of Columbus, Vasco da Gama, Magelhaens or Jacques Cartier. John Cabot was a Genoese though he sailed for the English King. For over two generations after that discovery of Newfoundland nothing much happened. True that a few English fishermen made the Atlantic passage more or less regularly to fish like others on "the banks." That, in a way, was a small beginning of the expansion but there was still no settlement. Then the epic opened when Drake went round the world and Sir Humphrey Gilbert with far larger though dreamy political ideas, the real pioneer of the English-speaking world overseas, obtained in 1577 his general patent of colonization. In June 1583 he with his intending colonists sailed from Plymouth for Newfoundland—"which was but 700 leagues from our English coast." He took formal possession and set up a pillar on which were engraved the arms of England. But ill-luck dogged him. After 17 days, he had to sail away again leaving nothing but the pillar behind him. He declared that they would all return "royally in the Spring." But he perished in his little "Squirrel"—10 tons!—having been heard in the storm to say a word that was to be in the future the soul of more than he knew: "We are as near to Heaven by sea as by land."

Raleigh followed. The "growing spots" were not to be in Newfoundland but amidst more favourable scenes on the Atlantic

coast of the American mainland. In the year after Gilbert went down, "Virginia" received its name but by no means its being. For more than two decades yet attempts at "plantation" would not root; but neither, now, would the dream die.

II. FIRST EXPANSION IN THE 17TH CENTURY: PURITANISM AND SEA-POWER

The 16th century gave place to the 17th. The old Queen passed away. Three years after, while Shakespeare was writing "King Lear," the Virginia Company was created on a more lasting foundation; and in December 1606 the first founding emigrants of the English-speaking world went out. Their vessels were the "Susan Constant," 100 tons, the "God Speed," 40 tons and the "Pinnace" 20 tons. In the spring of 1607 they found the James River and sailing upwards they fixed upon a landing place where six fathoms of water were so near to the shore that the ships could be tied to the trees. Jamestown, inaugurated on May 13, 1607, became memorable as the spot where the English-speaking race cast first root overseas and where the United States began.

The First Colony: Foundation and Spirit of Virginia.—The emigrants proper on embarking in the Thames numbered 143. Amongst them Captain John Smith was worth a host. The rest as a whole were an unlikely lot—for the most part ne'er do wells "packed thither by their friends to escape ill-destinies." In America, they were miserable. More than half died in twelve months, from privation and sickness and thriftlessness. Despite Smith's vigour this enterprise threatened to disappear like Raleigh's attempts in the generation before. The company sent out more colonists. But in the third summer, 1610, all agreed to quit the place. Lord Delaware's saving reinforcements came in the very nick of time. In 1611 a company of 650 new colonists arrived. After that—by coincidence it was the year when the Authorized Bible appeared—there was no more talk of abandoning the English-speaking settlement in Virginia. Let us follow its better, though not easy, fortunes there before turning to events northward. Plantations extended along the river-lines. Trade grew. There was continuous infiltration of emigrants from England. It had been hoped at first that the colony would supply shipbuilding materials; for them England then depended insecurely on the Baltic. But this was not to be the business of Virginia. Tobacco became its flourishing staple. Within one decade after the James River settlement was saved for good, 20,000 pounds of the leaf were annually exported when the new habit of smoking was spreading in Europe with amusing rapidity. In 1619 as many as 1,200 new colonists arrived. Virginia was growing like the tobacco.

Above all, in that same year occurred at little Jamestown one of the signal events in history foreshadowing the political future of the English-speakers overseas and revealing the chief secret of their free vitality. A parliament "broke out." The Virginia House of Burgesses was the first representative assembly yet seen outside Europe. In the same place about the same time negro slavery was introduced. How the colony went forward henceforth the figures of population estimated at irregular periods may indicate. In 1622—when King James at home was suppressing his parliament in the Stuart temper that would lead at last to Civil War—Virginia had 4,000 inhabitants. In 1649 when Charles the First was executed at home, there were 15,000. Another fifty years or so brought the number of whites up to 50,000 (and there were 20,000 blacks) when the 18th century began.

"New England."—But meanwhile ran parallel the sterner story of "New England." Captain John Smith gave it that name when he explored and mapped its coast in his last voyages after quitting Jamestown in its dismal days. On his map was a spot he called Plymouth. Here the Puritan pilgrims landed in 1620—the year after a parliament "broke out" in Virginia. We see already what different political and religious forces were bound in the end to converge. The sequel in the north is a tale so well-known that we need only indicate here at what rate the English-speakers grew in this hardy quarter. The "Mayflower" brought a hundred souls, men, women and children. More than half died in that first winter. Reinforcements were scanty in the first hard years. In 1622 only 35 new colonists arrived, and in the next year 96. Yet the roots were tough. The Puritan settlement numbered only about three hundred persons in 1630 at the end of its first decade; but at the end of the next, in 1640, the population of Plymouth Colony was 3,000; and so throve onwards.

Now, rather, take New England as a whole. Within a quarter of a century from the voyage of the "Mayflower" the Puritan emigration had brought the total number of settlers in the five original colonies up to over 25,000. And of these 5,000 had been born in New England (Fiske). An English-speaking and American-born generation—this as in Virginia was a new kind of fact in the world and one of endless significance. This lean, sinewy race threw itself with equal vigour into agriculture and sea-faring, religion and politics. Attracting the strongest fibre of native English character the Puritan colonies hardened it again and quickened it. Probably they had more continuous practical energy than any stamp of men seen up to then. By 1720, a century after the arrival of "the first hundred," the English-speakers of New England numbered about 100,000.

The Atlantic Chain of Settlements.—Meanwhile the Middle States and the southernmost Slave States had come variously into being. Pennsylvania amongst single colonies was second in strength. Along the Atlantic seaboard of the northern part of the New World, now stretched for more than a thousand miles, the English-speakers.

We must look back for a moment on the chequered interval in the mother-islands. There was no systematic self-conscious creation of Empire at any time. The French always were superior in logical plan. English ideas were as irregular as Shakespeare compared with Racine. But they left more and more room for individual initiative and free combination. They regarded colonies not only as reformatories for the evil-doing and sanatoria for the unfit—Virginia's early days suffered from this view as we have seen—but also, to quote Hakluyt himself, as places of safety, "if change of religion or civil war should happen in this realm." Religious change happened in the consciences of a very large part of "this realm" and civil war rending England nourished America.

Cromwell and the Connecting Seas.—That Civil War threw up Cromwell—"the greatest prince that ever ruled in England." This was the real turning point for English-speaking expansion. We must remember what had been taking place apart from the American mainland. Barbados and other sugar-islands had been acquired. When Jamaica was won from the Spaniards for the Lord Protector by Penn and Venables and settled soon after, England became predominant in the West Indies. This meant maritime and mercantile advance of the first order. The mighty thing was the creation by Cromwell of his new sea-power. To most foreign eyes, what could have seemed more audacious than his attempt, or more improbable than its success? The Dutch advantage at sea was overwhelming. The Puritan dictator first sought security by a project of alliance between the two Republics, the insular Ironsides providing the military arm: leaving Holland its naval supremacy. The confident Dutch declined the plan with some scorn. They did not know their man. When the struggle opened they relied, as well they might, on their wealth to outbuild him. But first he passed his Navigation Act striking at their carrying trade. Then by heroic finance, based on sweeping confiscation of Royalist estates, he launched in a few years over 150 warships; and his fleets at his death, manned by 22,000 men, had already reduced the Dutch from supremacy to doubtful equality, bound henceforward to sink slowly into inferiority. Through the two centuries and a half following, the sea-power of the English-speakers (the American Colonists playing their full part in various ways for several generations) rose to a wider mastery of the great waters than any age before had seen.

The conditions for the creation of the English-speaking world as we see it to-day were established. When in 1674 New Netherland became New York and New Jersey for good, the Dutch prospects in colonial rivalry were extinguished. But France remained and her spirited and highly organized people at that time were still four times as numerous as the English people. France would prove the formidable antagonist of the future.

III. 1674–1782: MAKING AND BREAKING OF THE "OLD EMPIRE"

Glance for a moment at the effect of these historical influences upon emigration across the North Atlantic. Every defeat or oppression of any religious cause in western Europe brought further reinforcements to the colonies. The Puritans were followed by Royalists, Catholics, Quakers; and, after the rampant orthodox reaction under Charles II., by Nonconformists of all sects. Transportation of criminals—many of whom would not be considered such under the humanized codes of our day—played its part though a minor one. When Cromwell sent the Irish to Barbados and elsewhere, they became indeed English-speakers in spite of themselves, but he set up a movement which was to have its Nemesis.

America and Mingled Immigration.—In the 18th century another factor became very notable. Penn opening his colony to all comers whatever their creed, if otherwise suitable, had drawn in already Welsh Baptists and Scoto-Irish Presbyterians. From the end of the 17th century, the emigrants from Ulster, and their kin from Scotland itself, streamed for generation after generation into North America. Their tough fibre, keen intelligence and concentrated practical energy, added a colonizing force second to none in worth. Impossible to overestimate its importance in American history. It is reckoned that at the time of the declaration of independence the Scoto-Irish and the Scots proper of similar type, formed one-sixth of the entire population—that is they were about half a million—and in the struggle they were the most vehement and unyielding of all. Already in North America, an "English-speaker" might be, and often was, something very different in blood, temperament, thought, and character from the average man of purely English race.

But this indeed was to be more and more the process of tremendous significance in America. First by thousands, and then by hundreds of thousands, and then by millions upon millions down to this day, it was to make "English-speakers" out of emigrants not derived from the "Anglo-Saxon" stock—that name itself a blurred generalization—and often having little affinity with it. The Dutch and Swedish strains had been there from old time. Germans came in numbers when Pennsylvania was opened on inviting terms, and they clung to the language and ways of their old Fatherland. Next French Huguenots came when Louis XIV. revoked the edict of Nantes. Fleeing on the contrary from Protestant oppression, the Celtic and Catholic Irish were already present though as yet not in large numbers. And the Jews had already made their appearance. When Oglethorpe founded the thirteenth colony, Georgia, as late as 1732, the settlers included Jews from most countries in Europe, but also more Germans (in great part from Salzburg, Bohemia and Moravia in the Austrian dominions) and Scottish Highlanders as well as English folk of every sort.

Yet "Basically English."—Despite all mingling and blending so far, let us make no mistake. England itself had been throughout as from the beginning the main reservoir wherefrom flowed the widening currents of American life. The pioneer race remained preponderant, no matter how deeply the numerous admixtures just described might modify the temper and traits of the social aggregate. Professor Beard puts it: "Beyond question the overwhelming majority of white people in the colonies were of English descent; the arrangement of classes was English; the law which held together the whole social order was English in essence. . . . The language of bench and bar, pulpit and press was English. . . . Whether for praise, blame or merriment, colonial America was basically English."

English-Speakers and France: the Decision (1756–1763).—For the affair of English-speaking expansion in the world the Seven Years' War was by far the largest event since the rise of Cromwell's new sea-power. With the opening of the final struggle between Great Britain and France, for the control of the whole American interior from the Mississippi Valley and the St. Lawrence to the Pacific Ocean, the issue was almost predestined. The little island at home, swarming at that time with every kind of vitality and ability—in literature, science, art as in trade, politics and arms—remained an impregnable stronghold of sea-power. The English-speakers on both shores of the Atlantic and in every field of adventure had at their head at last a leader aquiline in genius as in feature, Chatham. "England has been a long time in labour but she has brought forth a man." All put together this rising race—four-fifths of it then of the breed that made the language—were still so far exceeded by the numbers of the French in Europe that the situation always was a cause of anxiety. But France had the Pompadour at her head and Frederick the Great as well as Chatham on her hands. Above all—no single statement in this article is more enlightening—across the Atlantic, the ratio of English settlers to French was already (1756) at least twelve to one; some estimates make it as great as 15 to one, and it may have been so.

How had the relative positions of the rival colonists come to stand as it did? Long ago French enterprise had been earlier and more active in the field. There seemed no reason why that brilliant and teeming nation should not achieve colonial and maritime domination and a new world-empire. But European aims and a singular attachment to native soil forbade concentration upon overseas policy. When the power of Louis XIV. was at its zenith in the opening years of the 18th century he had less than 10,000 French-speaking subjects in North America, and even when the Seven Years' War (1756) began there were less than 100,000 in Canada.

By contrast what had been happening in the Thirteen Colonies? We have glimpses at irregular periods of the growth of their white population:

1688	200,000
1717	375,000
1756	1,150,000

If this breed was at least twelve to one in numbers, against the North American French-speakers, its resources were still larger in proportion. New York alone was more than equal in man-power to all the French settlements put together. So at the end of this World War (waged simultaneously in three continents) French aspirations were eliminated from North America in 1763, as Dutch sovereignty about 90 years before had been removed from New York. An "English-speaking world," politically undivided was established, but even now it held less than 12,000,000 English-speakers all told (while defeated France contained 20,000,000 people whose formidable possibilities were soon to shake the earth) but their position in world affairs was magnificent. The bulk of all North America was solidly in their hands; they were predominant in India; all the oceans were open to their maritime and commercial ascendancy. New England ports like Salem flourished on the India trade like the ports of Old England.

The Great Disruption as a Double Stimulus.—We must not attempt here to discuss the causes of the disruption of the Old Empire nor to follow the course of the War of Independence. France had her *revanche* at Yorktown but against the maritime coalition British sea-power in 1782 survived the deadliest of all its hours of peril; and the island retained Canada. In a very few years more, the American Union was constituted and the French Revolution broke out. The great disruption soon proved not to be a check but a stimulus in many ways to the growth of both branches of the English-speakers. In population and territories, for nearly three generations yet, and still more in commerce and wealth, the mother-island, not only unexhausted but more prolific inventive and successful than ever, was to remain preponderant. Only now began the astonishing movements which in another hundred years were to establish the English-speakers in two more continents. In the continent first settled, the progress of the new American Republic was to increase their numbers to a degree beyond imagination at that time. After the foundation of the United States, and just before the Revolutionary and Napoleonic Wars, there were in 1790 not much more than about 16,000,000 English-speakers in the world at the most, including nearly 4,000,000 in North America (but excluding those in the British islands using only Gaelic or Welsh), while there were over 26,000,000 persons to whom French was native, including its element in

Switzerland, in what we now call Belgium, in Canada, Louisiana and the West Indies. It is now convenient to divide the subject into two parts which will be brought together in a final view.

IV. AFTER 1782: BRITAIN'S REDOUBLED VITALITY

Take first the movement under the British flag. Only outstanding events and corresponding statistics need mention. The rest will be found under the heading BRITISH EMPIRE and in other articles relating to the mother-islands and to the British dominions. That the old country began to build up a new empire—in the sense of new colonies of her children, extending to shores far more distant than the trans-Atlantic seaboard—was and remains, so far as concerns increase in the number of English-speakers, the smaller part of the process. But the results are already big and still progressing, while their origins are as vivid in appeal to historic imagination as the beginnings of Virginia and New England.

New Colonies in Three Continents.—First Canada. It is estimated that after the separation of the Thirteen Colonies from the mother-country, over 40,000 American Royalists, for the most part of picked quality, went to what are now Nova Scotia, New Brunswick, Cape Breton Island and Ontario; and thus began the building up of the present English-speaking majority in the Canadian Confederation. Next Australasia—at the extremity of remoteness on the underside of the planet. A Frenchman wrote in the year of Yorktown that Captain Cook had sailed far south to redress the British loss in one continent by discovery in another. The English never were so planning. Their idea then was to keep up traditional transportation and to find fresh ground for the fruitful banishment of offenders. Instinct was true as usual. A penal settlement might grow into a colony. Accordingly in May 1787 Captain Philip with about 600 male and 185 female convicts sailed for Botany Bay but chose instead, at what is now Sydney, "one of the finest harbours in the world in which 1,000 sail of the line might ride in perfect security." More than half a century later began the settlement of New Zealand—the real *ultima Thule* of white home-making. By degrees were founded round the present island-continent of English-speakers all those colonies now joined together in the Australian Commonwealth. Meanwhile, the Mother Country had planted a community of its tongue and breed in yet a third continent—at Africa's southern extremity, annexed during the Napoleonic Wars. There in 1820, five years after Waterloo, the first British immigrants arrived. They, and those since added to them, have lived side by side with the Dutch through many vicissitudes; and though to-day they are a little less than half the white inhabitants of the South African Union, their greatest of world-languages is familiar to a majority.

We cannot mention here the dependencies—the "stepping stones" and stations strung along many shores and through all seas—where English is the official language and more or less spoken. Enough to say that to-day (within the British Empire but outside the mother-islands) in Canada, Newfoundland, the West Indies, in the Australian Commonwealth and New Zealand, in Southern Africa and more parts of that continent, and in other sundry places, there are at the hour of writing (towards the end of 1928) nearly 20,000,000 of white people to by far the greater part of whom English is native while to the rest it is a language of daily use.

Great Britain: New Numbers and Overflow.—But in the same period of nearly 150 years (1783–1928) covered by the preceding paragraphs, the development of population in Great Britain itself has been the most surprising thing ever known in equally limited circumstances of time and area. There are nearly three times as many native English-speakers in Great Britain as in all the rest of those territories—comprising a quarter of the earth and of its inhabitants—which are part of that entire British system, beyond all parallel not only in geographical range and total extent but in every kind of variety political and racial, religious and linguistic, climatic and economic. Let us look at the tables. As Great Britain and Ireland followed courses at first somewhat similar but afterwards tragically different for the smaller country, we must exhibit their statistics separately:—

	Great Britain	Ireland*
1760	8,100,000 (estimate)	2,900,000 (estimate)
1770	8,800,000 ,,	3,000,000 ,,
1780	9,400,000 ,,	3,200,000 ,,
1790	10,200,000 ,,	4,000,000 ,,
1801	10,900,000 census	4,700,000 ,,
1811	12,600,000 ,,	5,500,000 ,,
1821	14,400,000 ,,	6,800,000 census
1831	16,500,000 ,,	7,800,000 ,,
1841	18,700,000 ,,	8,200,000 ,,
1851	20,900,000 ,,	6,550,000 ,,
1861	23,100,000 ,,	5,800,000 ,,
1871	26,100,000 ,,	5,400,000 ,,
1881	30,100,000 ,,	5,200,000 ,,
1891	33,400,000 ,,	4,700,000 ,,
1901	37,500,000 ,,	4,500,000 ,,
1911	41,100,000 ,,	4,300,000 ,,
1921	43,000,000 ,,	4,500,000 ,,
1928	44,500,000 (estimate)	4,300,000 (estimate)

*Before the census of 1821 no certainty exists about the numbers of the Irish population. There are wide differences in the estimates. The figures above are suggested by the present writer on the basis of McCulloch "Statistical Account of the British Empire" (1839) and George O'Brien "Economic History of Ireland in XVIII. century" (1918).

Machine-Revolution and Swarming.—Each of these columns is of extraordinary meaning. Take the British column by itself. In 1760, while all the English-speaking peoples are still politically united, Great Britain is at the beginning of the industrial revolution. Her total population has not increased by much more than a couple of millions in a century and a half since Shakespeare's last years when the first small settlements of the race overseas had just begun in North America. (Remember that in this same year when George III. succeeded to the throne the total number of all the English-speakers overseas was also not much more than a couple of millions.) Now began that swarming of life at home which the whole of English-speaking life overseas did not for a long time overtake. The means of increase were created when machine invention began and steam as a driving-force was soon added. Town-life thickened where it never had been before. First, manufacture was revolutionized, then transport. Britain led the world in prodigious innovation. The population doubled in 50 years or so, during the earlier era of the manufacturing revolution. After that, the transport-revolution by means of railways and steam-shipping came into full swing and in another ordinary lifetime the population doubled again (from 16,500,000 souls in 1831 to 33,400,000 in 1891). In the shorter period since then, and especially under the influences of the World War, the rate of increase has slackened notably but the further absolute addition has been very large (from 33,400,000 in 1891 to 44,500,000 in 1928). Britain to-day is less in geographical size than a 30th part of the United States proper, but the number of its inhabitants is still nearly equivalent to 40 per cent of the population of the whole American Union. England, Scotland and Wales together are not quite equal in area to the States of New York and Pennsylvania put together; but in their crowded aggregate of human life, they very nearly equal the combined inhabitants of the New England States, New York, New Jersey, Pennsylvania, Ohio, Illinois and Michigan.

And yet in spite of this accumulation at home the originating island through the greater part of the period (1760–1928) dealt with in this section supplied to the United States, chiefly—in a lesser degree to Canada and Australia—millions and millions of nation-building emigrants. We shall get a clearer view of this process when examining presently the giant growth of the Great Republic.

V. IRELAND'S INCREASE, DISASTER AND EXODUS OVERSEAS

The Irish figures have an utterly different meaning both in their rise and fall. But their fall at home, terrible in its causes, was the next most powerful factor in promoting English-speaking expansion throughout the world. Here we note a curious thing. The effect of American influences on the economic and social life of Great Britain and Ireland has been enormous. The American

potato revolutionized Ireland twice, first by stimulus, then by destruction; American cotton and Eli Whitney's cotton-gin turned the old Slave States into the great source of raw material for England's chief textile industry; and, long afterwards, the flood of cheap American wheat swamped the former position of British agriculture.

The American Potato Revolutionizes Ireland.—Of these influences the most powerful historically for good and ill was the strange factor of the potato in Ireland. As every one knows it was introduced by Raleigh into his estates in the county of Cork about 1610 (when the question on the other side of the Atlantic was whether Virginia should be abandoned). Within two generations this facile product offering in good seasons a large yield from little labour became the common food of Ireland. The oppressed and neglected people, growing accustomed to the poorest nourishment in wretched mud-hovels, married young and bred rapidly—encouraged by religion as in French Canada and Italy. Shortly after the time when American Independence was won, the overgrowth of population in Ireland began to be abnormal and even startling as the figures show.

The land more and more subdivided began to swarm with small holdings and young families, more and more dependent on the potato, raised with ease and in quantity on almost any sort of soil. But it was a hazardous crop periodically subject to failure. Minor famines preceded the great one, but their warning was not learned. In 1845 the Irish population had doubled itself within the memory of many persons then living and had reached a figure of nearly 8,300,000 souls. Then Ireland was swept by a catastrophe comparable with the general calamity of the Black Death in western Europe during the 14th century and with the devastation of 17th century Germany by the Thirty Years' War. "The priesthood favoured early marriages. The Irish policy favoured subletting. Early marriages and sub-letting combined made for an over-rapid increase of population. . . . Nearly three and a half millions of the people lived in mud-cabins, badly thatched with straw, having each but one room and often without a window or a chimney" (Right Hon. Sir James O'Connor, *History of Ireland, 1798–1924*, pp. 275–282). In these circumstances of life on the margin of subsistence with no resource in an evil day, the terror came like the potato itself from the other side of the Atlantic. The terror was the disease soon known as the blight, turning in a few days the expected food to rottenness.

The Blight and the Flight.—The blight first appeared in America in 1844. The year after, it attacked all western Europe. Twelve months later, in the black summer of 1846, it destroyed utterly the food-basis of the majority of the Irish peasants on their crude little plots. Probably the population had reached its maximum on the eve of inconceivable ruin and may have numbered very nearly eight and a half million. The sequel was exodus. Within one decade afterwards a quarter of the whole Irish people as numbered before the blight—that is to say over 2,000,000 souls—emigrated, mainly to the United States. That outpouring did not cease. In the two generations between the Great Famine and the World War well over 5,000,000 emigrants quitted Ireland—an enormous number relatively to so small a country—and nearly four-fifths of them, with all their promise of large posterity in any new home, took ship for the United States. Many of them, especially in the original years of the great flight, were Gaelic-speaking.

Thus by strange fortune the Irish disaster played a great part in English-speaking expansion.

But Total Irish Emigration much less than British.—Still it was not the main part. Great Britain itself, the mother-island of the language, the law, the systems of popular government, the machine-revolution and the sea-power, still sent out overseas the largest nation-building forces, though not so large a proportion of them went to the United States. Great Britain continued to increase while Ireland diminished. If Irish emigration in the whole century between the end of the Napoleonic wars in 1815 and the outbreak of the World War in 1914 amounted to something more than a total of 5,000,000 souls, the number of English and Scotch emigrants, with the small Welsh contingent was well over 9,000,000. Most of them were the pick of the stock. Agriculturists and artisans, they left their native fields and towns to "better themselves" as the word went. After the close of the American Civil War the Irish Celtic emigrants soon ceased to be in a majority. By comparison the English and Scotch settling overseas outnumbered them more and more thenceforward—by two to one for instance in the decade 1871–81, by three to one in the couple of decades thereafter, and so onward in rising proportion. There has been nothing at all in history like England and Scotland together as a reservoir of human vitality maintaining at home on an area considerably less than half the size of France a ceaseless increase of population, yet as ceaselessly supplying streams of life to those new nations across the ocean whereof one has become far mightier than the mother.

VI. 1790–1928: GROWTH AND TRANSFORMATION OF THE UNITED STATES

We turn now to that unparalleled factor which in relatively recent times has advanced by leaps and bounds the numbers of the English-speakers (multiplied owing to the absorption of masses of other breeds) and has raised them to their present predominance in white civilization. That factor has been the growth, during the 19th century and since, of the United States, where reside to-day nearly two-thirds of the whole aggregate of nearly 200,000,000 using the same great language. But for this, the present vogue of that tongue would not have existed. When George Washington died in 1799 the total of English-speakers in North America was about the same, a little over 5,000,000, as in England when Shakespeare died. By 1928 the number had risen in the American Republic alone to over 120,000,000. It is of extreme importance to realize clearly by what variety of racial contributions this enormous aggregate has been so rapidly created.

America's Thirty-fold Increase.—For convenience, let us take first a statistical view of the American process corresponding to the figures previously given for Great Britain and Ireland. The population of the United States from its federal beginnings mounted up decade by decade until our own time in the following manner:—

1790–1928: Population of the United States

1790 . .	3,929,214	1870 . .	38,558,371
1800 . .	5,308,483	1880 . .	50,155,783
1810 . .	7,239,881	1890 . .	62,947,714
1820 . .	9,638,453	1900 . .	75,994,575
1830 . .	12,866,020	1910 . .	91,972,266
1840 . .	17,069,453	1920 . .	105,710,620
1850 . .	23,191,876	1928 (end)	121,000,000
1860 . .	31,443,321		

Nothing like this 30-fold increase in little more than four generations has ever been known. The interacting causes, American and European, political and economic, are so various and complex, that not all of them can be examined here. The chief forces are evident and some of them already have been explained in the preceding sections.

Before Mass-Immigration.—Most evident in the first half-century (1790–1840) after the American Union was constituted, was the increase in the native-born stock which seems to have more than trebled itself in the period. The westward movement, from the Atlantic fringe to the Mississippi and beyond to the Pacific coast, was only beginning; the scope for fresh settlement and enterprise unbounded. But, for reasons beyond the scope of discussion here this rate of reproduction by the American-born did not continue. Immigration became the greatest developing force towards the middle of the 19th century—that is at a time well-recollected by many persons still living when the present century opened.

Influx and Assimilation.—It is supposed that from the end of the War of Independence to 1830 less than 400,000 immigrants altogether entered the United States of America. They were a minor though increasing factor for yet another decade. After that, the deluge. The movement in the mass is best shown in tabular form over-leaf:—

1830–1928: Immigration into the United States

1831–40	600,000
1841–50	1,700,000
1851–60	2,600,000
1861–70	2,300,000
1871–80	2,800,000
1881–90	5,300,000
1891–1900	3,800,000
1901–10	8,800,000
1911–20	5,500,000
1921–28 (lowest estimate)	3,200,000
Total	36,600,000

From this prodigious influx in less than one century, perhaps over two-thirds of the existing white population of the United States are mostly or partly derived.

There we touch on the most extraordinary part of the subject. The United States became a machine for turning foreign-speakers by millions upon millions into English-speakers. This meant a profound change from the time when the constitution was adopted and the American Union established. Then 90 per cent of American whites were of British race and 80 per cent of the English race proper. Remember well, that in the period covered by the table above the immigrants into the United States from England, Scotland, Wales and Northern Ireland—the elements strictly called British—have been less than an eighth of the whole. Those from Catholic Ireland have been somewhat more than an eighth. The whole number from the British islands has been little more than a quarter of the entire mass of arrivals into the American Republic from other countries during the last hundred years.

German and Norse Comers (as in Saxon England).—The bulk of that mass, nearly three-quarters of it, came from all the regions of Continental Europe and ultimately from the races least akin to the earlier America-making type. But for a long time this latter aspect did not appear. For after the new epoch of mass-immigration was opened by the Irish famine in 1846 the next great reinforcement was the German; distinctive but related; harmonizing quietly and well with the original north European elements. We have seen that the infiltration of this great race began in the 17th century. It went on through the 18th century. The German strain practically counts as one of the original elements in the United States. Already in 1790 it was 6 per cent of the whole. It was reinforced by a slowly enlarging flow until the 19th century was nearly half through. Then German migration to America became a sweeping tributary. First, the potato blight appeared in Germany as in Ireland and was accompanied by bad harvests generally. Next, after the revolutionary idealism of 1848, came crushing political disillusionment, and industrial depression. Between 1845 and 1875 over 2,000,000 born German-speakers went to the United States (including those from Austria). Over two and a half millions more followed during the next 20 years (1875–1895). In the middle of this period the flow was at its fullest. In the next period of nearly 20 years (1895–1914) Teutonic emigration diminished very rapidly. By comparison with its former volume, it became a trickle of no relative importance. Nevertheless, it added by degrees another half-million arrivals to their kindred, in the United States. The total German inflow into the English-speaking Republic from 1845 to the outbreak of the World War, was fully equal to the Irish though it reached its height later and fell off more abruptly. Scandinavian emigration meanwhile was a strong secondary movement always, and in the last two decades of the old pre-war order in Europe became stronger than the German. This was no new kind of thing in the world. Norse immigrants though they came into the old islands blade in hand had been merged with English-speakers of the pre-Conquest sort, a thousand years before.

Economic Interactions between America and Europe.—The economic and psychological interactions between Europe and the new continents would deserve a volume. We have seen how Raleigh's potatoes twice changed, and changed out of recognition each time, the social state of a whole nation, Ireland. When Eli Whitney invents the cotton-gin there is a potent stimulus to American supply of raw material; equally this develops Lancashire manufacture on the other side; textile progress in Britain further stimulates in the southern States, production and slave labour. But British invention itself acts with revolutionary effect in every field of industry and transport. James Watt and George Stephenson introduce into the world steam-power and the railway. These two things in the end do more than anything else to open up the United States interior, to knit the Republic together from ocean to ocean, to unlock its resources, to multiply its people and transform its aspect. Is wheat-growing extended by railway construction financed by British loans? Then, an inundation of American wheat-imports soon has a swamping effect on the old conditions of insular agriculture. The effect of this is to send British emigrants in far larger numbers overseas. When the United States is unusually prosperous European emigration generally is stimulated; but it is also increased when Europe suffers from economic depression. In that continent the effects of these economic interactions added to the political and religious factors went deeper and deeper. They first influenced western Europe; then Germany and the centre; and then reached the south and the east.

"The New Immigration" from South and East Europe.—From this furthest effect a complete transformation of the racial influx into the United States was to come. And its volume was swollen while its character was totally altered. This movement in its heavy proportions began towards the end of the 19th century and went on with cumulative effect until the World War. It pumped into the arteries of the American people a full infusion of blood from southern and eastern Europe. The eventual results upon the temperament and mentality of the whole nation cannot yet be measured; but what more immediately concerns the present subject is that this novel kind of absorption meant another stage in the creation of still more millions and millions of English-speakers out of the most dissimilar varieties of foreign elements.

For nearly 20 years after the close of the Civil War the percentage of south Latin and Slav blood in the total of annual immigration was relatively small though increasing. In the '90s it became strongly predominant; and in the 20th century became three-fourths of the whole. Take first the new Latin arrivals. In 1871–80 only 50,000 Italians entered the United States; in 1881–90 there were 300,000; in 1891–1900 over 650,000; in 1901–19 nearly 3,000,000. The aggregate of the arrivals from the Slav speaking countries, Russia, Poland, Lithuania, Czechoslovakia, Eastern Galicia, Yugoslavia, showed a parallel rise but was still greater. Add the other racial elements from south-eastern Europe —Greeks, Magyars, Rumanians and the rest. Altogether in one quarter of a century, the "new immigration" poured in more millions than British, Irish and Germans together had brought over in the previous generation. And the latest elements were for various reasons—during some considerable period at least, bound to increase faster on American soil than any of the rest.

VII. A GENERAL VIEW OF ENGLISH-SPEAKING LIFE

We must now indicate in broad figures the whole sweep of expansion which has created this English-speaking "world." But first it will be convenient here to show the growth of the British self-governing dominions overseas, adding the smaller elements in the West Indies and other scattered possessions. The estimate is complicated by the need to make allowance for the French in Canada, and the Dutch in South Africa—Australia and New Zealand being as much British, and as mainly English, by descent as were the people of the United States up to the middle of the 19th century.

White Population. Canada, Australasia, South Africa, etc.

1800	(less than) 500,000
1825	(nearly) 1,000,000
1850	2,500,000
1875	7,000,000
1900	11,000,000
1928	(nearly) 20,000,000

Of this latter number there are about three millions whose native or preferred speech is French or Dutch. Many of these also use English familiarly. It may be remarked in passing that there are

still 200,000 people even in the British islands who know no English but speak only Gaelic, Erse or Welsh.

The Rise to Nearly 200,000,000.—Now we can take together the mother-islands, the United States, the British self-governing Dominions, with small additions for other territories thinly settled and for all islands, outposts and administered regions. The Pisgah sight of the whole appears thus:—

1600–1928: General View of the Increase of English-speakers

1600	5,500,000
1700	8,000,000
1800	19,000,000
1825	32,000,000
1850	51,000,000
1875	82,000,000
1900	128,000,000
*1928 (about)	190,000,000

*United States 121,000,000; Great Britain and Ireland 49,000,000; rest of the British Empire nearly 20,000,000.

To appreciate this table we must recollect the comparison not only with French (necessarily drawn into reference in former passages) but with other races. Even a hundred years ago English, so far from being as now the foremost, in extent of use amongst the languages of white peoples was only fourth in that list. Russian-speakers probably came first (counting subdivisions but disregarding the subject races of the Tsardom) rising towards 40,000,000. French-speakers (including those in Belgium, Switzerland, Canada) were second with nearly 35,000,000. Germans were a close third with some 34,000,000 (adding those in Austria and Switzerland). While below the latter figure was the number in the world (excluding those speaking Gaelic or Welsh only in the British Isles) to whom English was a mother-tongue. Now, the latter is easily first with its 190,000,000 of native and newly incorporated speakers; Russian second with over 130,000,000; German third with nearly 80,000,000; Spanish fourth with some 60,000,000; and French fifth with about 50,000,000 counting its coloured speakers in the colonies of the Republic as well as its speakers by race in Belgium, Switzerland and Canada.

In addition, there are some millions of civilized persons in other nations to whom English is almost as familiar as their own tongue; and it is used by more millions amongst the native populations under the British flag. Thus it is safe to say that this leading world-language which grew so slowly that even up to the beginning of the last century it was fourth on a list of comparative numbers of persons speaking European languages, has multiplied itself tenfold since then and is now well-known to more than 200,000,000 persons altogether.

Wider Spheres of Influence.—And here open still wider considerations. The vogue of the language is exceeded by relative positions and responsibilities in other respects. Between them, the English-speaking communities in politics either control or predominantly influence nearly half the land-area of the whole earth and much more than a third of its entire population—variously estimated at between 1,800,000,000 and 2,000,000,000. Jointly they hold the absolute supremacy of all the oceans. They decided the issue of the World War. They created the League of Nations, though the United States afterwards withdrew and stands apart. But none the less the Washington Government by the Kellogg Pact has induced all civilization to denounce war—except in self-defence or against direct aggression on established spheres of influence—as an international crime worthy of outlawry.

Britain in Asia and Native Africa.—In India and beyond a handful of trained British administrators organize or supervise the government of 325,000,000 Asiatics; and in the Dark Continent, the government of over 60,000,000 Africans including direct or indirect responsibility for the whole length of the Nile from its equatorial lakes to Egypt; while the Palestine mandate in the same experienced hands makes the Zionist hope possible. As well the original islanders control in many seas a thousand other islands, amongst them Singapore and Hongkong which were nothing when occupied and are now amongst the densest seaports in the world. Where this administration has advanced amongst coloured races numbering a fifth of the human species, roads and railways, harbours and irrigation, posts and telegraphs, have followed as a matter of course; but also social security, legal justice, religious freedom, educational progress, newspapers, ideas of liberty, and, above all, medical services and sanitation. The new experiment in Indian self-government by representative institutions, is a thing of measureless interest. Whatever happens in the future, the story of organization in Asia and Africa by handfuls of English-speakers will remain one of the legends of history.

The Co-Nations.—Yet all this is but part of the tale. Nearly two-thirds of the territories included in what is called the British Empire are not an empire, but the very opposite. They are not under any central control whatever. The British self-governing dominions overseas are rather less restrained by the mother country than is South America by the Monroe Doctrine. Great Britain and Northern Ireland, the Irish Free State, Canada and Newfoundland, Australia and New Zealand, the South African Union, are an association of free and equal Commonwealths held together by tradition, by good-will and good-judgment but above all by the extent of their liberty.

The United States and its Orbit.—Next, turn to the American Union which includes nearly two-thirds of all the English-speakers. It is in many ways as different as possible from the other system just described. The Republic is as consolidated as the Empire is dispersed. The former occupies half a continent with two long fronts on two main oceans. It is in itself by far the mightiest single nation. It has applied machine-power and raised average human prosperity with unexampled success. Its available wealth is practically equal to that of all Europe put together—if Europe could be put together. America produces over 20 per cent of the world's wheat, over 40 per cent of its coal, over 50 per cent of its copper, nearly 60 per cent of its cotton, fully 60 per cent of its steel and over 70 per cent of its oil. Based on her massive gold-reserves she has become the chief creditor nation. Nowhere and at no time has civilization seen anything like this position relative to other countries. But just as in the case of the original island though in a different way, America's political orbit is far larger than her own extent. North and south in the double-continent of the New World, she predominates in fact—however considerate may be the formulations of the Monroe Doctrine—over an area larger than that of the entire British Empire. As already suggested in passing, her power of influence over the South American nations is greater than Britain's power of influence over the self-governing co-nations of the British Empire.

Republic and Empire.—Where so many things in all this study are either unlike other recorded movements of races and languages or utterly exceed them in measure, another extraordinary thing is the existence side by side of two systems, each so gigantic in different ways as the American hegemony and the British Empire under English-speaking leadership. The Republic with all its racial admixtures is by no means so miscellaneous as is the Empire with its extreme range of geographical distribution and its bewildering variety of human composition.

VIII. TOWARDS 300,000,000: THE FUTURE AND ITS PROBLEMS

Since this English-speaking situation in the world would be inconceivable if it did not actually exist, can we speculate usefully upon the prospects and problems of the future? In spite of the American Immigration Laws of 1921 reducing in a drastic way the influx from southern and eastern Europe, it is generally assumed that the population of the United States alone will be about 150,000,000 by 1950 and over 200,000,000 by the end of the century. The British islands seem likely before very long to become stationary at a limit of about 50,000,000. Though nothing like the rate of multiplication of English-speakers in the 19th century seems likely to occur in the future, it is reasonable to assume that their aggregate will reach over 300,000,000 by the end of the 20th century. It would seem that of white races only the Russian-speakers have some chance—by no means necessarily a sure chance—of ultimately attaining equal numbers.

Anglo-Americanism is not Anglo-Saxonism.—A main

question, therefore, for the world, and perhaps its principal question, is whether the English-speaking communities will prove capable of pursuing in the greatest matters concerning them and all mankind a common world-policy. Will settled friendship prevail or will friction increase? Concord or discord? Upon the answer everything may depend for the better or worse course of general civilization. In the last few years relations have not been satisfactory nor can it ever be easy to make them perfect. To distinguish between speech and race—Hindu orators for instance, like orators before them, have an unapproachable fluency in the English language for agitation against English rule—is as we saw at the outset, an elementary business of the modern historian. The common language of the English-speaking world expresses many profound diversities of race, temperament and thought; of historic imagination and present political sympathy. In face of these facts the old "Anglo-Saxon" theory has been for many years not only obsolete but prejudicial. A much broader basis of intelligence and appreciation is required. In America or Australia an ordinary citizen of Irish-Celtic descent may cease in reason to cherish the former bitterness of the old feud but cannot be expected to feel a positive pro-British instinct. It is natural for an American of German blood to think of Germany with sentiments of affection and romance. And so with other millions of Italian or Slav blood in the American Union. They have like those of British origin, but usually more so, their own cults of ancestor-worship, and the mother-island plays no part in their dream. Yet all these necessarily are English-speakers.

Sea-power and Sea-law.—These variations of feeling are apt to accentuate any political disagreement or misunderstanding that may arise from time to time between Britain and America. There has been no war between them for well over a century, and this again—considering how obstinate are apt to be the quarrels of kinsmen—is one of the more significant and encouraging facts of modern history. For, controversies have been recurrent, sharp and sometimes dangerous. Under past conditions of contact phases of friction were inevitable; but we are all prone to forget how much they have diminished in frequency and severity. The chief matter of practical difference has been that of naval power and maritime law—as we might well expect since the seas are the common pathway for the traffic and trade and personal voyages of all English-speakers; and this question, owing to the epochal events and changes of recent years, has become all-important for their present and future relations.

From its beginning the American Union has urged the largest rights of neutrals to trade freely upon the high seas in time of war. The island depended for its life upon the utmost use of sea-power as against land-power. This controversy led to the last armed quarrel in 1812. During the American Civil War the maritime controversy in another form became threatening again, but was settled for the time by a memorable arbitration heralding the best hopes of to-day. After the outbreak of the World War the British blockade, the only means of preventing the triumph of the Central Empires, made the maritime tension so acute that if German policy had been more judicious, the United States, possibly, might have declared against the Allies. Even when President Wilson was their Associate he demanded amongst his Fourteen Points, the Freedom of the Seas and made it plain that America otherwise must proceed to create a fleet strong enough to assert in all circumstances her own freedom. The British preferred the latter alternative formidable as it was, for the sound reason—peace being still insecure—that the former might have left them at a deadly disadvantage against military possibilities in Europe and Asia. Accordingly, the American fleet was developed with the purpose of making it second to none.

Naval Parity and its Implications.—The Washington Conference of 1921 thus became the most momentous deliberation that had ever affected simultaneously all the English-speaking peoples. Britain ceded her majestic tradition of separate sea-supremacy and accepted the principle of naval equality with America—the United States, in the new international spirit, renouncing the power they possessed of creating a naval dominance of their own. None the less, dispute gradually arose as to the technical arrangements required to realize in fact, without injustice to either side, the accepted theoretical parity. It became active in 1927 at the abortive Geneva Conference on the subject—acutely touching certain types of cruisers—and remained more or less unpleasant down to the end of 1928. Then American opinion having rejected larger propositions of naval increase favoured Mr. Coolidge's recommendation to build 15 large cruisers for parity. British opinion was equally resolved not to enter upon any competition in naval armaments with the United States.

In any case American parity will exist in strength and practice. This, as a result of the late War, is the largest world-change of its kind since Cromwell. It means two very different things. On the one hand, the British navy alone cannot determine future sea-law. Britain cannot have more right to interfere with American commerce than America with British commerce; and thus the way is open and wide towards such a revision of sea-law as shall remove the old cause of difficulty and the last remaining danger to the future of English-speaking relations. Happily this course seems pretty sure to be taken. For on the other hand, their joint sea-power while they remain in amity is far greater than ever and more deeply secured. The British islands can accept the "freedom of the seas" now that the rise of the American navy places a double-guarantee behind it. Far more than ever, for the old land with its industrial democracy under universal suffrage, "peace is the greatest of British interests"; and apart from that, nowhere is the idealism of peace more earnest and profound. But if the hope of world-peace were frustrated, then under the new sea-law which naval parity implies and demands, America even as a neutral would be the sure source of the sea-supplies that are Britain's life.

IX. THE KEY OF THE WORLD

Upon the degree to which the two peoples may be at one or at odds the future of mankind evidently will depend more than upon any other political influence for generations to come. Since the days of the old exclusive "Anglo-Saxon" fallacy, suggesting a unity of race such as long since ceased to exist, exaggeration in the usual way has swung over to the other extreme. Of late years, it has become a fashion to emphasize and overcolour the modern contrasts between the mother-island and the United States.

The Theory of "Foreigners": its Exaggerations.—It is frequently said indeed that the American and British nations have become permanently "foreign" to each other. This vivacious paradox will not last. Not only is it as we have seen a sweeping falsification of history; but it is a distortion of relative values; and makes a part of the facts greater than the whole. You might as justly say that the German Reich and German Austria are foreign to each other. The essential characteristic of "foreignness" as between two peoples is that they are in the mass mutually unintelligible. In the far end, a common language, whatever the original racial varieties of those who speak it, makes for common sympathies. This very process made Great Britain itself. Those, for example, of German or Italian descent amongst the citizens of the United States have every claim to be proud of their derivation and to feel with their races on the other side. But those mainly of British descent, the largest and strongest element in North America, are assuredly not less qualified to be proud of their names and origin; and to say with Wordsworth:—

> ". . . we are sprung
> Of earth's best blood, have titles manifold."

Theirs is the main blood of the makers of America. From them came the foundations, the framework, the Constitution and the laws, no less than the very language, without which, and its absorbing influences, the unity of the American nation itself, despite all its modern mingling of nations, could by no possibility have been preserved.

The Real Community.—In America as in Britain, English will continue to be the language of life, of publication, of education. Numberless little usages of words and phrases, peculiar to one side or the other cannot alter this movement. An English artisan picks it all up very rapidly after landing in the United States. To-day as formerly, American literature at its best often prefers to show an English style of fastidious purity, yet vital,

untouched by imitative pedantry. The English-speakers of any of the sea-spread communities can enter anywhere into full private intercourse at once. They can read at once each others' books and newspapers. Between the masses of any truly "foreign" nations none of this is possible. There is far more community than "foreignness" in the English-speaking world. Modern invention as it increases all the facilities for intercourse and knits new practical ties of all kinds tends to increase that community. Despite the breadth of the ocean there are countless private friendships between American and British individuals. Between many of them indeed, it is "the genius of friendship."

This Hope, or None.—For over a hundred years all pessimistic or interested expectations of a breach between the two peoples have been frustrated. They have eliminated many worse causes of friction than any recently arisen. They have settled amicably maritime broils, fishery disputes, boundary disputes. The poison has been extracted from the old sting of the Irish question. Now, their further and lasting agreement is indispensable to the other great hopes of mankind. If Britain and America with the same great mother-tongue in common, with so many similarities in democratic institutions and social ideas, with all their practical ties and human intimacies—if these two proved unable to set an unbreakable example of good understanding, there could be no rational hope that other nations truly and completely "foreign" to each other would appease their feuds and learn instead to live in creative harmony. With their numbers, their prospects of further growth, their command in effect of nearly half the earth's surface and more than half its resources at present available, with their power over all the seas—the English-speaking peoples, and these alone, have in their hands for good or evil the key of the world's destinies. By discord pushed to the worst they could bring about universal chaos followed by a new Dark Age such as some thinkers in continental Europe imagine. By concord they can ensure by degrees disarmament, mediated settlements, and peace for long generations, perhaps for ever. Their past has been very great, but if—as the signs on the whole strongly promise—they are true to the duties of their opportunities the greatest epochs of their history are yet to come. (J. L. G.)

BIBLIOGRAPHY.—*See* references at end of articles on GREAT BRITAIN, BRITISH EMPIRE, the different British Dominions, and the UNITED STATES. *See* also John Fiske, *Beginnings of New England* (1889), *The American Revolution* (2 vols., 1891), *Dutch and Quaker Colonies in America* (1899) and *New France and New England* (1902); C. P. Lucas, *Historical Geography of the British Colonies* (2nd ed., R. E. Stubbs, 1925); G. A. T. O'Brien, *Economic History of Ireland in the 18th Century* (1918); J. O'Connor, *History of Ireland, 1798–1924* (1925); C. A. Beard and M. R. Beard, *The Rise of American Civilization* (1927); also *The Cambridge Modern History*, especially vol. vii.; and articles "Auswanderung" and "Bevölkerungswesen" in *Handwörterbuch der Staatswissenschaften* (8 vols., Jena, 1924).

ENGRAVING. In its widest signification, engraving is the art of cutting lines or furrows on plates, blocks or other shapes of metal, wood or other material. In this sense the craft has been used for decorative purposes from remote antiquity. In the narrower connotation with which this article is concerned, *i.e.*, engraving for the sake of printing impressions on paper or allied fabrics, the art cannot be traced back before the Christian era. By a transference of terminology, illogical but stereotyped by usage, these impressions or prints are also called engravings. In the still more limited signification of line-engraving, the art does not go back before the first half of the 15th century.

The term is used, however, in a looser sense to include all the methods of engraving, cutting or treating plates, or blocks of metal, wood or stone, for printing impressions. These methods can be classed most conveniently as: (1) *Relief prints;* (2) *Intaglio prints;* (3) *Surface prints,* according as to whether the black line of the design (*i.e.*, the part inked for printing) on the original block, plate or stone is (1) in relief, (2) in intaglio (*i.e.*, cut into the surface), (3) on the surface (*i.e.*, on a level with the rest of the surface).

These divisions correspond roughly to (1) *Woodcut and wood-engraving;* (2) *Engraving and etching on metal;* (3) *Lithography;* each class requiring a different kind of printing.

Woodcut, the earliest of the methods used for making prints, as far as records are known, whether in the East or in Europe; the furrows on the block are cut by a knife, and it is only in its later development that the graver replaces the knife, being used on sections of box-wood instead of a softer wood in the plank.

In the East the earliest certain date of a picture printed on paper from a wood-block occurs in a Chinese work, the *Diamond Sutra* Roll of A.D. 868 (Stein collection, British Museum), but this shows an art already in considerable development. In Europe the printing of wood-blocks on textiles was a frequent practice in the middle ages, but impressions on paper hardly date before about 1400.

The earliest *line-engravings* were probably printed a few decades later; the first dated example belongs to 1446. Line-engraving was certainly developed by the goldsmiths, having a particularly close relationship to niello work, though Vasari errs in referring the actual discovery to the Florentine niello-engraver, Finiguerra.

Etching, in which the furrow is not cut, but bitten (etched, eaten) by acid, was not practised until about 1500, the earliest dated etching belonging to 1513.

Dry-point, in which the plate is scratched with a steel point like a pencil; used occasionally from the end of the 15th century, but not to any large extent until Rembrandt's time; it has constantly been used since by etchers, either purely or in combination with etching.

Mezzotint, the earliest of the processes to aim at purely tonal effects, was discovered by Ludwig von Siegen about 1642, and practised with the greatest brilliance in the later 18th century for the reproduction of Reynolds and contemporary portrait painters.

Aquatint, another tone process, wherein the grain is achieved by etching through a porous ground, is generally supposed to have been introduced by J. B. Le Prince about 1768, though occasional examples of a similar grain may be quoted at an even earlier period than that.

Stipple, another method introduced about the middle of the 18th century, is obtained by a system of dots, first etched and then finished with the point of a curved stipple graver. A system of dots, obtained by various means such as roulettes, is also the basis of *crayon-engraving,* which imitates the character of a crayon drawing. It was the immediate forerunner and constant companion of stipple.

Many of the intaglio methods already described are occasionally found in combination on the same plate: such as line-engraving on the basis of an etched foundation (particularly in the 18th and 19th centuries); etching touched with dry-point; aquatint combined with various forms of crayon-engraving, especially by the colour engravers of the 18th century. Line-engraving, etching and other intaglio methods are sometimes found combined with woodcut or wood-engraving, notably in certain 17th and 18th century chiaroscuro engravings, and in Baxter's colour-prints in the 19th century.

Lithography was introduced by Aloys Senefelder about 1798. It may be regarded as the most direct method of imitating the character of original chalk drawing, but it possesses qualities of its own which justify its position apart from the multiplication of designs.

The following notes deal with general matters relating to engraving and prints:—

Original Engraving (etching, etc.) does not imply the original plate (block, etc.), but any print of which the engraver is his own designer.

Impression is the term applied to any print from block, plate or stone.

State signifies a stage of development in an engraving. An artist often takes impressions (or proofs) of his work at various *states* of an engraving.

Counterproof is a proof taken, not from the original plate, but from a wet impression, with the purpose of obtaining a picture in the same direction as the original plate, generally to aid the engraver in making corrections or additions to his copper.

In view of the common misconception that engraving invariably implies reproduction (for the multiplication of an original design

by engraving must be clearly distinguished from an engraving which reproduces the work of another artist), it is necessary to emphasize the importance of engraving in its various manifestations as a medium of original expression, constantly appreciated and used for the sake of its own inherent and varied qualities by many of the greatest artists from the 15th century onwards.

(*See* Woodcut and Wood-engraving, Line-engraving, Etching, Dry-point, Mezzotint, Aquatint, Stipple and Crayon-engraving, Lithography, Glass-prints, Monotypes, Printing of Engravings, Colour-printing.)

Bibliography.—*Guide to the Processes and Schools of Engraving*, issued by the British Museum. (A. M. H.)

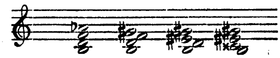
ENGROSSING, a term used in two legal senses: (1) the writing or copying of a legal or other document in a fair large hand (*en gros*), and (2) the buying up of goods wholesale in order to establish a monopoly and sell at a higher price. Engrossing and the kindred practices of forestalling and regrating were early regarded as serious offences in restraint of trade, and were punishable both at common law and by statute. They were of more particular importance in relation to the distribution of corn supplies. The statute of 1552 defines engrossing as "buying corn growing, or any other corn, grain, butter, cheese, fish or other dead victual, with *intent to sell the same again.*" The law forbade all dealing in corn as an article of ordinary merchandise, apart from questions of foreign import or export. The theory was that when corn was plentiful in any district it should be consumed at what it would bring, without much respect to whether the next harvest might be equally abundant, or to the immediate wants of an adjoining province of the same country. The first statute on the subject appears to have been passed in the reign of Henry III., though the general policy had prevailed before that time both in popular prejudice and in the feudal custom. The statute of Edward VI. (1552) was the most important. Any one who bought corn to sell it again was made liable to two months' imprisonment with forfeit of the corn. A second offence was punished by six months' imprisonment and forfeit of double the value of the corn, and a third by the pillory and utter ruin. Severe as this statute was, liberty was given by it to transport corn from one part of the country to another under licence of men of approved probity, which implied that there was to be some buying of corn to sell it again and elsewhere. Practically "engrossing" came to be considered buying wholesale to sell again wholesale.

"Forestalling" was different. Statutes were directed against dealers who bought or contracted for corn and other provisions, and spread false rumours in derogation of the public and open markets appointed by law. The statute of Edward VI. was modified by many subsequent enactments, particularly by the statute of 1663, which declared that there could be no "engrossing" of corn when the price did not exceed 48*s.* per quarter, and which Adam Smith recognized, though it adhered to the variable and unsatisfactory element of price, as having contributed more to the progress of agriculture than any previous law in the statute book.

In 1773 these injurious statutes were abolished, but the penal character of "engrossing" and "forestalling" had a root in the common law of England, as well as in the popular prejudice, which kept the evil alive to a later period. In 1844, all the statutes, English, Irish and Scottish, defining the offences, were repealed and with them the supposed common law foundation. In the United States there have been strong endeavours by the Government to suppress trusts and combinations for engrossing. (*See* also Trusts; Monopoly.)

See J. S. Girdler, *Observations on Forestalling, Regrating and Ingrossing* (1800); D. Macpherson, *Annals of Commerce* (1805); W. Cunningham, *Growth of English Industry and Commerce;* W. J. Ashley, *Economic History;* Sir J. Stephen, *History of Criminal Law;* Murray, *New English Dictionary.*

ENHARMONIC, a musical term having more than one meaning. In its earliest use it was applied to one of the three genera in ancient Greek music, viz., the diatonic, the chromatic and the enharmonic, the last-named containing intervals smaller than a semitone, termed dieses. In modern usage it is employed in such terms as "enharmonic modulation," "enharmonic notation," and the like, when, in consequence of the adoption of equal temperament, what are actually two different notes, *e.g.*, C sharp and D flat, are treated as one and the same. Thus in the following example, illustrating how a chord can be enharmonically altered, the notes as actually sounded on the pianoforte are the same in each instance, but in consequence of the altered notation each chord is, harmonically considered, entirely different and belongs to a different key:



To which it should be added that an enharmonic change of notation may also be adopted for simple convenience of performance (*i.e.*, to avoid a multiplicity of sharps or flats) and without any modulatory purpose. (*See* Harmony; Modulation.)

ENID, a city of Oklahoma, U.S.A., 65m. N.W. of Oklahoma city; the county seat of Garfield county. It is on Federal highways 64, 164 and 81; has an air port; and is served by the Frisco, the Rock Island and the Santa Fe railways. The population was 16,576 in 1920 (94% native white), and was estimated locally at over 31,000 in 1928. It is the leading grain market of the State, and the general trade centre for a rich agricultural district, producing chiefly grain, live stock, alfalfa, milk, poultry and broom corn, and for the oil and gas fields in the eastern and southern part of the county. It has railroad shops, terminal elevators (capacity 3,000,000bu.), oil refineries, flour mills and meat-packing plants, a milk condensery and factories making agricultural implements, tractors, threshers and wire. The output of the factories within the city in 1927 was valued at $10,000,000 and included 6,000,000 lb. of butter. Enid was founded and incorporated in 1893.

ENIGMA, a riddle or puzzle, especially a form of verse or prose composition in which the answer is concealed by means of metaphors. Such were the riddle of the Sphinx and the riddling answers of the ancient oracles. The composition of enigmas was a favourite amusement in Greece and prizes were often given at banquets for the best solution of them (Athen. x. 457). In France during the 17th century enigma-making became fashionable. Boileau and J. J. Rousseau did not consider it beneath their literary dignity. The word is applied figuratively to anything inexplicable or difficult of understanding.

ENIMAGAN, an independent linguistic stock of South American Indians, so called from the Enimagas (Enimas) who were one of its best known tribes. The area occupied by these tribes in south-eastern Bolivia in the northern Chaco extends from the Paraguay river between 22° and 20° S. lat. northwestward to about 62° W. long. The more important tribes of the stock to-day are the Lenguas (*q.v.*) and the Guanas, the latter to be distinguished from the tribe of the same name in the Brazilian province of Matto Grosso, who are of Arawakan (*q.v.*) stock. The Enimagan tribes were originally a semi-nomadic, hunting and fishing folk, living in communal reed thatched huts often as much as a hundred and twenty feet long. Woollen or cotton mantles formed their ordinary dress, together with short kilts of the same material. The bow was their main weapon. They were good canoemen, and made a serviceable but rather crude pottery. The tribal chiefs were usually hereditary, but had little power. The dead were buried in shallow graves.

See G. Boggiani, *Compendio de etnografia paraguaya moderna* (Revista Inst. Paraguay, vol. iii., pp. 141–189); L. Kersten, "Die Indianerstämme des Gran Chaco, etc." (*Internat. Archiv für Ethnographie*, vol. xvii., pp. 1–75).

ENKHUIZEN, seaport in the province of North Holland on the Zuider Zee, and a railway terminus, 11½ m. N.E. by E. of Hoorn, with which it is also connected by tramway. Pop. (1927) 8,852. Enkhuizen has examples of domestic architecture from the 16th and 17th centuries, when it was an important and flourishing city. Some ruined gateways such as the Dromedary (1540) which overlooks the harbour are still standing. The Zuiderkerk, or South church, has a conspicuous tower (1450–1525). The Westerkerk, or West church, possesses a beautifully carved Renais-

sance screen and pulpit of the 16th century, and a quaint wooden bell-house (1519). The town hall (1688) contains some finely decorated rooms, a collection of local antiquities and the archives. Other buildings are the orphanage (1616), the weigh-house (1559), the upper story of which was once used by the Surgeons' Gild; the former mint (1611); and the ancient assembly-house of the dike-reeves of Holland and West Friesland. Enkhuizen possesses a considerable fishing fleet and has some shipbuilding.

ENKIDU, the name of the friend of Gilgamesh, the hero in the Babylonian epic (*see* GILGAMESH, EPIC OF). Enkidu is represented in the epic as the type of the primeval man. He is a wild man who lives with the animals of the field until lured away from his surroundings by the charms of a woman. Created to become a rival to Gilgamesh, he strikes up a friendship with the hero, and together they proceed to a cedar forest guarded by Khumbaba, whom they kill. The goddess Irnina (a form of Ishtar, *q.v.*) in revenge kills Enkidu, and the balance of the epic is taken up with Gilgamesh's lament for his friend, his wanderings in quest of a remote ancestor, Ut-Napishtim, from whom he hopes to learn how he may escape the fate of Enkidu, and his finally learning from his friend of the sad fate in store for all mortals except the favourites of the god, like Ut-Napishtim, to whom immortal life is vouchsafed as a special boon.

This ancient legend of the satyr Enkidu is believed by some to be the source of the legend of the beguiling of Adam by Eve in the Hebrew of Genesis iii.

ENLIGHTENMENT, a term used as the equivalent of the German *Aufklärung* to designate a period of great intellectual activity in the cause of general education and culture, including the preparatory self-emancipation from mere prejudice, convention and tradition. The name is applied primarily to the movement in 18th century Germany which was inspired by the so-called popular philosophy of Lessing, Mendelssohn, Reimarns and others. It is sometimes extended so as to include the England of Locke and Newton and the France of Condillac, Diderot and Voltaire. Occasionally the term is also applied to the Greece of the Sophists (*q.v.*) and the study of the Renaissance.

See the Histories of Philosophy by W. Windelband, by J. E. Erdmann and by F. Überweg.

ENNA: *see* CASTROGIOVANNI.

ENNEASTYLE, in architecture, the term applied to a building or portico with nine columns on the front.

ENNEMOSER, JOSEPH (1787–1854), Austrian medico-philosophic writer, was born on Nov. 15, 1787, at Hintersee in Tirol. After fighting against the French in 1809 and again in 1813–14, he took his M.D. at Berlin in 1816, and three years later was appointed professor of medicine at the new University of Bonn. He practised at Innsbruck from 1837–1841, when he moved to Munich, where he became widely known by his use of hypnotism. He died on Sept. 19, 1854, at Egern.

Besides his chief work, *Der Magnetismus in seiner geschichtlichen Entwickelung* (1819; 2nd ed., 1844, partial Eng. trans. 1854), Ennemoser's writings include: *Historisch-psychologische Untersuchungen über den Ursprung und das Wesen der menschlichen Seele* (1824; 2nd ed., 1851); *Der Magnetismus im Verhältnis zur Natur und Religion* (1842; 2nd ed., 1853), and *Anleitung zur mesmerischen Praxis* (1852).

ENNIS, county town of Co. Clare, Ireland, on the river Fergus, 25 m. N.W. from Limerick by rail. Pop. of urban district (1926), 5,517. Incorporated in 1612, it returned two members to the Irish parliament until the Union. The Roman Catholic church is the pro-cathedral of the diocese of Killaloe; the parish church was formed out of the ruins of the Franciscan abbey founded in 1240. The ruins of Clare abbey, founded in 1194, and of Killone abbey are near the town. Five miles N.W. is Dysert O'Dea, with a cross, a round tower and a castle. Ennis (Gaelic *Innis,* an island) has breweries, distilleries and flour mills. Limestone is quarried in the neighbourhood.

ENNIS, a city of Ellis county, Texas, U.S.A., 33m. S.S.E. of Dallas, on Federal highway 75, and served by the Southern Pacific and the Texas Midland railways. The population was 7,224 in 1920 (27% negroes), and was estimated locally at nearly 11,000 in 1928. Ellis county is one of the principal cotton growing counties in the country (130,690 bales in 1926), and the city's chief industries are cotton gins and compresses and cotton-seed oil mills. It has railroad shops also. Ennis was settled in 1871 and incorporated as a city in 1872.

ENNISCORTHY, a market town of Co. Wexford, Ireland, on the river Slaney. Pop. of urban district (1926), 5,545. The castle was founded in 1176. Ferns, nearby, was the seat of a former bishopric, and the cathedral, ruins of an Augustinian monastery founded about 1160, and of a Norman castle, may still be seen. Enniscorthy was incorporated by James I. It was taken by Cromwell in 1649 and burnt in 1798. There are breweries, flour mills, tanneries and wool factories. Trade in agricultural produce is facilitated by water communication with Wexford. There are fowl-markets and horse-fairs.

ENNISKILLEN, WILLIAM WILLOUGHBY COLE, 3RD EARL OF (1807–1886), British palaeontologist, was born on Jan. 25, 1807, and educated at Harrow and Christ Church, Oxford. Lord Cole, as he then was, amassed with his friend Sir Philip de M. G. Egerton a fine collection of fossil fishes now in the British Museum. He died on Nov. 21, 1886, being succeeded by his son (b. 1845) as 4th earl.

The first of the Coles (an old Devonshire and Cornwall family) to settle in Ireland was Sir William Cole (d. 1653), who was "undertaker" of the northern plantation and received a grant of a large property in Fermanagh in 1611, and became provost and later governor of Enniskillen. In 1760 his descendant John Cole (d. 1767) was created Baron Mountflorence, and the latter's son, William Willoughby Cole (1736–1803), was in 1776 created Viscount Enniskillen and in 1789 earl. The 1st earl's second son, Sir Galbraith Lowry Cole (1772–1842), was a prominent general in the Peninsular War, and colonel of the 27th Inniskillings, the Irish regiment with whose name the family was associated.

ENNISKILLEN (INNISKILLING), market town and county-town of Co. Fermanagh, Ireland, situated on an island between upper and lower Loughs Erne, 116 m. N.W. of Dublin by rail. Pop. of urban district (1921) 4,847. It was incorporated by James I. In 1689 it defeated a force sent by James II. Two miles away is Devenish island, with the abbey of St. Mary, founded by St. Molaise (Laserian) in the 6th century, and with a round tower 85 ft. high and a cross. Enniskillen has tanneries and a small manufactory of cutlery. Trade is in agricultural produce. There are extensive water communications by river and by the loughs Erne, and also by the Ulster canal to Belfast. The loughs contain trout, large pike and other coarse fish.

ENNIUS, QUINTUS (239–170 B.C.), ancient Latin poet, was born at Rudiae in Calabria. Familiar with Greek as the language in common use among the cultivated classes of his district, and with Oscan, the prevailing dialect of lower Italy, he further acquired a knowledge of Latin; to use his own expression (Gellius xvii., 17), he had three "hearts" (*corda*), the Latin word being used to signify the seat of intelligence. We first hear of him in 204 in the Second Punic war. He served as a centurion in Sardinia and he attracted the attention of Cato the elder, who took him to Rome in the same year. Here he taught Greek and adapted Greek plays for a livelihood; his writings gained him the friendship of the greatest men in Rome, including the elder Scipio and Fulvius Nobilior, whom he accompanied on his Aetolian campaign (189). Through the influence of Nobilior's son, Ennius subsequently obtained Roman citizenship (Cicero, *Brutus*, 20, 79). He lived at Rome till his death. The epitaph which he composed for himself expresses his pride in his achievement "Let no one weep for me, or celebrate my funeral with mourning; for I still live, as I pass to and fro through the mouths of men." The fragments of his work and the testimony of his countrymen show us a man of a cheerful nature (Hor. *Epp.* ii. 1. 50; Cic. *De sen.* 5); of great industry and versatility; combining imagination and a vein of religious mysticism with a sceptical indifference to popular beliefs and a scorn of religious imposture; and tempering the gravity of a Roman with a genial capacity for enjoyment (Hor. *Epp.* 1, 19, 7).

Till the appearance of Ennius, Roman literature had been most successful in comedy. Naevius and Plautus were men of popular fibre. Ennius, on the other hand, was in sympathy with the

dominant aristocratic element in Roman life. Under his influence literature began to appeal to a limited and cultivated class, but at the same time to express more truly what was greatest and most enduring in the national traditions. He was a man of many-sided activities. He dealt with questions of Latin orthography, and is said to have been the first to introduce shorthand writing in Latin. He attempted comedy, but with so little success that in the canon of Volcacius Sedigitus he is placed tenth, and last in the list of comic poets. He may be regarded also as the inventor of Roman satire, in its original sense of a "miscellany," although it was Lucilius who gave it the character of a criticism of men and manners. The *saturae* of Ennius were collections of writings on various subjects, written in various metres and contained in four (or six) books, and included metrical versions of the physical speculations of Epicharmus, and of Euhemerus. Original compositions were also contained in these *saturae*, and among them the panegyric on Scipio, unless this was a drama. The satire of Ennius seems to have resembled the more artistic satire of Horace in its record of personal experiences, in the occasional introduction of dialogue, in the use made of fables with a moral application, and in the didactic office which it assumed.

But the chief distinction of Ennius was gained in tragic and narrative poetry. The titles of about 25 of his tragedies are known to us, besides fragments, the longest consisting of about 15 lines. These tragedies were mostly adaptations and translations from Euripides. One or two were original dramas dealing with Roman subjects (*praetextae*); thus, the *Ambracia* treated of the capture of that city by his patron Nobilior, the *Sabinae* of the rape of the Sabine women. The language is generally nervous and vigorous, but flows less smoothly than that of the dialogue of Latin comedy. It shows the same tendency to aim at effect by alliterations, assonances and plays on words. The rudeness of early art is most apparent in the inequality of the metres in which both the dialogue and the "recitative" are composed.

But his greatest work, which was admired by Cicero and Lucretius and imitated by Virgil, was the *Annales*, a narrative poem in 18 books, containing the record of the national story from mythical times to his own. Although the conception of the work implies a confusion of the provinces of poetry and history, yet it was the instinct of genius to discern in the idea of the national destiny the only possible motive of a Roman epic. The poem (to judge from the fragments, amounting to about 600 lines), although rough, unequal and often prosaic, seems to have breathed the true Roman spirit, and to have contained flashes of poetic imagination—that *ingenium* which later critics regarded as the distinguishing characteristic of Ennius. Ennius prided himself especially on being the first to form the strong speech of Latium into the mould of the Homeric hexameter in place of the old Saturnian metre. And although it took several generations of poets to beat their music out to the perfection of the Virgilian cadences, yet in the rude adaptation of Ennius was first discovered the secret of what ultimately became one of the grandest organs of literary expression. The inspiring idea of the poem was perfected by Virgil in his Aeneid, which is linked to the ancient tradition by the deliberate and skilful use of phrases of Ennius. The occasional references to Roman history in Lucretius are evidently reminiscences of the *Annales*. He as well as Cicero speaks of him with pride and affection as "Ennius noster." Of the great Roman writers Horace had least sympathy with him; yet he testifies to the high esteem in which he was held during the Augustan age. Ovid expresses the grounds of that esteem when he characterizes him as

"ingenio maximus, arte rudis."

A sentence of Quintilian expresses the feeling of reverence for his genius, mixed with distaste for his rude workmanship, with which the Romans of the early empire regarded him: "Let us revere Ennius as we revere the sacred groves, hallowed by antiquity, whose massive and venerable oak trees are not so remarkable for beauty as for the religious awe which they inspire." (*Inst. or.* x. 1. 88).

Editions of the fragments by L. Valmaggi (Turin, 1900, with notes), J. Vahlen (Leipzig, 1903); G. Pascoli in *Epos* (Livorno, 1911); L. Müller in Postgate's *Corp. Poet. Lat.*; E. M. Steuart (1925) with notes; monographs by L. Müller (1884 and 1893), C. Pascal, *Studi sugli scrittori Latini* (1900); *see* also Mommsen, *History of Rome*, bk. iii. ch. 14. On Virgil's indebtedness to Ennius *see* V. Crivellari, *Quae praecipue hausit Vergilius ex Naevio et Ennio* (1889); E. Norden, *Ennius und Vergilius* (1915); de Gubernatis, *Ennio* (Turin, 1915).

ENNODIUS, MAGNUS FELIX (A.D. 474–521), bishop of Pavia, Latin rhetorician and poet. He was born at Arelate (Arles) and brought up at Ticinum (Pavia) or possibly Mediolanum (Milan). When the lady to whom he was betrothed went into a convent Ennodius entered the Church, and was ordained deacon (about 493). From Pavia he went to Milan, where he remained until made bishop of Pavia about 515. As bishop of Pavia he played a considerable part in ecclesiastical affairs. On two occasions (in 515 and 517) he was sent to Constantinople by Theodoric on an embassy to the emperor Anastasius, to endeavour to bring about a reconciliation between the Eastern and Western churches. He died on July 17, 521; his epitaph still exists in the basilica of St. Michael at Pavia (*Corpus Inscriptionum Latinarum*, v., pt. ii., No. 6464).

Ennodius is one of the best representatives of the twofold (pagan and Christian) tendency of 5th century literature, and of the Gallo-Roman clergy who upheld the cause of civilization and classical literature against the inroads of barbarism. But his anxiety not to fall behind his classical models—the chief of whom was Virgil—his striving after elegance and grammatical correctness, and a desire to avoid the commonplace have produced an affected style, which, aggravated by rhetorical exaggerations and popular barbarisms, makes his works difficult to understand.

His works include:—(1) Letters on a variety of subjects, addressed to high church and state officials, which are valuable for the religious and political history of the period. (2) Miscellanies, of which the most important are: *The Panegyric of Theodoric*, written to thank the Arian prince for his tolerance of Catholicism and support of Pope Symmachus (probably delivered before the king on the occasion of his entry into Ravenna or Milan); *The Life of St. Epiphanius*, bishop of Pavia, the best written and perhaps the most important of all his writings, an interesting picture of the political activity of the church; *Eucharisticon de Vita Sua*, a sort of "confessions," after the manner of St. Augustine; the description of the enfranchisement of a slave with religious formalities in the presence of a bishop; *Paraenesis didascalica*, an educational guide, insisting on the claims of grammar as a preparation for the study of rhetoric. (3) Discourses (*Dictiones*). That on the anniversary of Laurentius, bishop of Milan, is the chief authority for the life of that prelate; the scholastic discourses, rhetorical exercises for the schools, contain eulogies of classical learning, distinguished professors and pupils; the controversial deal with imaginary charges, the subjects being chiefly borrowed from the elder Seneca; the ethical harangues are put into the mouth of mythological personages. (4) Poems, including two *Itineraria*, descriptions of a journey from Milan to Brigantium (Briançon) and of a trip on the Po; an apology for the study of profane literature; an epithalamium, in which Love is introduced as execrating Christianity; a dozen hymns, after the manner of St. Ambrose, probably intended for church use; epigrams on various subjects.

There are two excellent editions of Ennodius by G. Hartel (vol. vi. of *Corpus scriptorum ecclesiasticorum Latinorum*, Vienna, 1882) and F. Vogel (vol. vii. of *Monumenta Germaniae historica*, 1885, with exhaustive prolegomena). Edition with French translation, by S. Léglise (1906 foll.). On Ennodius generally consult M. Fertig, *Ennodius und seine Zeit* (1855–60); A. Dubois, *La Latinité d'Ennodius* (1903); F. Magani, *Ennodio* (Pavia, 1886); A. Ebert, *Allgemeine Geschichte der Litt. des Mittelalters im Abendlande*, i. (1889); M. Manitius, *Geschichte der christlich-lateinischen Poesie* (1891); Teuffel, *Hist. of Roman Literature*, § 479 (Eng. tr., 1892).

ENNS, a small town of about 4,200 inhabitants in Upper Austria, on the left bank of the Enns near its confluence with the Danube. This site lay on one of the old salt routes across the Danube to Bohemia so that this is one of the oldest towns in Austria; nearby is the site of the Roman *Laureacum*. The present town grew around a castle built in 900 by the Bavarians as an outpost against Magyar attacks but the settlement soon gained prosperity as a market and obtained a charter as a free town in

1212. Passing to the Hapsburgs in 1275 it obtained the protection necessary to its development and now maintains its early functions as a regional centre. Three miles distant lies the magnificent Augustinian monastery of St. Florian, a foundation due to the Benedictines, who occupied it from the 7th to the 11th century; the library is famous for its collection of old manuscripts.

ENOCH was (Gen. iv. 17, 18) the eldest son of Cain, who named a city after him. But in the genealogy of the Priestly document he appears as the *seventh* in descent from Adam in the line of Seth. The brief notice in Gen. v. 21–24 is certainly a fragment from an Enoch myth. The fact that his years are given as 365 suggests that he was a solar hero. A connection between Enoch and the Euedorachos who is seventh in the list of antediluvian kings given by Berossus, and may be the Enmeduranki or Enmeduranna of other similar Babylonian lists, is possible, but precarious. (*See* Enoch, Book of, and Enoch, Book of the Secrets of.) Enoch appears in the Old Testament also as the name of clans belonging respectively to Midian and Reuben.

ENOCH, BOOK OF. The *Book of Enoch,* or, as it is sometimes called, the *Ethiopic Book of Enoch,* in contradistinction to the *Slavonic Book of Enoch* (*see* later), is perhaps the most important of all the apocryphal or pseudapocryphal biblical writings for the history of religious thought. It is not the work of a single author, but rather a conglomerate of literary fragments which once circulated under the names of Enoch, Noah and possibly Methuselah. In the *Book of the Secrets of Enoch* we have additional portions of this literature.

The *Book of Enoch* was written in the second and first centuries B.C. It was well known to many of the writers of the New Testament, and in many instances influenced their thought and diction. Thus it is quoted by name as a genuine production of Enoch in the Epistle of Jude, 14 *sq.*, and it lies at the base of Matt. xix. 28 and John v. 22, 27, and many other passages. It had also a vast indirect influence on the Palestinian literature of the 1st century of our era. Like the Pentateuch, the Psalms, the Megilloth, and the Pirke Aboth, this work was divided into five parts. With the earlier Fathers and Apologists it had all the weight of a canonical book, but toward the close of the 3rd and the beginning of the 4th century it began to be discredited, and finally fell under the ban of the church. Almost the latest reference to it in the early church is made by George Syncellus in his Chronography about A.D. 800. The book was then lost sight of till 1773, when Bruce discovered the Ethiopic version in Abyssinia.

That the *Book of Enoch* was written in Semitic is now accepted on all hands, but scholars are divided as to whether the Semitic language in question was Hebrew or Aramaic.

The author of the earliest portions was a Jew who lived in northern Palestine, in the land of Dan, near the headwaters of the Jordan. This fact "helps to explain the influence the book had upon the religion that was cradled in Galilee" (Burkitt). Of the authors of the other three books incorporated in the work we know nothing but what can be gleaned from their writings as to their religious standpoint. Charles holds that all the books were written by *Chasidim* (the "saints" of the Psalms), or by their successors the Pharisees; but Leszynsky has shown conclusively that a great portion of the earlier parts of Enoch emanated from Sadducaean circles. These two diametrically opposed standpoints are perhaps not really so antagonistic as appears at first sight, for the *Chasidim,* who existed long before the Pharisees and Sadducees emerged as opposed parties, included men of different views which in later times crystallized into what we understand by Pharisaic and Sadducaean; the *Chasidim* were, moreover, the spiritual forbears of the Apocalyptists. When, therefore, it is maintained that all the books incorporated in Enoch were written by *Chasidim,* it does not follow that the "Pharisaic" standpoint was the only one represented. Even in the later parts of the work, written when Pharisees and Sadducees were definitely opposed parties, it is evident that not all can be said to represent the Pharisaic standpoint; this is seen especially in some of the teaching concerning the Messiah, in the generally speaking universalistic spirit—which is quite un-Pharisaic, and in the attitude towards the Law which, while loyal, is not that of the Pharisees. Some parts are purely Pharisaic, and it seems certain that the whole work in its present form has been worked over by a Pharisee or Pharisees; but that all the post-Maccabaean portions in their original form emanated from Pharisaic circles seems hardly possible. It is far more likely that, with the exception of certain passages, the various component parts of the work were written by Apocalyptists who, while neither Pharisees nor Sadducees, were sufficiently wide in their outlook to hold views characteristic of each.

As regards the analysis of the book five main divisions can be recognized:

(1) *Chap. lxxii.–lxxxii.* constitutes a work in itself, the writer of which had very different objects before him than those of the writers of the rest of the book. His sole aim is to give the law of the heavenly bodies. The date of this section can be partially established, for it was known to the author of Jubilees, and was therefore written before the last third of the 2nd century B.C.

(2) *Chaps. lxxxiii.–xc.*—This section was written before 161 B.C., for "the great horn," who is Judas the Maccabee, was still warring when the author was writing. These chapters recount three visions: the first two deal with the first-world judgment; the third with the entire history of the world till the final judgment. An eternal Messianic kingdom at the close of the judgment is to be established under the Messiah, with its centre in the New Jerusalem set up by God Himself.

(3) *Chaps. xci.–civ.*—In the preceding section the Maccabees were the religious champions of the nation and the friends of the *Chasidim.* Here they are leagued with the Sadducees, and are the declared foes of the Pharisaic party. This section was written therefore after 134 B.C., when the breach between John Hyrcanus and the Pharisees took place and before the savage massacres of of the latter by Jannaeus (95 B.C.), for it is not likely that in a book dealing with the sufferings of the Pharisees such a reference would be omitted. These chapters indicate a revolution in the religious hopes of the nation. An eternal Messianic kingdom is no longer anticipated, but only a temporary one, at the close of which the final judgment will ensue. The righteous dead rise not to this kingdom, but to spiritual blessedness in heaven itself—to an immortality of the soul.

(4) *Chaps. i.–xxxvi.*—This is the most difficult section of the book. It is very composite. Chaps. vi.–xi. are apparently an independent fragment of the Enoch Saga. It is itself compounded of the Semjaza and Azazel myths, and in its present composite form is already presupposed by lxxxviii.–lxxxix.1; hence its present form is earlier than 166 B.C. It represents a primitive and very sensuous view of the eternal Messianic kingdom on earth, seeing that the righteous beget 1,000 children before they die. These chapters appear to be from the Book of Noah; for they never refer to Enoch, but to Noah only (x.1); xii.–xvi., on the other hand, belong to the Book of Enoch, representing for the most part what Enoch saw in a vision; i.–v. seem to be of a different date and authorship from the rest.

(5) *Chaps. xxxvii.–lxxi.*—These constitute the well-known "Similitudes." They were written before 64 B.C., for Rome was not yet known to the writer, and after 95 B.C., for the slaying of the righteous, of which the writer complains, was not perpetrated by the Maccabean princes before that date. This section consists of three similitudes—xxxviii.–xliv., xlv.–lvii., lviii.–lxix. These are introduced and concluded by xxxvii. and lxx. There are many interpolations—lx., lxv.–lxix.25, confessedly from the Book of Noah; most probably also liv.7–lv.2. Whence others, such as xxxix.1, 2*a*, xli.3–8, xliii. *sq.*, spring is doubtful. Chaps. l, lvi.5–lvii. 3*a* are likewise insertions.

See Charles, *The Book of Enoch* (1912), and in the S.P.C.K. "Translations of Early Documents" (1917); Leszynsky, *Die Sadduzäer* (1912); *Burkitt, Jewish and Christian Apocalypses* (1914).

(W. O. E. O.)

The Book of the Secrets of Enoch, or *Slavonic, Enoch.* This new fragment of the Enochic literature came to light through five mss. discovered in Russia and Servia. Its contents are:

Chaps. i.–ii. Introduction: life of Enoch: his dream, in which he is told that he will be taken up to heaven; his admonitions

to his sons. iii.–xxxvi. What Enoch saw in heaven. iii.–vi. The first heaven; the rulers of the stars; the great sea and the treasures of snow, etc. vii. The second heaven; the fallen angels. viii.–x. The third heaven; Paradise and place of punishment. xi.–xvii. The fourth heaven; courses of the sun and moon; phoenixes. xviii. The fifth heaven; the watchers mourning for their fallen brethren. xix. The sixth heaven; seven bands of angels arrange and study the courses of the stars, etc.; others set over the years, the fruits of the earth, the souls of men. xx.–xxxvi. The seventh heaven; the Lord sitting on His throne with the ten chief orders of angels. Enoch is clothed by Michael in the raiment of God's glory and instructed in the secrets of nature and of man, which he wrote down in 366 books. God reveals to Enoch the history of the creation of the earth and the seven planets and circles of the heaven and of man, the story of the fallen angels, the duration of the world through 7,000 years, and its millennium of rest. xxxviii.–lxvi. Enoch returns to earth, admonishes his sons; instructs them on what he had seen in the heavens, gives them his books. Bids them not to swear at all, nor expect any intercession of the departed saints for sinners. lvi.–lxiii. Methuselah asks Enoch's blessing before he departs, and to all his sons and their families Enoch gives fresh instruction. lxiv.–lxvi. Enoch addressed the assembled people at Achuszan. lxvii.–lxviii. Enoch's translation. Rejoicings of the people on behalf of the revelation given them through Enoch.

A large part of this book was written for the first time in Greek. On the other hand, some sections may wholly or in part go back to Hebrew originals. In its present form the book was written in Egypt, and probably some time between 30 B.C. and A.D. 70. It was written after 30 B.C., for it makes use of Sirach, the (Ethiopic) Book of Enoch and the Book of Wisdom. It was written before A.D. 70; for the temple is still standing, *see* lix.2. The author was an orthodox Hellenistic Jew who lived in Egypt. He believed in the value of sacrifices (xlii.6; lix. 1, 2, etc.), but is careful to enforce enlightened views regarding them (xlv. 3,4; lxi. 4,5.) in the law lii.8,9; in a blessed immortality, l. 2; lxv. 6,8–10, in which the righteous should be clothed in "the raiment of God's glory," xxii.8. In questions relating to cosmology, sin, death, etc., he is an eclectic, and allows himself the most unrestricted freedom, and readily incorporates Platonic (xxx.16), Egyptian (xxv.2) and Zend (lviii.4–6) elements into his system of thought.

See Morfill and Charles, ***The Book of the Secrets of Enoch*** (1896); Forbes and Charles, *Apoc. and Pseudepigrapha* (1912).

(W. O. E. O.; R. H. CH.)

ENOMOTO, BUYO, VISCOUNT (1839–1909), Japanese vice-admiral, was born in Tokyo. He was the first officer sent by the Tokugawa government to study naval science in Europe, and after going through a course of instruction in Holland he returned in command of the frigate "Kaiyō Maru," built at Amsterdam to order of the Yedo administration. The salient episode of his career was an attempt to establish a republic at Hakodate. Finding himself in command of a squadron which represented practically the whole of Japan's naval forces, he refused to acquiesce in the deposition of the Shōgun, and, steaming off to Yezo (1867), proclaimed a republic and fortified Hakodate. He was soon compelled to surrender, but the newly organized government of the empire instead of inflicting the death penalty on him and his principal followers, as would have been the inevitable sequel of such a drama in previous times, punished them with imprisonment only, and four years after the Hakodate episode, Enomoto received an important post in Hokkaido, the scene of his attempt. Subsequently (1874), as envoy in St. Petersburg, he concluded the treaty by which Japan exchanged the southern half of Saghalien for the Kuriles. He received the title of viscount in 1885, and afterwards held the portfolios of communications, education and foreign affairs. He died at Tokyo in 1909.

ENOS, a town of European Turkey, in the vilayet of Adrianople, on the river Maritsa, where its estuary broadens to meet the Aegean sea. Pop. (1905) about 8,000. Enos occupies a ridge of rock surrounded by broad marshes. It was the seat of a Greek bishop, but the Greek population has left and the town is almost completely in ruins, although in 1921 when it was in Greek hands it was largely rebuilt. It long possessed a valuable export trade, owing to its position at the mouth of the Maritsa, the great natural waterway from Adrianople to the sea. But its commerce has declined, owing to the unhealthiness of its climate, to the accumulation of sandbanks in its harbour, which now only admits small coasters and fishing-vessels, and to the rivalry of Dédéagatch, a neighbouring seaport connected with Adrianople by rail. It is crowned by an old castle of the Genoese Gattelusi. Hellenic remains are not uncommon and there are three fine Byzantine churches near the castle.

ENRÍQUEZ GÓMEZ, ANTONIO (*c.* 1602–1662?) Spanish dramatist, poet and novelist of Portuguese-Jewish origin—known also as Enrique Enríquez de Paz—won distinction with his play *A lo que obliga el honor* (1642), but is best represented by *El Siglo Pitagórico y Vida de don Gregorio Guadaña* (1644), a striking picaresque novel in prose and verse, dedicated to the Maréchal de Bassompierre.

ENSCHEDE, in the province of Overysel, Holland, near the German frontier, and a junction 5 m. S.E. of Hengelo. Pop. (1927) 46,748. It is the centre of the flourishing cotton-spinning and weaving industries of the Twente district; while by the railway via Gronau and Koesfeld to Dortmund it is in direct communication with the Westphalian coalfields. Enschede possesses an industrial trade school, and a large park used as a recreation ground for its growing population. About two-thirds of the town was burnt down in 1862.

ENSEMBLE (Fr.), in music, signifies the combination of several performers, vocal or instrumental, as in the "ensemble numbers" of an opera (trio, quartet and so forth). By extension, the term is applied further to the process of combining in this manner and to the degree of skill with which it is accomplished. Thus in this sense it may be said that the ensemble of a choir or of a quartet was poor.

ENSENADA, CENON DE SOMODEVILLA, MARQUES DE LA (1702–1781), Spanish statesman, was born at Alesanco near Logroño on June 2, 1702. He entered the civil service, and was employed on various important missions. In 1736 Charles, afterwards King Charles III. of Spain, conferred on him the Neapolitan title of Marques de la Ensenada. In 1742 he became secretary of State and war to Philip, duke of Parma. In the following year (April 11, 1743), on the death of Patiños's successor Campillo, he was chosen by Philip V. as minister of finance, war, the navy and the Indies (*i.e.*, the colonies), and became, in fact prime minister at the age of forty-one. During the remainder of the king's reign, which lasted till July 11, 1746, and under his successor Ferdinand VI. until 1754, Ensenada was the effective prime minister.

His administration is notable in Spanish history for the vigour of his policy of internal reform. Under his direction the despotism of the Bourbon kings became paternal. Public works were undertaken, shipping was encouraged, trade was fostered, numbers of young Spaniards were sent abroad for education. Many of them abused their opportunity, but on the whole the prosperity of the country revived, and the way was cleared for the more sweeping innovations of the following reign. Ensenada was a strong partisan of a French alliance and of a policy hostile to England. Sir B. Keene, the English minister, supported the Spanish court party opposed to him, and succeeded in preventing him from adding the foreign office to others which he held. Ensenada would probably have fallen sooner but for the support he received from the Portuguese queen, Barbara. In 1754 he offended her by opposing an exchange of Spanish and Portuguese colonial possessions in America which she favoured. On July 20, he was arrested by the king's order, and sent into mild confinement. On the accession of Charles III. in 1759, he was released from arrest and allowed to return to Madrid. On April 18, 1766 he was again exiled from court, and ordered to go to Medina del Campo. He had no further share in public life, and died on Dec. 6, 1781.

For his administration *see* W. Coxe, ***Memoirs of the Kings of Spain of the House of Bourbon*** (1815), but the only complete account of

Ensenada is by Don Antonio Rodríguez Villa, *Don Cenón de Somodevilla, Marqués de la Ensenada* (Madrid, 1878).

ENSIGN. The word is derived through the Fr. *enseigne* from the Latin plural *insignia*, a distinguishing token, emblem or badge such as symbols of office, or in heraldry, the ornament or sign, such as the crown, coronet or mitre borne above the charge or arms. The word is more particularly used of a military or naval standard or banner. In the British navy, ensign has a specific meaning, and is the name of a flag having a red, white or blue ground, with the Union Jack in the upper corner next the staff. The white ensign (which is further distinguished by having a red St. George's Cross quartered upon it) may only be used by the Royal Navy and the Royal Yacht Squadron, while the blue and red ensigns are the badges of the Royal Naval Reserve, some privileged companies, and the Mercantile Marine, respectively (*see* FLAG).

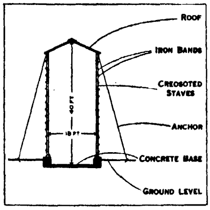
Until 1871 the lowest grade of commissioned officers in the infantry of the British army had the title of ensign (now replaced by that of second lieutenant). The title is still used within the Foot Guards. It is the duty of the officers of this rank to carry the colours of the regiment (*see* COLOURS, MILITARY). In the 16th century ensign was corrupted into "ancient," and was used in the two senses of a banner and the bearer of the banner. In the United States navy, the title ensign superseded in 1862 that of *passed midshipman*. It designates an officer ranking with second lieutenant in the army.

ENSILAGE, the process of preserving green crops in a succulent condition in a silo, *i.e.*, a pit, a stack or a tall cylindrical tower above ground (from Gr. σιρός, Lat. *sirus*, a pit for holding grain). The fodder which is the result is called silage.

The method seems to have been practised in Central Europe (its principles are similar to those involved in the making of sauerkraut) when special attention was first directed to it by Auguste Goffart, a French agriculturist, who in 1877 published a work (*Manuel de la culture et de l'ensilage des maïs et autres fourrages verts*) detailing the experiences of many years in preserving green crops in silos. A translation of Goffart's book by J. B. Brown was published in New York in 1879. This attracted considerable attention in the United States, where the practice was then in its infancy. With the development of the tower silo and the investigations of S. M. Babcock, of Wisconsin, and others the practice has become the main source of succulent fodder for winter feeding in America and in other parts of the world where labour is costly. In the United Kingdom, following the disastrously wet year, 1879, and investigations by George Fry, of Chobham, the practice was widely tried, but under the conditions then prevailing proved unsuccessful. It was revived by George Jaques, of Tivetshall, Norfolk, who, in 1912, introduced the tall America tower silo, and aided by investigations at Cambridge and elsewhere the practice shows slow but steady growth.

Conditions for Silage.—The conditions necessary for the proper preservation of silage are exclusion of air after fermentation is complete, and the presence of carbonic acid gas and certain organic acids formed by the fermentation of the silage, which together prevent the development of moulds on the succulent fodder. Several organic acids are commonly present including acetic acid (the acid of vinegar), lactic acid (the acid of sour milk) and butyric acid (the acid of rancid butter). These to a large extent determine the quality of the silage. If butyric acid predominates it always results in an evil-smelling silage commonly called "sour." This type of silage is generally produced when one of two conditions prevail, either the ensiling of an immature and very succulent crop, when the fodder packs so tightly in the silo that the proper fermentation is prevented by insufficient air, or the use of crop that has been "laid" or "lodged" and has partially rotted in the field, in which case the decomposition continues in the silo. Partial drying of such crops before ensiling will serve to prevent the formation of butyric acid and "sour" silage. If air has free access to the fermenting fodder during ensilage, much heat is produced. When the temperature exceeds 45° C a pleasant sweet-smelling silage is produced, commonly called "sweet" silage. Such silage is frequently found in silage stacks and may be found close to the top of a tower silo, in both these cases air having easy access during fermentation. If the fodder when ensiled is reasonably mature, and the supply of air during fermentation is controlled by close packing, the resulting silage has the smell of acetic acid, and is then described as "acid" silage. This type is the usual product of tower silos and silage clamps.

The most suitable crops for silage in Britain are mixtures containing pulse and cereals and, in suitable localities, maize. In warmer climates maize is used almost exclusively. Meadow grass and sown grass mixtures can advantageously be made into silage when weather conditions prevent hay-making, but cruciferous crops (mustard, turnip, cabbage, etc.) are not suitable. On heavy soils and in districts of considerable rainfall the best mixture is composed largely of beans, with a light seeding of tares or peas and oats of a straw-producing variety. This mixture produces heavy crops which, owing to the robust stems of the beans, stand well, smother weeds and are easy to harvest. On light soils in a dry district beans are unsuitable. In this case a mixture of oats and tares alone is more suitable, but again the proportion of tares must not be too large lest the climbing stems and weight of the tares cause the whole crop to be "laid" on the ground. Maize can only be grown satisfactorily on warm soils in early districts, and even then care must be taken to use suitable varieties which ripen early. The varieties commonly grown in Britain for green soiling are unsuitable because they do not mature early enough. At the time of ensiling maize should be so mature that the fully formed cobs contain grains which are firm and glazed. The most suitable varieties are Jaune Gros du Domaine, a French variety, and to a lesser extent Salzer's North Dakota and Longfellow, which are American varieties.



SECTION OF A SILO BUILT WITH CREOSOTED WOOD STAVES, STRENGTHENED WITH IRON BANDS; LARGELY USED IN AMERICA FOR CORN ENSILAGE

Value of Silage.—Well made silage is a wholesome and nutritious food for all classes of cattle. Live stock—weaning calves, baby beeves and milking cows—all thrive upon it, digest it readily, and keep in good coat and condition when fed upon it. It is an equally suitable food for sheep, though not quite so easily fed to them as to cattle. Horses eat it readily when fed in small quantity with their chaff; being fibrous, silage is not very suitable for pigs.

It can be fed, if required, immediately it is made, or in times of plenty it can be stored in the silo for indefinite periods without depreciation, provided air is excluded. In silage stacks and clamps air cannot be completely excluded, and therefore continuous wastage is occasioned by storage. Digestibility experiments have shown that well made silage possesses a feeding value in accordance with that suggested by its chemical analysis, and feeding experiments have confirmed this fact. In one series of experiments by H. E. Woodman at Cambridge, in which parts of the same oat and tare crop cut at the same time, were fed firstly as green crop, secondly as hay, and thirdly as silage, it was shown that the food value of the silage was equal to the green crop and greater than that of the hay.

Types of Silo.—A typical modern silo is a cylindrical structure made of wood, concrete or iron, varying in diameter between 12 and 20 ft. and in height between 30 and 45 feet. Silos constructed of concrete are generally more costly to erect than those of iron or wood, but are more durable if suitably reinforced. Wooden silos require more annual attention to keep them in order, and iron silos require to be painted annually inside to preserve the walls from the effects of the acids in the silage. The effective capacity of silos may be calculated by first deducting from the height of the silo about 4 ft., the approximate depth left vacant after the silage has settled. The cubical contents of the remainder of the silo in feet multiplied by 40 lb., the average

weight of a cubic foot of silage, will give the effective capacity. Tall silos are filled by power-driven silage cutters, which first cut the fodder into short lengths and then elevate it to the top of the silo by blowing it through hollow tubes.

Stack silage by reason of the large surface exposed to the air is liable to continuous moulding and consequently to considerable wastage from decay. For this reason it is not suitable for general adoption in ordinary farm practice. But it involves no capital outlay and can be brought into play at a moment's notice. It is therefore a useful method of saving hay crops in seasons when hay-making is rendered impossible or difficult by continuous rain. Clamp silage is liable to similar though smaller losses. It, too, involves little time or outlay in preparing the clamp. The site for the clamp must be carefully chosen lest the clamp becomes full of water in winter. This method may be adopted in regular farm practice, as, for example, with maize in South Africa, where subsoil water is not troublesome, or less frequently in Britain with mixed crops. Like stack silage it may also be used to save hay crops in adverse seasons.

In general it may be said that silage making lends itself to industrial conditions of management more than most farming processes, and for this reason the practice is likely to secure a permanent place in agriculture.

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The United States.—Maize (Indian corn) is the principal American silage crop and probably constitutes more than 90% of the total amount. Where climatic conditions are favourable it produces more actual food material per acre than any other crop that can be grown. Ordinarily, maize should be harvested for silage about a week or ten days before it would be cut for shocking. At this time the kernels are well dented and glazed. Since there is a steady increase in all the nutrients of the crop up to maturity, it is best to plant a variety that will mature sufficiently for silage before frost. In any locality the variety most commonly raised for corn will ordinarily give the best results for silage. This means the use of short-season varieties in the north and long-season varieties in the south.

Next to maize the sorghums, both saccharine and non-saccharine, constitute the most satisfactory silage crop. Being somewhat more drought resistant than maize, they are generally used where the rainfall is rather limited and also in some of the hot, irrigated districts where maize does not thrive. In feeding value good sorghum silage is nearly equal to maize silage. In recent years sunflowers have received considerable attention as a silage crop especially in the extreme north where the seasons are too short and too cool for maize. The silage is much less palatable but after the animals become accustomed to the flavour they eat considerable quantities of it and seem to do well. Legumes alone have not proved altogether satisfactory as a silage. In some cases they have yielded a palatable product; in others a silage that was rank flavoured and not relished by cattle. One reason for this failure is the higher water content. For this reason such crops should be allowed to become as mature as practicable before ensiling, or if cut earlier, should be allowed partially to cure. Mixtures of maize and legumes make excellent silage. Small grains, peas and oats mixed, beet tops, cane tops, rape, etc., are ensiled in a limited way with a fair degree of success.

In the United States the stack silage is used chiefly in putting up refuse from pea canneries. This method of preserving fodder in a succulent state has also been employed occasionally with maize and sweet clover. The pit or trench silos are employed chiefly in those regions where the rainfall is rather limited. In locating such silos it is essential that they be placed in firm, dry and well-drained soil, otherwise there is danger of spoilage through accumulation of water in the pit. The advantages of the pit and trench silos are that they are cheap, easily constructed, will not blow down, and do not require the silage blower in filling.

The preservation of forage as silage possesses a number of advantages, especially with coarse plants like maize and sorghum. Among these advantages are: (1) Silage preservation saves all of the forage in edible form. The loss both in preserving and feeding is much smaller than with dry fodder. (2) Silage is more palatable than dry fodder and animals will eat a larger quantity. (3) Silage preservation is not dependent upon favourable weather conditions. (4) Silage requires less space for storage than the equivalent amount of hay or fodder. (5) The cost of the ration is materially reduced by feeding ensilage to all classes of live stock.

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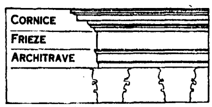
ENSTATITE, a rock-forming mineral belonging to the group of orthorhombic pyroxenes. It is a magnesium metasilicate, $MgSiO_3$, often with a little iron replacing the magnesium. As the iron increases in amount there is a transition to bronzite (*q.v.*), and with still more iron to hypersthene (*q.v.*). Enstatite was first described by G. A. Kenngott in 1855, and named from ἐνστάτης "an opponent," because the mineral is almost infusible before the blowpipe; the material he described consisted of imperfect prismatic crystals, previously thought to be scapolite, from the serpentine of Mt. Zdjar near Schönberg, Moravia. Crystals suitable for goniometric measurement were later found in the meteorite which fell at Breitenbach, Bohemia. Large crystals, a foot in length and almost altered to steatite, were found in 1874 in the apatite veins transversing mica-schist and hornblende-schist at the apatite mine of Kjörrestad, near Brevig, Norway.

The compound obtained from dry melts of the composition $MgSiO_3$ is not enstatite, but a monoclinic mineral clinoenstatite known only in meteorites. Clinoenstatite appears to be the stable modification of $MgSiO_3$ at all temperatures below its incongruent melting point. It melts with decomposition at 1,557°C., with formation of forsterite. Enstatite itself above 1,260°C., is converted into clinoenstatite. It has been crystallized from melts with albite and sodium silicate and obtained as an unstable phase from $MgSiO_3$ glasses at a temperature of 1,000°–1,100°C. The limited miscibility of enstatite with diopside indicates that enstatite and clinoenstatite are distinct minerals, for the latter forms a complete series of solid solutions with the monoclinic pyroxene. Intergrowths of enstatite and clinoenstatite are known in meteorites. The rhombic pyroxene alters in nature to a lamellar serpentine known as bastite. The chief mode of occurrence of the mineral is as a constituent of basic igneous rocks—norites, pyroxenites, and some peridotites, and in dolerites and basalts. (C. E. T.)

ENTABLATURE, in architecture, the assemblage of horizontal mouldings and bands, supported by, and immediately above, the columns of classic buildings, or similar forms in any other style (*see* ORDER). It is usually divided into three main portions; the lowest, called the architrave (*q.v.*), originally the beam running from support to support; the central one called a frieze (*q.v.*), consisting of an unmoulded band with or without ornament; and the topmost, called the cornice (*q.v.*), formed of a series of mouldings that project from the face of the frieze. Occasionally, in Greek and Renaissance work, the frieze is omitted, as in the caryatid porch of the Erectheum at Athens. In Georgian and American colonial work, the architrave is sometimes omitted, as in many of the designs of Robert Adam.



ENTABLATURE

ENTADA, in botany, a woody climber belonging to the family Leguminosae and common throughout the tropics. The best-known species is *Entada scandens,* the nicker bean or sword bean, so called from its large woody pod, 2 to 4 ft. long and 3 to 4 in. broad, which contains large, flat, hard, polished, chestnut-coloured seeds, often made into snuff-boxes or match-boxes. A preparation from the kernel is used as a drug by the natives in India. The seeds will float for long in water, and are often thrown up on the north-western coasts of Europe, having been carried by the Gulf Stream from the West Indies; they retain their vitality, and under favourable conditions will germinate.

ENTAIL. The law of entail was initiated in England by the Statute of Westminster the second (1285) in the chapter headed *De Donis Conditionalibus.* Strictly speaking, a form of entail was known before the Norman feudal law had been introduced into England. The common form was a grant "to the feoffee and the heirs of his body." These grants were also known as *feuda conditionata,* because if the donee had no heirs of his body the estate reverted to the donor. The donee could, however, if he had an heir of the body born alive, alienate the land, and defeat the right of the donor. Since the passing of the above statute an estate given to a man and the heirs of his body has been known as an estate tail, or an estate in fee tail, the word tail being derived from the French *tailler,* to cut, the inheritance being by the statute cut down and confined to the heirs of the body. The power of alienation was re-introduced by the judges in Taltarum's case (*Year Book,* 12 Edward IV., 1472) by means of a fictitious suit or recovery which had originally been devised by the regular clergy for evading the statutes of mortmain. This was abolished by an act passed in 1833. (*See* ESTATE; FINE.) A deed enrolled in the central office of the Supreme Court was substituted, but by the Law of Property Act 1925 the necessity of enrollment was abolished. Disentailment by a tenant in tail in remainder still requires the consent of the protector, generally the tenant for life, required by the act of 1833. By s. 176 of the Law of Property Act 1925 a tenant in tail in possession, by following the terms of the section, may dispose of the estate by will as if he had been absolute owner of it as an equitable interest at his death. Under the same act an estate in tail is now an equitable estate only (s.39) and an entailed interest may be created even in personal property (s.130).

ENTASIS, in architecture, the convex curve given to the taper of a column, spire or similar upright member, in order to avoid any appearance of hollowness or weakness. Entasis is almost universal in classic columns. It is exaggerated in Greek archaic Doric work, but grows more and more subtle during the 5th and 4th centuries B.C. Many attempts have been made to find a mathematical basis for the entasis, and it has been reduced to all kinds of elliptical, hyperbolic, parabolic and even cycloidal curves. The immense variety of forms found indicates, probably, that the curve was laid out free-hand and purely empirically. Entasis is occasionally found in Gothic spires, and in the smaller Romanesque columns.

ENTELECHY, a term used by Aristotle for that which realizes or makes actual the otherwise merely potential. The idea which is expressed by the term entelechy (ἐντελέχεια) is intimately connected with Aristotle's distinction between matter and form, or the potential and actual. Briefly, one may say that he analysed each thing into the stuff or elements of which it is composed and the form or the order in which they are arranged. The mere stuff or matter is not yet the real thing, it needs what is variously described as a certain form or essence or function to complete it; only it must be remembered that matter and form are never separated; they can only be distinguished. So, *e.g.,* in the case of a living organism one may distinguish the mere matter of the organism (as though it were a mere synthesis of inorganic substances, one might almost say) from a certain form or essence or function or inner activity without which it would not really be a living organism at all; and this "soul" or vital function, as it may be called, is what Aristotle calls the "entelechy" (or first entelechy) of a living organism. Similarly, in the case of man rational activity is what makes him really a man, as distinguished from a mere animal, and so on. Leibniz, following Aristotle, called his "monads" (or spiritual substances) entelechies, in virtue of their inner self-determined activity. And more recently the term has been revived by H. Driesch in connection with his vitalistic biology to denote an interval perfecting principle which, he supposes, exists in all living organisms. (*See* ARISTOTLE, LEIBNITZ, FORM, VITALISM, EVOLUTION.)

ENTERIC FEVER, a name often given to typhoid fever (*q.v.*). When physicians separated from typhus fever a group of cases having special features they called the latter "typhoid." As the distinction between typhus and typhoid fevers became better recognized a tendency arose to replace the name "typhoid" by "enteric" as indicating the predominant intestinal lesions. In time it was recognized that "enteric" fever was not a single disease but that more or less identical symptoms were caused by different varieties of bacilli. Hence arose the modern differentiation of enteric fever into typhoid fever and three varieties of paratyphoid fever, each of the four conditions being dependent upon a special variety of bacillus, viz., B. typhosus, B. paratyphosus A, B. paratyphosus B, and B. paratyphosus C. In epidemiology and other conditions in which this differentiation is not or cannot be made "enteric" is used as a group term.

ENTERITIS, a general medical term for inflammation of the bowels, often associated with gastritis and dependent upon bacterial infection conveyed by food, but also resulting from irritant poisons, *e.g.,* copper sulphate.

ENTEROPNEUSTA, a class of Protochordates. *See* BALANOGLOSSUS; PTEROBRANCHIA.

ENTEROZOA, a zoological term, now obsolete, for all animals other than Protozoa (*q.v.*); the reference is to the possession of an enteron or body-cavity. The word is now replaced by Metazoa (*q.v.*).

ENTERTAINMENTS DUTY. This particular form of the taxation of luxuries was adopted by the parliament of the United Kingdom as a means of raising further revenue during the World War. The duty was imposed by the Finance (New Duties) act, 1916, sec. 1 of which provides that as from May 15, 1916, a duty is to be charged on all payments for admission to any entertainment as defined by the act, at the rates specified. The rates of duty were varied by subsequent acts, but the scheme of the duty as laid down in the Act of 1916 has not been substantially altered, and remains as a description of the principles under which the tax has continued to be collected. The machinery by which the duty is levied is provided by an enactment that no person is to be admitted for payment to any entertainment except with a ticket stamped with a stamp denoting that the proper duty has been paid, or (in special cases with the approval of the commissioners of customs and excise) through a barrier which automatically registers the number of persons admitted. An exception is made in cases where the proprietor of the entertainment makes arrangements approved by the authorities for furnishing returns of the payments made for admission, and gives security for the due payment of the duty.

"Entertainment" includes any exhibition, performance, amusement, game or sport to which persons are admitted for payment. The duty, however, is not charged in any of the following cases:

(*a*) Where the whole of the takings are devoted to philanthropic or charitable purposes without any charge on the takings for any expenses of the entertainment; (*b*) Where the entertainment is of a wholly educational character or is provided by a school not conducted for profit; (*c*) Where the entertainment is intended only for the amusement of children and the charge for admission does not exceed one penny per head; (*d*) Where the entertainment is provided for educational or scientific purposes by a society not seeking to make profit, or with the object of reviving national pastimes. If the whole of the proceeds are devoted to philanthropic or charitable purposes, and the expenses of the entertainment do not exceed 30% of the receipts, the duty paid is repaid to the proprietor on proof of the facts. A "proprietor" for the purposes of the duty is defined as including any person responsible for the management of the entertainment.

The duty is not charged in respect of entertainments consisting solely of an exhibition (1) of the products of an industry, or of materials, machinery, appliances or foodstuffs used in the production, or displays of skill by workers in the industry; or (2) of works of graphic art, sculpture, and arts craftsmanship, executed and exhibited by persons who practise graphic art, sculpture or arts craftsmanship for profit and as their main occupation, or of displays of skill by such persons in such arts or crafts; or (3) of articles or displays of skill which are of material interest in connection with the public health. Failure to comply with the requirements of the act involves the person admitted in a penalty of £5, and the proprietor in a penalty of £50 in respect of each offence. In the case of subscriptions to clubs or societies which include the right of admission to entertainments, the duty is payable on the amount of the subscription or on such part thereof as the commissioners consider to represent the right of admission to entertainments. Rent paid primarily for the purpose of securing admission to an entertainment (*e.g.*, the rent of a box at the opera) is chargeable to the duty.

It has been held by the courts in England that a musical performance provided during a meal to the guests at a restaurant is not an entertainment within the meaning of the act. On the other hand, where a Masonic festival was held which consisted of a dinner followed by a concert, the concert was held to be an entertainment.

The rate of duty depends upon the amount of the payment for admission. The rates have varied from time to time. Those in force in 1928 were as follows:

Payment exceeding	6d. but not exceeding	7d.	— 1d.
" "	7 " " "	8	— 1½
" "	8 " " "	1/1	— 2
" "	1/1 " " "	1/3	— 3
" "	1/3 " " "	2/0	— 4
" "	2/0 " " "	3/0	— 6
" "	3/0 " " "	5/0	— 9
" "	5/0 " " "	7/6	—1/-
" "	7/6 " " "	10/6	—1/6
" "	10/6 " " "	15/0	—2/-
" "	15/0—2/0 for the first	15/- and 6d. for every 5/- or part of 5/- over 15/-.	

The annual yield of the tax is about £5,750,000.

(J. S. S.)

ENTHUSIASM, a word originally meaning inspiration by a divine afflatus or by the presence of a god. The Gr. *ἐνθουσιασμός*, from which the word is adapted, is formed from the verb *ἐνθουσιάζειν*, to be *ἔνθεος*, possessed by a god (*θεός*). Applied by the Greeks to manifestations of divine "possession," by Apollo, as in the case of the Pythia, or by Dionysus, as in the case of the Bacchantes and Maenads, it was also used in a transferred or figurative sense; thus Socrates speaks of the inspiration of poets as a form of enthusiasm (Plato, *Apol. Soc.* 22 C). Its uses, in a religious sense, are confined to an exaggerated or wrongful belief in religious inspiration, or to intense religious fervour or emotion. In England, and more especially in the 18th century, Enthusiasm was the term applied, not without a suggestion of suspicion or contempt, to emotional or fanatical religion. Enthusiasm, says Locke, is "founded neither on reason nor divine revelation," but rises "from the conceits of a warmed or over-weening brain"; it is, says Johnson, "A vain belief of private revelation; a vain confidence of divine favour or communication." But in modern usage enthusiasm has lost its peculiar religious significance, and means a whole-hearted devotion to an ideal, cause, study or pursuit.

ENTHYMEME, in formal logic, the technical name of a syllogistic argument which is incompletely stated. Any one of the propositions may be omitted, but in general it is that one which is most obvious or most naturally present to the mind. In point of fact the full formal statement of a syllogism is rare, especially in rhetorical language, when the deliberate omission of one of the propositions has a dramatic effect. Thus the suppression of the conclusion may have the effect of emphasizing the idea which necessarily follows from the premises. Far commoner is the omission of one of the premises which is either too clear to need statement or is such that its omission is desirable. This use of the word differs from Aristotle's original application of it to a syllogism based on probabilities or signs (*ἐξ εἰκότων ἢ σημείων*); *i.e.*, on propositions which are generally valid (*εἰκότα*) or on particular facts which may be held to justify a general principle or another particular fact (*Anal. prior β* xxvii. 70 a 10).

See text-books on logic; Sir W. Hamilton's *Discussions;* Mansel's ed. of *Aldrich*, Appendix F; H. W. B. Joseph, *Introd. to Logic;* A. Wolf, *Essentials of Logic* (1926).

ENTOMOLOGY (Gr. *ἔντομα*, insects, and *λόγος*, a discourse), the science that treats of insects, *i.e.*, of the animals included in the class Insecta of the great phylum Arthropoda. The term, however, is somewhat elastic in its current use, since students of centipedes and spiders are often reckoned among entomologists. As the number of species of insects is believed to exceed that of all other animals taken together, it is no wonder that their study should form a special division of zoology.

Beetles (Scarabaei) are the subjects of some of the oldest sculptured works of the Egyptians, and references to locusts, bees and ants are familiar to all readers of the Hebrew scriptures. The interest of insects to the eastern races was, however, economic, religious or moral. The science of insects began with Aristotle, who included in a class "Entoma" the true insects, the arachnids and the myriapods, the Crustacea forming another class ("Malacostraca") of the "Anaema" or "bloodless animals." For nearly 2,000 years the few writers who dealt with zoological subjects followed Aristotle's lead.

The foundations of modern entomology were laid by a series of wonderful memoirs on anatomy and development published in the 17th and 18th centuries. Of these the most famous are M. Malpighi's treatise on the silkworm (1669) and J. Swammerdam's *Biblia naturae*, issued in 1737, 50 years after its author's death, and containing observations on the structure and life-history of a series of insect types. Aristotle and Harvey (*De generatione animalium*, 1651) had considered the insect larva as a prematurely hatched embryo and the pupa as a second egg. Swammerdam, however, showed the presence under the larval cuticle of the pupal structures. His only unfortunate contribution to entomology—indeed to zoology generally—was his theory of pre-formation, which taught the presence within the egg of a perfectly formed but miniature adult. A year before Malpighi's great work appeared, another Italian naturalist, F. Redi, had disproved by experiment the spontaneous generation of maggots from putrid flesh, and had shown that they can only develop from the eggs of flies.

Meanwhile the English naturalist, John Ray, was studying the classification of animals; he published, in 1705, his *Methodus insectorum*, in which the nature of the metamorphosis received due weight. Ray's "Insects" comprised the Arachnids, Crustacea, Myriapoda and Annelida, in addition to the Hexapods. Ray was the first to formulate that definite conception of the species which was adopted by Linnaeus and emphasized by his binominal nomenclature. In 1735 appeared the first edition of the *Systema naturae* of Linnaeus, in which the "Insecta" form a group equivalent to the Arthropoda of modern zoologists, and are divided into seven orders, whose names—Coleoptera, Diptera, Lepidoptera, etc., founded on the nature of the wings—have become firmly

established. The fascinating subjects of insect bionomics and life-history were dealt with in the classical memoirs (1734–42) of the Frenchman, R. A. F. de Réaumur, and (1752–78) of the Swede, C. de Geer. From the 18th century until the present day, it is only possible to enumerate the outstanding features in the progress of entomology. In the realm of classification, the work of Linnaeus was continued in Denmark by J. C. Fabricius (*Systema entomologica*, 1775), and extended in France by G. P. B. Lamarck (*Animaux sans vertèbres*, 1801) and G. Cuvier (*Leçons d'anatomie comparée*, 1800–05), and in England by W. E. Leach (*Trans. Linn. Soc.* xi., 1815). These three authors definitely separated the Arachnida, Crustacea, and Myriapoda as classes distinct from the Insecta. The work of J. O. Westwood (*Modern Classification of Insects*, 1839–40) connects these older writers with their modern successors. Among the latter F. Brauer (1885) laid the foundations of the system of classification used to-day and recognized the fundamental division of insects into the two subclasses Apterygota and Pterygota. Further advances were made by D. Sharp (1899), who first showed the importance of external and internal methods of wing-growth in classification, and other systems were formulated by C. Börner (1904) and A. Handlirsch (1908).

In the anatomical field the work of Malpighi and Swammerdam was at first continued most energetically by French students. P. Lyonnet had published in 1760 his elaborate monograph on the goat-moth caterpillar, and H. E. Strauss-Dürckheim in 1828 issued his great treatise on the cockchafer. But the name of J. C. L. de Savigny, who (*Mém. sur les animaux sans vertèbres*, 1816) established the homology of the jaws of all insects whether biting or sucking, deserves especial honour. Many anatomical and developmental details were carefully worked out by L. Dufour (in a long series of memoirs from 1811–60) in France, by G. Newport ("Insecta" in *Encyc. Anat. and Physiol.*, 1839) in England, and by H. Burmeister (*Handbuch der Entomologie*, 1832) in Germany. Through the 19th century, as knowledge increased, the work of investigation became necessarily more and more specialized. Anatomists like F. Leydig, F. Müller, B. T. Lowne and V. Graber investigated in detail some one species or special points in the structure of some particular organs, using in elucidation the ever-improving microscopical methods of research. These investigators were followed by researchers in various fields; among the more notable, B. Grassi, J. Kunckel d'Herculais, A. S. Packard, A. Berlese and F. Silvestri. One of the most important advances in general entomology is due to J. H. Comstock who, with his collaborator, J. G. Needham, laid the foundations of our modern conception of wing-venation, replacing the existing chaos by an orderly system. Among other important landmarks are N. Wagner's discovery of paedogenesis in the gall midge *Miastor* (1863): P. Marchal's discovery of polyembryony in the Chalcids (1898) and F. Silvestri's subsequent researches in that subject. The last mentioned investigator's discovery of the obscure orders Protura in 1907 and the Zoraptera in 1913 is also notable. The difficult subject of the internal changes undergone in the late larva and pupa during metamorphosis is essentially a modern study. Since A. Weismann (1864), J. Van Rees (1885) and A. Kowalevski (1871) laid the basis of these investigations, notable advances have been made by J. Anglas (1900), C. Perez (1902–20), A. Berlese (1900) and others.

The embryology of insects is entirely the study of the last century. C. Bonnet indeed observed in 1745 the virgin reproduction of Aphides, but it was not until 1842 that R. A. von Kolliker described the formation of the blastoderm in the egg of the midge *Chironomus*. Later A. Weismann traced details of the growth of embryo and pupa among Diptera, and A. Kowalevski, in 1871, first described the formation of the germ layers in insects. Further progress in embryology resulted from improvements in technique, and in Germany the subject has attracted a large band of workers among whom V. Graber, K. Heider, R. Heymons, O. Bütschli and H. Henking, may be mentioned. In Russia, N. Kholodkovski was an early embryologist of note and in the United States the researches of W. M. Wheeler are important.

The work of de Réaumur and de Geer in the bionomics and life-history of insects has been continued by numerous observers, among whom may be specially mentioned in France E. Perris, J. H. Fabre, C. Janet and C. Ferton. In England the early workers, W. Kirby and W. Spence, were followed by J. Lubbock (Lord Avebury), L. C. Miall, D. Keilin and others. In the United States a large number of life-histories were elucidated by C. V. Riley; A. S. Packard studied the Lepidoptera, while, concerning Hymenoptera, W. M. Wheeler and G. W. and E. G. Peckham made significant contributions. Experimental entomology is a relatively new and growing subject attracting many workers to-day. M. Standfuss, F. Merrifield and E. B. Poulton have studied problems of coloration in this connection, while the effects of temperature and other factors have been investigated by P. Batchmejew and others. The past history of insects has also attracted attention. One of the first significant contributions was made by O. Herr (1847–53); S. H. Scudder has studied the insect remains in American rocks, while in Europe, C. Brongniart and A. Handlirsch are outstanding names; fossils of Australia and elsewhere have been studied with conspicuous ability by R. J. Tillyard.

In the last 30 years or so there have been remarkable developments in the study of insects in relation to man and his welfare, and the subject of Economic Entomology (*q.v.*) has assumed a position of commanding importance. The investigations of insects from the purely utilitarian aspect has also proved a far reaching stimulus to entomology, which to-day can claim a larger band of students and devotees than any other branch of zoology.

After the publication of C. Darwin's *Origin of Species* (1859) a fresh impetus was given to entomology as to all branches of zoology, and it became generally recognized that insects form a group convenient and hopeful for the elucidation of certain problems of animal evolution. The writings of Darwin himself and of A. R. Wallace (both at one time active entomological collectors) contain much evidence drawn from insects in favour of descent with modification. The phylogeny of insects has since been discussed by F. Brauer, A. S. Packard, A. Handlirsch and many others; mimicry and allied problems of coloration by H. W. Bates, F. Müller, E. B. Poulton, M. C. Piepers, and G. A. K. Marshall; the bearing of insect habits and structure on theories of selection by A. Weismann, G. W. and E. Peckham, G. H. T. Eimer and others: variation was the subject of studies by W. Bateson and M. Standfuss; while problems of heredity have been investigated through the medium of insects by T. H. Morgan and his colleagues, L. Doncaster, R. Goldschmidt and others.

Societies for the discussion and publication of papers on entomology became established as the number of students grew larger. The Société Entomologique de France was founded in 1832 and the Entomological Society of London in 1833, similar societies were founded in Breslau in 1839, Holland in 1845, Belgium in 1855, while one of the first American societies was that of Philadelphia, founded in 1859. In Europe the development and progress of such societies have been largely due to the efforts of men who devoted their leisure time to entomology, though in America it is the professional entomologist who figures largest in such activities. Recognition of the scientific and educational value of entomology as a branch of zoology is a very recent development and has in the main been stimulated by the growing importance of the economic aspects of the subject.

The great amount of literature on entomology that appears annually in various languages far exceeds that on any other branch of zoology. H. A. Hagen's *Bibliotheca Entomologica* (Leipzig, 1862–63) catalogues all publications up to 1863, while the yearly volumes of the *Zoological Record*, commencing in 1864, keep the student abreast of the times. An account of the labours of Malpighi, Swammerdam, and other early entomologists is given in L. C. Miall's *Lives of the Early Naturalists* (1912) and in L. F. Henneguy's *Les Insectes* (1904). Among scientific periodicals devoted to general entomology the *Transactions of the Entomological Society of London* and the *Entomologist's Monthly Magazine* are the leading English journals. In France the *Bulletin and Annales de la Société Entomologique de France* occupy first place. Among North American periodicals the *Canadian Entomologist*, *Proceedings of the Entomological Society of Washington*, and the *Annals of the Entomological Society of America* may be mentioned. References to the chief literature on entomology are given in the article INSECTS and in those articles devoted to the separate orders.

(G. H. C.; A. D. I.)

ECONOMIC ENTOMOLOGY

Economic entomology is the name given to the study of insects in their relations to man, his domestic animals and crops, and of the practical methods by which the activities of the injurious species may be counteracted. The subject also takes into account those insects that are beneficial to man, either with respect to certain economic products which they yield, such as silk, wax and lac, or as agents in controlling other insects which have injurious propensities. It is convenient, therefore, to deal with insects of economic importance under two categories; *i.e.*, species that are injurious and those which are beneficial.

INJURIOUS INSECTS

Injurious insects include members of almost all orders and comprise species which destroy cultivated plants and forest trees, others which injure grain and stored products, manufactured goods and raw materials; there are again species which infest domestic animals as well as those which molest or harm man himself. An idea of the losses occasioned by insect pests may be gained from the following figures. The Mexican cotton-boll weevil is estimated to cost the cotton-growing States of North America from £20,000,000 to £30,000,000 annually; the codling moth causes over £2,400,000 loss to fruit growers in the United States each year; rice leaf-hoppers in 1914 entailed a loss of nearly £1,000,000 in one division only of the Central Provinces of India. In Great Britain the ox warble fly has been estimated to injure hides to the extent of £400,000 per annum and the frit fly to destroy eight bushels of oats in each acre grown in an average year. The aggregate losses from insect pests to farm crops alone in the United States were estimated to amount in 1912 to a sum greater than the total cost of education in that country for the same year.

It has to be remembered that the very methods man has adopted in civilization favour the multiplication and spread of insect pests. The cultivation of large areas of country devoted to the production of a single crop provides unlimited means for the rapid multiplication of pests affecting that crop; at the same time the growth of railroad and maritime communications facilitates the spread of insects from one country into another. From among 73 of the worst insect pests of the United States, 37 have been introduced from foreign countries. Of these latter most of them have entered America unaccompanied by natural enemies that help to keep them in check in the lands whence they originally came. The European corn borer, cotton-boll weevil, San José scale, gypsy and brown-tail moths, alfalfa weevil, oriental peach moth and Japanese beetle, along with other pests, have all entered the United States from foreign lands, and have found conditions highly favourable to their multiplication and spread. Similarly the woolly aphis and greenhouse white-fly are believed to have entered the British Isles and other European countries from abroad, the grape-vine Phylloxea, a North American insect threatened in 1870 to destroy vine culture in Europe, and quite recently the Colorado potato beetle has become established in the Gironde area of France. Quarantine regulations, if strict, do much to preclude the entry of foreign pests into a country, but the innate difficulties attending the total exclusion of such immigrants are too great for legislative methods to be anything more than only partially effective.

Some of the more important insect pests are enumerated below, while further information is given in the separate articles devoted to the various orders to which these pests belong.

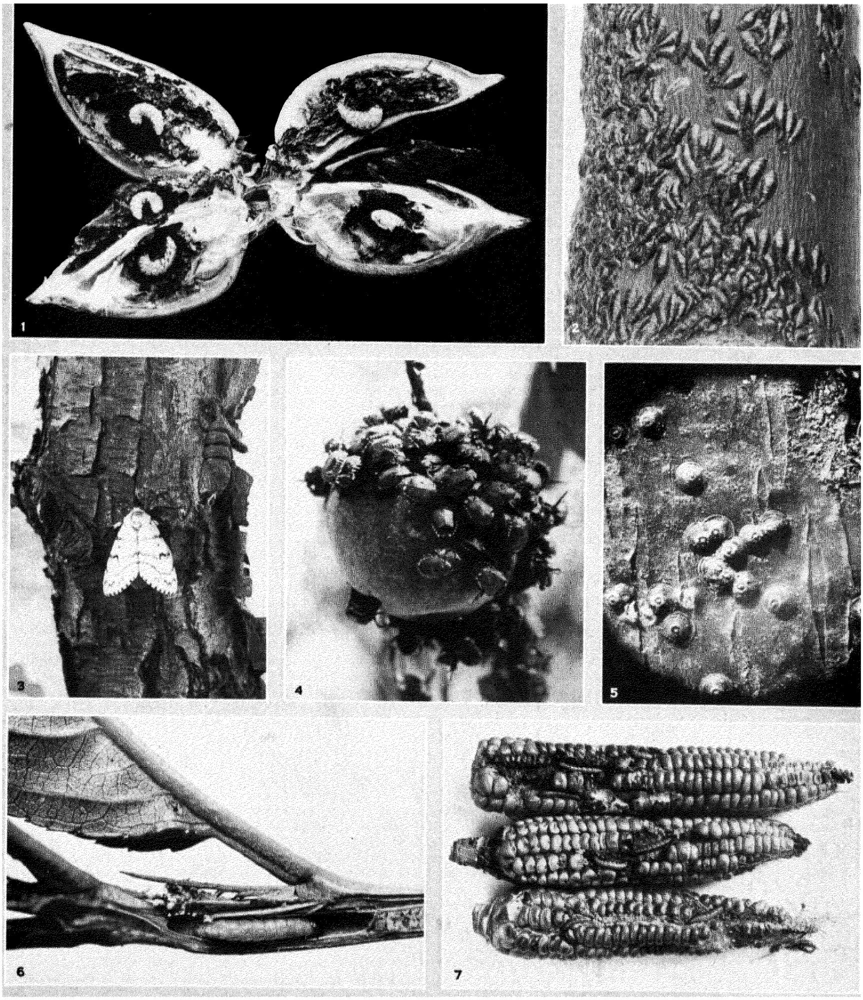
Insects Affecting Cultivated Crops.—Among the more important pests of cereals, frit fly (*Oscinella frit*) takes a serious toll of oats and to a lesser degree wheat, barley and rye over most of Europe, and the gout fly (*Chlorops taeniopus*) attacks barley. Wireworms or injurious larvae of click beetles (family *Elateridae*) attack the roots, not only of cereals but of many other crops also, and at times cause great damage. Among other pests, the Hessian fly (*Mayetiola destructor*) attacks wheat on both sides of the Atlantic, while the chinch bug (*Blissus leucopterus*) is exceedingly destructive to all kinds of cereals and grasses over eastern North America. Caterpillars of the type known as army worms and cut worms, together with locusts (*q.v.*) are important enemies of many crops in various parts of the world. The European corn borer (*Pyrausta nubilalis*) is an Old World pest of maize and other plants, but since 1917, when it was discovered near Boston (Mass.), it has become one of the worst of all immigrant insects found in the United States and Canada, where it now threatens the very existence of the maize crop and has largely resisted attempts to check its ravages and increasing spread.

Clovers and lucerne are subject to injury from various insects especially root-feeding larvae of weevils (*Sitona*); although lucerne is relatively free from serious pests in Europe, the alfalfa weevil (*Phytonomus posticus*) is a major pest in Utah, Colorado and adjacent States, having been imported from Europe. Vegetables suffer many pests and certain of these occur in both Europe and North America, notable examples being the onion fly (*Hylemyia antiqua*), the cabbage root fly (*Pegomyia brassicae*), carrot fly (*Psila rosae*), the asparagus beetle (*Crioceris asparagi*) and the cabbage white-butterflies (*Pieris*). In the United States curcubitaceous plants suffer heavily from the striped cucumber beetle (*Diabrotica vittata*) and the squash bug (*Anasa tristis*). In Great Britain and most parts of Europe the potato is singularly free from pests of the foliage, but in North America it is consistently attacked by the Colorado beetle (*Leptinotarsa decemlineata*). Beans, mangolds and sugar-beet are infested by the bean aphis (*Aphis rumicis*) over much of Europe, while flea beetles (*Phyllotreta spp.*) riddle the foliage and destroy seedling turnips, mangolds and other crops.

The cotton crop in many parts of the world has a formidable enemy in the pink boll-worm (*Pectinophora gossypiella*), while bugs of the genus *Dysdercus* known as cotton stainers also cause great damage, especially in the West Indies. The Mexican cotton-boll weevil (*Anthonomus grandis*) is one of the most severe of all insects affecting this crop, but is confined to Central America and the United States. In the latter country vast sums of money are annually spent in combating it. Sugar cane is especially attacked by moth borers, notably the widely spread species *Diatraea saccharalis*. Other moth borers include *Chilo simplex* in India, where it is a most important enemy of the crop, and the grey borer (*Laspeyresia schistaceana*) of Java. The borer weevil (*Rhabdocnemis obscura*) attacks not only sugar cane, but also banana and various palms all over the tropics, while in Trinidad, the frog-hopper (*Tomaspis saccharina*) causes immense damage and is exceedingly difficult to control. At one time the leaf-hopper (*Perkinsiella saccharicida*) threatened the existence of the sugar cane industry in the Hawaiian Islands until it became effectually suppressed by biological methods of control.

In North America tobacco suffers from the flea beetle (*Epitrix parvula*) and caterpillars of hawk moths among other pests. In Ceylon tea is affected by the shot-hole borer beetle (*Xyleborus fornicatus*), while in Assam the Capsid bug *Helopeltis theivora* is a major pest locally known as tea blight. Coffee has numerous pests including moth borers, beetle borers, leaf-miners and numerous scale insects.

The insect enemies of fruit and fruit trees would require several columns for their enumeration alone. Scale insects are of great importance in many lands. The San José scale (*Aspidiotus perniciosus*) in warm climates attacks all fruit and many other kinds of tree and multiplies with great rapidity. In North America it is a permanent enemy, extending all over the United States and into southern Canada. The fluted scale (*Icerya purchasi*) of Australia has spread throughout the world wherever citrus fruits are grown, but is effectively controlled by biological measures. Citrus fruits suffer from many other scale insects and from mealy bugs. In California several species of these pests are being repressed by biological measures, but spraying and fumigating under tents are resorted to on a large scale also. Among aphides the woolly aphis (*Eriosoma lanigera*) of the apple is prevalent in all parts of the world wherever that fruit is extensively cultivated, and mention must also be made of the Phylloxera of the vine (*q.v.*). Among beetle pests the plum curculio (*Conotrachelus nenuphar*) is well known in North America, where the recently introduced Japanese beetle (*Popillia japonica*) skeletonizes the leaves and destroys the fruit of many trees and shrubs; its larvae,



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INSECT PESTS AFFECTING AMERICAN TREES AND CROPS

1. Mexican boll weevil (*Anthonomus grandis*) showing larva and pupa, the most destructive pest affecting the cotton crop in the U.S.A. 2. Oyster shell scale (*Mytilaspis pomorum*) or bark louse. The insect lives under the shell-like covering feeding on the sap of the tree. 3. Gipsy moth (*Porthetria dispar*), an enemy of fruit trees. This insect, of recent appearance in America, is being combated by government aid. 4. Japanese beetles (*Popillia japonica*) devouring a peach. These pests likewise consume the leaves of fruit trees, and the larvae are destructive below ground to roots of grasses. 5. San José scale (*Aspidiotus perniciosus*) on the bark of fruit tree. The insect feeds on the leaves and sap of many trees and shrubs. 6. European corn-borer (*Pyrausta nubilialis*) lodging in a weed. The moth lays its eggs on the leaf or stalk. Larva and pupa develop in the stem and bore toward the grain or ear of corn. 7. The corn-borer feeding in ears of maize. This insect threatens the most valuable crop of the United States, Indian corn. Measures to check its spread include destruction of stalks after harvesting and introduction of the European parasites of the borer

it may be added, are destructive below ground to lawns and golf-greens. In Europe the apple blossom weevil (*Anthonomus pomorum*) destroys the opening flower buds, and among moth pests, caterpillars of the winter moth (*Cheimatobia brumata*) and other Lepidoptera destroy the foliage of various fruit trees; in North America those known as canker worms and tent caterpillars are exceedingly destructive. Since 1916 the oriental peach moth (*Laspeyresia molesta*) has become an immigrant pest attacking plum, cherry, peach, quince and apple with great severity in the eastern United States. The stem borer leopard moth (*Zeuzera pyrina*) attacks both fruit and shade trees in several parts of the world, while the codling moth (*Cydia pomonella*) has spread throughout the world where the apple is cultivated and causes vast damage by its caterpillars, boring into the fruit. Among fly pests the Mediterranean fruit fly (*Ceratitis capitata*) and its allies attack an enormous variety of succulent fruits in most warm countries with the exception of California. Other pests include the pear fruit midge (*Contarinia pyrivora*) and the pear leaf midge (*Perrisia pyri*). Hymenopterous pests include various sawfly caterpillars attacking apple, pear, cherry, gooseberry and currants, and most species occur in both Europe and North America.

Insects Affecting Forest and Shade Trees.—In Europe the oak and other forest trees suffer defoliation by various caterpillars, notably those of the pea green moth (*Tortrix viridana*), nun moth (*Lymantria monacha*) and of numerous Geometers such as the pine moth (*Bupalis piniaria*), winter moth (*Cheimatobia brumata*), march moth (*Anisopteryx aescularia*) and mottled umber moth (*Hibernia defoliaria*). In America the gypsy moth (*Porthetria dispar*) and the brown-tail moth (*Euproctis chrysorrhoea*) have both been accidentally introduced from Europe and defoliate a great variety of trees. The first-mentioned species especially has entailed and is still entailing enormous expense in efforts to control its spread; already about £5,000,000 have been devoted to destroying these two pests by the legislatures of the eastern States, apart from very large allocations of Federal money for the same purpose. The European elm-leaf beetle (*Galerucella luteola*) is another serious defoliator, and in parts of the United States thousands of fine elms have been killed by this insect. Sawfly caterpillars of various species are very destructive defoliators of larch and other coniferas on both sides of the Atlantic, and these same trees also suffer heavily from shoot-destroying moth larvae, notably, the pine-shoot moth (*Evetria buoliana*) in Europe and restricted regions in the United States, and the spruce and balsam bud-worm (*Harmolegia fumiferana*), in the United States and Canada. Great injury to conifers is also caused by aphides of the genus *Chermes* and its allies. Perhaps the most severe of all forest pests are the bark and ambrosia beetles (*Scolytidae*), which attack conifers and to an extent some broad-leafed trees. The species *Dendroctonus ponderosae* is stated to have destroyed in 1919 more than a billion cubic feet of timber in the Black Hills forest reserve in the United States. Other species are almost equally destructive both in the United States and Canada and probably few coniferous forests in any part of the world are exempt from the depredations of these beetles.

The solid wood of all types of tree is infested with timber-boring larvae of Buprestid and Longicorn beetles, particularly in warm countries where these two families attain their maximum development. It is estimated that 1,200,000 cu.ft. of Sal timber is damaged annually in the Indian forests by the Longicorn, *Hopolcerambyx spinicornis*. In many parts of the world timber is injured by wood-wasps (*Siricidae*) and wood-boring moth larvae, notable examples of the latter belong to the family *Cossidae*, which includes the leopard moth, goat moth and the bee-hole borer of teak. Mention must also be made of the pine weevil (*Hylobius abietis*), which is exceedingly destructive to young conifers in Great Britain.

Insects Affecting Stored Products and Manufactured Goods.—Most of the insects which come under this category are cosmopolitan pests that are readily transferred from one country to another through commerce. Among the many pests of stored grain, flour and meal, the granary weevils (*Calandra granaria* and *oryzae*) are among the best known, while the mealworms (*Tenebrio*) and the saw-toothed grain beetle (*Silvanus surinamensis*) also occur with great frequency. Among moths, the caterpillars of the Mediterranean flour moth (*Ephestia kuehniella*) and the Indian meal moth (*Plodia interpunctella*) render flour and meal unfit for consumption, while the caterpillars of the Angoumois grain moth (*Sitotroga cerealella*) attack grain in the field as well as in storage.

Among pests which attack clothing and carpets, the clothes moths (*Tinea pellionella* and *Tineola biselliella*) are well known and their larvae also attack wool, hair, feathers and dried skins. Beetles of the genera *Anobium* and *Xestobium* bore into furniture and the rafters of old buildings, and the larder beetle (*Dermestes lardarius*) and its allies infest skins, wool, meat, ham and cheese. Stored and manufactured tobacco is attacked by the cigarette beetle (*Lasioderma serricorne*) and dried museum specimens of natural objects by the beetle *Anthrenus scrophulariae*, which also attacks carpets and other materials. Drugs such as aconite and opium, together with biscuits, chocolate, pepper, ginger and many other substances, are infested by *Sitodrepa paniceum*, which is often known as the drugstore beetle.

Insects Affecting Domestic Animals.—Among the most important of these are the ox warble flies (*Hypoderma*), which are prevalent throughout Europe, North America and other parts of the world. They occasion great losses to cattle raisers by the presence of the grubs beneath the skin which cause irritation and deterioration of the flesh, reduction of milk and perforation of the hides; anaphylactic shock may also result when the grubs under the skin are crushed, and illness or even death of the host may supervene. The sheep *bot-fly* (*Oestrus ovis*) is of worldwide distribution and its larvae infest the sinuses of the head; sheep also suffer from the ked or "tick" (*Melophagus ovinus*) which causes irritation and loss of flesh, and is especially harmful to lambs. The sheep-maggot flies of Australia cause immense losses through their larvae infesting the wool and skin and causing septic wounds. Horses and mules are very prone to attack from bot flies of the genus *Gastrophilus* and their larvae infest the throat, stomach and intestines, attaching themselves to the lining walls of the parts concerned. In Russia the flesh fly (*Sarcophaga magnifica* [*Wolfarti*]) causes great suffering to domestic animals, owing to even the smallest wound becoming infested with its larvae. The screw-worm fly (*Chrysomyia macellaria*) is a very similar type of pest in the south-west United States and its larvae often cause fatal injuries. Lice or Siphunculata are irritating blood-sucking ectoparasites which cause wasting of the flesh when very numerous: horses, cattle and swine are all liable to infestation. Biting lice or Mallophaga are particularly irritating pests of poultry and some species also infest domestic animals; lastly, fleas of various kinds occur on domestic animals and birds.

Insects Affecting Man.—Many kinds of flies and certain other insects harm or molest man himself in various ways: some of these are merely irritating or annoying, while others act as agents, conveying the pathogenic organisms of some of the most virulent diseases from one person to another. For a discussion of this subject the reader is referred to MEDICAL ENTOMOLOGY and PARASITOLOGY.

Insect Vectors of Plant Diseases.—During recent years it has become increasingly evident that certain insects disseminate diseases among plants. Several bacterial diseases, such as fire blight of apples and pears and wilt diseases in other plants, are known to be spread from plant to plant by insects. The recently recognized group of virus diseases known under the names of mosaic, leaf curl and leaf roll, have been shown in some cases to be conveyed from diseased to healthy plants by the punctures of sap-sucking Hemiptera. Thus, curly top in beet is transmitted by the leaf hopper, *Eutettix tenella*, sugar-cane mosaic by the aphid, *Aphis maidis*, and aster yellows disease by the leaf-hopper, *Cicadula sexnotata*. Recent research points to the growing importance of virus diseases, and their transmission by insects, in plant pathology.

BENEFICIAL INSECTS

It is only too often overlooked that man derives vast direct and indirect benefits from insects. Practically every species is preyed upon and kept within bounds by the attacks of other insects, either

parasites or predators, while bacterial and protozoal diseases, birds and insectivorous mammals, also contribute to the destruction of a large bulk of insect life. But for these natural controls man would stand little chance of successfully competing with insects in maintaining his food supply. Among predators, ground beetles and ladybirds along with their larvae, together with larvae of lacewings and many flies, are of great importance, but the palm of efficiency must be allotted to the parasitic forms such as Tachinid flies, and almost all members of the great groups of parasitic Hymenoptera, which probably account for the destruction of a greater proportion of insect life than we have adequate means of appreciating. The importance of these predators and parasites is becoming increasingly recognized by economic entomologists, and is further discussed in the succeeding section on control measures.

There is also to be recollected the fact that insects are the most important of all agents concerned with the pollination of flowers. In the case of fig-growing the flowers of the cultivated fig need to be pollinated from the wild or caprifig. The structure of the fig flower is such that pollination requires to be carried out by the intervention of a small Chalcid *Blastophaga*. In California and elsewhere profitable fig-growing did not become possible till this insect was introduced and established so that it could carry out its useful work. One need scarcely mention the enormous benefits man has derived from the use of honey, beeswax and silk. Lac, which is still an important commercial product, and has not been supplanted by any artificial substitute, is yielded by the Indian scale insect (*Tachardia lacca*). Cochineal is yielded by another Coccid, *Dactylopius coccus,* indigenous to Mexico, but now established in other lands, and the drug cantharidin is obtained from blister beetles (family *Cantharidae*). Again, several kinds of insect are used as ornaments, such as the ground pearls of the West Indies and the Buprestid beetles of the Orient and South America, while many showy butterflies and beetles are used for various decorative purposes. Finally, a number of insects are, or have been, used by uncivilized man as food. Apart from manna of biblical times—which is almost certainly a kind of honey dew—grasshoppers, caterpillars, water-boatmen and termites are used as food by various races. Many aquatic insects are important items in the diet of fresh-water fishes, and other insects are used by anglers as bait.

Another possible benefit to be derived from insects is their utilization in checking the spread of noxious weeds resisting all other measures of restraint. Success in this field has been achieved in the Hawaiian Islands, in checking the spread of *Lantana* by introducing into that territory insects which prey upon that plant in its natural home in Mexico. Strenuous and encouraging efforts are being made to control prickly pear in Australia by similar means, and experiments are being carried out with a view to attempting the control of blackberry, gorse and other noxious weeds in New Zealand by insects imported from other parts of the world. Work of this character has its drawbacks and every care has to be exercised lest the introduced species may turn their attention to economic plants and so become pests rather than benefits to the countries concerned.

CONTROL MEASURES

Methods of controlling noxious insects are very diverse and are discussed under four headings below.

Cultural Methods.—Cultural methods as a rule involve some change in the normal course of agricultural operations and frequently they have the advantage of being preventive rather than remedial in effect. Such methods aim at enabling the crop to escape the severity of attack by a specific pest by altering the time of sowing, by special type of cultivation or manuring, by changing the rotation so that the susceptible crop occupies a different place in the rotation scheme, or by the use of a less susceptible variety of the crop concerned. It is also to be remembered that many pests are concealed feeders and are, therefore, safe from the effects of insecticidal treatment, or the crop may be of such a character as to render such treatment impossible. As examples of cultural measures the following are noteworthy. The only satisfactory means of coping with the frit fly consists in sowing sufficiently early, so that by the time the insect appears the crop has reached a stage when it is not liable to attack. Attacks of wheat bulb fly (*Hylemyia coarctata*) may be avoided by never allowing that crop to follow a summer fallow or early potatoes, since the eggs are laid in the bare soil or on ground sparsely covered by a growing crop. Again, American vines are largely resistant to the gallicolae generations of the Phylloxera, certain varieties of cotton are resistant to attacks by leaf-hoppers, and apples grown on North Spy stocks are not liable to attack by woolly aphis. Manuring with nitrogenous fertilizers has been shown to facilitate the recovery of tea from attacks of the shot-hole beetle borer in Ceylon, and phosphatic manures appear to hasten the maturing of the ears of barley to a condition which is less liable to attack by gout fly. In Trinidad the control of the sugar-cane frog-hopper is no longer an entomological problem, but is one of cultivation. Under conditions where the water content of the soil is disturbed, it is probable that the constitution of the sap of the plants is altered and that water shortage is a possible cause of increased susceptibility to frog-hopper damage.

Physico-chemical Methods.—Most measures which come under this category are remedial rather than preventive and the most important involve the application of chemical substances termed insecticides. Insecticides may be divided into stomach poisons, contact poisons, fumigants and winter washes. Many of them may be applied either in the form of wet sprays or as dusts.

Stomach poisons are effective against biting insects which devour foliage, and their object is to coat the plants with a toxic substance which the insects will devour, along with their food. In the application of sprays the essential basis, therefore, is the toxic compound, but other material (soap, etc.) has to be added in order to facilitate the mixing of such a compound with water and to ensure its spreading over and effectively wetting the foliage. Among the best-known stomach poisons are arsenicals, especially Paris green, lead arsenate and calcium arsenate.

Contact poisons are used against sucking insects which derive their nutriment from the sap. It is evident that coating the plant with an external poison will have little effect against pests of this character and consequently contact insecticides, which kill by being applied to the outsides of the insects themselves, become necessary. The most valuable of all contact insecticides is nicotine, which is largely used in the form of nicotine sulphate at the rate of one gallon of the compound (containing 40% nicotine) to about 800 to 1,000gal. of water. Among other contact insecticides pyrethrum, derris, quassia, oil-emulsions, soaps and lime-sulphur are used for various pests.

Fumigants are effective in glasshouses, warehouses and also for treating living trees in the field, in which case the plants are covered with special hoods or tents for the purpose. Hydrocyanic acid gas is one of the best-known fumigants for glasshouse work throughout the world; carbon disulphide is put to various uses and is also applied against root pests in the soil. Among other fumigants, nicotine, carbon tetrachloride, chlorpicrin and paradichlor-benzene may be mentioned.

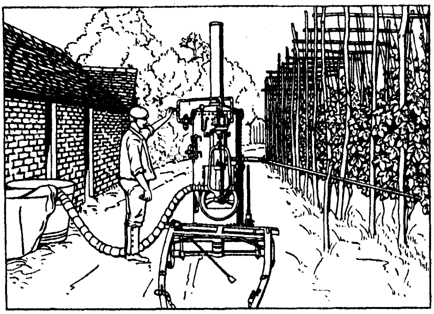
BY COURTESY OF THE IMPERIAL WAR MUSEUM

FIG. 1.—KNAPSACK SPRAYER, SUITABLE FOR LIQUID INSECTICIDES AND IN GENERAL USE FOR SPRAYING POTATO CROPS AGAINST BLIGHT

Winter washes are applied during the dormant season and are designed to kill the eggs and other over-wintering stages of insects present upon the trunks and branches of fruit trees. Such washes include caustic alkalis, lime-sulphur, miscible oils and tar distillate compounds.

The usual method of applying insecticides is in the form of sprays, and on a small scale, knap-sack sprayers (fig. 1) which can be carried on the back of the operator, are widely in vogue. On a field scale horse-drawn or mechanically driven machines are necessary (fig. 2) and many patterns are on the market. The nozzles aim at producing the spray in a fine mist and can be fitted

to any length of tubing so as to reach to the tops of high trees if necessary. Pumps keep the insecticide constantly mixed, and at the same time discharge it forcibly through the nozzles wherever it is required. In America the use of insecticides in the form of dusts has come greatly into use during recent years. The toxic compound is used in powdered form, diluted and mixed with a suitable carrier such as kaolin, hydrated lime or ground dolomite.



BY COURTESY OF MERRYWEATHER & SONS, LTD.

FIG. 2.—STEAM SPRAYING PUMP IN KENTISH HOP FIELDS
The pump is a simple, reliable apparatus suited to unskilled hands. It is of the single cylinder direct-acting type, can supply wash for eight jets to spray simultaneously, and weighs 12 cwt.

The dusting can either be done by hand machines or horse-drawn apparatus. In the latter case the dust is expelled by the air blast created by a fan which is geared to the wheels of the machine. At the present time dusting materials are usually more expensive than those required for spraying, but the labour and time consumed are less and the equipment lighter and more easily used on bad ground. Also, the water difficulty—400 to 500gal. being required to spray an acre of fruit trees—is done away with. Dusting, however, can usually only be carried out when the foliage is wet with dew to give adhesion to the particles and is precluded by high winds. During the last seven years the use of the aeroplane has come very much to the front in the United States, particularly for dusting cotton with calcium arsenate against the boll weevil. Many acres of fruit have also been treated by this method, and by applying Paris green, large areas of standing water have been dusted to kill mosquito larvae. The evolution of types of aeroplanes capable of manoeuvring under the special conditions required, has led to rapid advances in this method of control. Before many years elapse it is likely to be widely used in the control of forest pests and locust invasions, and tests have already been carried out in Germany, Russia and other countries. In Great Britain the uses of the aeroplane are very limited, but in the cases of potatoes and fruit where considerable areas are under cultivation, the method has its possibilities. Among the advantages of the aeroplane is speed, it being possible to dust 600 to 1,000ac. in one hour and one plane is capable of doing the work of 50 to 75 cart dusting machines in the same time.

Among other physico-chemical methods the use of heat for killing pests in mills and warehouses is coming to the fore, while in some cases light traps are effective in the quantitative destruction of such pests as the paddy borer. As a rule, however, the expense and trouble of maintaining light traps are not commensurate with the results obtained. The use of attractive volatile reagents has great possibilities as lures, very much on the same principle of the moth collector's sugar mixture. Fermented molasses is used as a bait for the destruction of vine moths in France and geraniol has recently been shown to be powerfully attractive to the Japanese beetle in the United States.

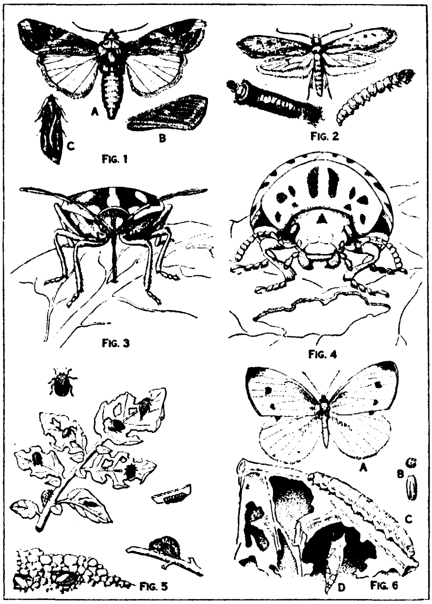
Biological Methods.—Biological or natural methods of control involve the use of parasites, predators, or disease organisms for the purpose of ensuring a high rate of mortality to the particular pest concerned. This type of control has been successful in cases where a noxious insect has been introduced into a country unaccompanied by those natural enemies which restrain it in the land whence it came. The first example of this kind was achieved in 1889, when the Australian ladybird (*Novius cardinalis*) was introduced into California for the purpose of destroying the cushiony scale (*Icerya purchasi*) of citrus fruits. The experiment proved so successful that this method of control has been applied in almost all countries where that pest has been prevalent, with equally satisfactory results. In the Hawaiian Islands almost all the pests of sugar cane have been so effectually controlled by biological means that they are no longer a menace. Special mention needs to be made of the control of the cane leaf-hopper by Chalcid wasps and a Capsid bug (*Cyrtorhinus mundulus*) introduced from Queensland and Fiji. The cane-borer beetle has also been largely kept under control by a Tachinid fly obtained in New Guinea, and the *Anomala* beetle by a Scoliid wasp from the Philippines. Great benefit has been derived from the introduction of a tiny Chalcid (*Aphelinus mali*) from the United States into New Zealand, where it is effectually destroying the woolly aphis of apple. In Fiji the coco-nut moth gives every promise of being controlled by a Tachinid fly which is prevalent in Malaysia. There are again other cases where results have not been so readily obtained, and efforts have been going on for many years to secure some measure of control over the gypsy and brown-tail moths by the importation of a whole range of parasites that attack these insects in their various stages. In the same way likely parts of the world are being searched for parasites of the European corn-borer, the Japanese beetle and other introduced pests of the United States.

Legislative Control.—Legislative control may be broadly divided into two classes—external measures and internal measures. External measures are framed to exclude the entry of foreign pests into a country through commerce, and they form the subject of legislation in most civilized nations. Internal measures take the form of special acts designed for enforcing the adoption of adequate methods of treatment by growers, and are aimed at destroying or restraining the spread of noxious insects within a particular country. The assistance of legislation enables the official entomologist to secure the compulsory application of important measures for the benefit of the community.

GROWTH AND DEVELOPMENT OF ECONOMIC ENTOMOLOGY

Great Britain.—In most civilized countries there now exist services under Government auspices for dealing with insect and other pests of cultivated plants and crops. For many years economic entomology was not officially recognized in Great Britain and the subject was left to the good will of two public-spirited private individuals; viz., John Curtis and Eleanor A. Ormerod. John Curtis's work was coincident with the founding of the Royal Agricultural Society in 1840, and on behalf of that body he prepared a series of reports upon insects affecting various crops for the years 1841 to 1857. Previously he had contributed essays on injurious insects to the columns of the *Gardener's Chronicle* of Lindley, and the experience thus gained from both these activities enabled him to publish his standard book on farm insects in 1860. Eleanor Ormerod carried forward and greatly extended the work of Curtis, and may be rightly regarded as the patron saint of British economic entomology. From 1876 to 1893, in her capacity of honorary consulting entomologist to the Royal Agricultural Society, she accomplished an enormous amount of valuable advisory work. During that period she published at her own expense, 17 well illustrated reports on injurious insects, which did much towards educating the farmers of the country in the matter of crop pests. She also published a *Manual of Injurious Insects* and numerous smaller works. Her efforts made the work of Curtis and the early American entomologists accessible to the agricultural community and she may be truly said to have been the pioneer who laid the basis for future progress in Great Britain. In 1889 the Board of Agriculture was formed and Sir Charles Whitehead was its technical adviser on crop pests and other problems. He issued a number of reports and bulletins up to the year 1894. For some years following the board had no

whole-time technical adviser on entomological matters and sought any assistance needed, mainly from outside quarters. In 1907 the Destructive Insects act of 1877 (which previously only applied to the Colorado beetle) was enlarged so as to enable the board to deal with all pests which may attack crops, trees and bushes. In consequence of passing this act the board created a special staff of inspectors set apart for dealing with plant pests,



1. Fall army worm; A. moth; B. forewing; C. pupae; 2. Clothes moth; 3. Harlequin cabbage bug; 4. Colorado potato bug; 5. Life history of Colorado potato bug; 6. Common cabbage worm; A. female butterfly; B. egg as seen from above and side; C. larva in natural position on cabbage leaf. D. suspended chrysalis

and also an official entomologist with office accommodation in London. In 1909 the passing of the Development Fund act marked a great advance with respect to all problems relating to insects and other pests of cultivated plants. It provided much needed financial resources for a definite scheme for research and advisory work. The development scheme progressed in several stages, and finally led to the establishment of a phytopathological service of England and Wales. The latter is now divided into two sections, one official and the other non-official. The official section is directly controlled by the Ministry of Agriculture (formerly the Board of Agriculture) and is divided into the plant-pathology laboratory at Harpenden, Herts, an administrative unit in London, and an inspectorial staff of about 30 members. The pathological laboratory is under a director who is, at present, also the official Government entomologist, and there is a small staff of entomologists and mycologists. The non-official section is distributed through various universities, colleges and institutes in the country, and consists of research and advisory divisions. Financial provision comes from Government funds, but the actual duties are largely carried out without State supervision. The research division is located among five centres, the most important being the phytopathological research institute attached to the Rothamsted Experimental Station. In addition to workers in mycological subjects, this institute has a permanent staff of four entomologists and is a main centre for entomological investigation in Great Britain. Entomologists are also on the staffs of the Long Ashton Fruit Station, Bristol, the fruit station at East Malling and the Lea Valley station for glasshouse crops at Cheshunt. The advisory division is located in 14 centres or provinces, each centre being established at a university or agricultural college. The advisory staff consists of an entomologist and other specialists in each province, who diagnose troubles on behalf of farmers and carry out experiments in the practical control of pests within the local area concerned.

The Imperial Bureau of Entomology.—A second important development in British economic entomology took place with the founding of the Imperial Bureau of Entomology in 1913. This bureau, whose offices are in London, is supported financially by contributions from the Imperial Government and the Governments of the dominions, colonies and other dependencies of the empire. It issues a monthly review of all current literature bearing on economic entomology in various countries, and a bulletin for the publication of original researches. It also gives advice to entomologists throughout the empire, identifies insects and advises the Colonial Office on appointments and other entomological matters. Under a grant from the Empire Marketing Board it also maintains a parasite laboratory at Farnham Royal, Bucks.

United States.—In the United States economic entomology has advanced to a higher degree of efficiency than in any other country. Most of the important advances in remedial measures have been made in America, where also some of the most exact and thorough life-history studies of insect pests have been traced out. Economic entomology in America may be said to start with T. W. Harris, of Massachusetts, who was probably the first entomologist in that country to receive public compensation for his labours. His now classic report on insects injurious to vegetation appeared in 1841, and was elaborated in 1862 as a treatise in book form; this work is still much consulted by the practical entomologists of the north-eastern section of the country. The first scientific man officially commissioned to investigate insect pests was Asa Fitch, who held the courtesy title of State entomologist of New York from 1854 to 1872. His 14 annual reports on the injurious insects of New York comprise a mass of useful information respecting their life-histories. Almost simultaneously with Fitch's appointment came the establishment of an entomologist under the general Government of the United States. In 1854 T. Glover was selected for this post and he was succeeded by C. V. Riley in 1878. Owing to a misunderstanding Riley resigned the following year and J. H. Comstock succeeded him as Federal entomologist. Comstock, during the two years of his office, published exceedingly valuable works dealing with cotton, orange and scale insects, which are masterpieces of thoroughness and practicability. In 1881 C. V. Riley resumed charge, and from this time till 1894 he remained continuously in office. He accomplished work of the highest order and has been largely instrumental in placing economic entomology upon its present sound footing in the United States. He developed not only the scientific aspects of the subject and published a vast amount of detailed life-history studies, but under his direction advances were made in insecticides and spraying methods of far-reaching application. Riley's work at the Federal division of entomology, and his earlier labours in the employ of the State of Missouri (to be mentioned hereafter), place him among the outstanding economic entomologists of the world. He was succeeded in 1894 by L. O. Howard, who remained in office till 1927, when C. L. Marlatt assumed charge. Under Howard's lengthy and sagacious administration, economic entomology in the Federal Department of Agriculture has been carried forward into a position of efficiency and commanding importance unequalled in any other country. At the present day it forms one of the largest bureaus of the department and has a fiscal grant from Congress which amounted in 1925–26 to $2,500,000 and a staff of over 400 trained entomologists. The chief of the bureau is located in Washington, together with the offices of the heads of the various divisions into which it is organized. The staff are stationed all over the country wherever problems need urgent attention, and in the case of

major investigations the work is centred in special laboratories established in areas best adapted to the enquiries in question. Among the most notable of these special laboratories are the cotton-boll weevil laboratory at Tallulah (La.); the gypsy moth laboratory at Melrose Highlands (Mass.); the Japanese beetle laboratory at Riverton (N.J.); the corn borer laboratory at Arlington (Mass.); the bee culture laboratory at Somerset (Md.), and the European parasite laboratory at Hyères, France.

Outside the activities of the Federal Government the legislatures of the various States have their own entomological organizations. Up to 1888 only four States supported official economic entomologists: Massachusetts (A. S. Packard Jr.), New York (Asa Fitch), Illinois (W. Le Baron) and Missouri (C. V. Riley). It was in the capacity of State entomologist for Missouri that C. V. Riley issued his nine reports, which first established his reputation; they are characterized by their original, scientific and practical character, and the very wide range of insect pests which they cover. These reports and the excellence of their original illustrations have made their author's name familiar to economic entomologists outside the United States. In 1888 the organization of the agricultural experiment stations under the Hatch Act was of great importance to economic entomology in America, and at the present day there are one or more experiment stations in every State of the Union. These stations, often in conjunction with State agricultural colleges, maintain among them a staff of more than 200 entomologists, and disseminate a vast amount of practical information through the medium of reports and bulletins.

Mention must also be made of the United States entomological commission, founded under special act of Congress in 1877, which gave a great impetus to original investigation. Although primarily intended to study the Rocky Mountain locust depredations, the commission also carried out important work on other major pests as well as publishing a standard treatise on insects affecting forest and shade trees. Outside official circles the most important organization is the American Association of Economic Entomologists, which was founded in 1889 and had, in 1927, 849 practical entomologists on its membership roll.

Canada.—The first Government entomologist in Canada was James Fletcher, of the Dominion experimental farms, Ottawa, who was appointed in 1884, and his reports and other contributions laid the basis for future work in that country. Fletcher's activities were furthered in every way by W. Saunders, the then director of the experimental farms, who was also an economic entomologist of high reputation. In 1908 Fletcher was succeeded by C. G. Hewitt, through whose energies entomology was raised to the status of a separate branch of the Canadian Department of Agriculture, with greatly enhanced scope and activities, and its own offices and laboratories in Ottawa. At the present day the branch is directed by the dominion entomologist assisted by an associate dominion entomologist and two divisional chiefs; there are also entomologists in charge of 14 branch laboratories distributed throughout the country. Outside official work, economic entomology in Canada is mainly centred in the Entomological Society of Ontario, whose annual reports, which are subsidized by the State, are of recognized practical and educational value.

Other Parts of the British Empire.—The agriculture departments of most of the dominions, colonies and other dependencies of the empire have on their staffs one or more men qualified to help the agricultural community to battle against insect pests. The largest entomological organization is that of the Union of South Africa, which maintains a staff of about 20 entomologists. A certain number of these are engaged in teaching the subject in colleges and schools of agriculture, but the majority are employed by the division of entomology under the Union Department of Agriculture. The division is directed by a chief and the staff are engaged in the study and control of cotton insects, locusts, tsetse fly, tobacco insects and other problems. In Australia the important post of Commonwealth entomologist has recently been established and there are one or more official entomologists attached to the agricultural departments of the provinces. In India there is an Imperial entomologist at the Pusa research institute and also entomologists in the agricultural departments of the different provinces. A number of entomologists are officially employed under the Wellcombe tropical research laboratories and the Gezira research farm in the Sudan.

Finally, it should be mentioned that good work in economic entomology is being done in most European countries and in Japan.

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Insects affecting domestic animals: M. Neveu-Lemaire, *Parasitologie des Animaux Domestiques* (1912); E. Seguy, *Les Insectes Parasites* (1924) and various other works on Parasitology. Control methods: R. A. Wardle and P. Buckle, *Principles of Insect Control* (Manchester, 1923); E. Bourcart, *Insecticides, Fungicides and Weedkillers* (1926); O. G. Anderson and F. C. Roth, *Insecticides, Fungicides and Appliances* (1923). For aeroplane dusting *see* B. R. Coad, E. Johnson and C. L. McNeil, *Bull. 1204, U.S. Dept. of Agric.* (1924) and A. D. Imms, *Journ. Ministry Agric.* (vol. xxiii., 1926). Development of Economic Entomology: consult the following special articles: L. O. Howard "Rise and Present Condition of Official Economic Entomology" (*Insect Life*, vol. vii.); "Progress in Economic Entomology in the United States" (*Yearbook, United States Dept. Agric.*, 1899); C. G. Hewitt, "A Review of Applied Entomology in the British Empire" (*Annals Entom. Soc. Amer.* vol. ix., 1916); J. C. F. Fryer and G. H. Pethybridge, "The Phytopathological Service of England and Wales" (*Journ. Ministry of Agric.*, vol. xxxi., 1924); P. Marchal, "Les Sciences biologiques appliquées de l'Agriculture aux États-Unis" (*Ann. Service des Epiphyties*, vol. iii., 1916. Periodical literature: Periodical literature on economic entomology has assumed enormous proportions and is published not only in special journals devoted to the subject, but is also scattered through numerous other serial publications. *The Review of Applied Entomology* abstracts all papers published on insects affecting agriculture, and the chief journals devoted to original papers in economic entomology include the *Bulletin of Entomological Research* (London), *Journal of Economic Entomology* (Geneva, N.Y.), *Zeitschrift für angewandte Entomologie, Redia* (Florence and *Bolletino del Laboratorio di Zoologia Agraria* (Portici). *The Annals of Applied Biology, Annales du Service Epiphyties*, and the *Journal of Agricultural Research* also publish numerous papers on injurious insects and control methods. Other periodical literature includes the almost innumerable annual reports and bulletins published by agricultural departments of almost every civilized country of the world. Among them, those of the various State experimental stations and of the Department of Agriculture of the United States, the Entomological Society of Ontario, and the agricultural departments of India, South Africa, Egypt, etc., may be specially mentioned. (A. D. I.)

MEDICAL ENTOMOLOGY

Although medical entomology includes in its scope venomous and parasitic arthropoda that inflict minor hurts upon the individual human body, its main concern is with arthropoda which, either as the necessary intermediary hosts or as the fortuitous mechanical disseminators of other pathogenetic organisms, stand in the main line of causation of serious endemic and epidemic disease.

Manson's Discovery.—Such insect-borne disease, though from of old a topic of popular belief and even of rational speculation, was first clearly demonstrated by Manson, who discovered, in 1879, how the embryos of the worm that causes a common filarial disease of the tropics are extracted from one human host by a female mosquito and then pass through their larval development within that insect's body before they can find their way into another human host. The value of this discovery, however, was not generally appreciated until 1898, when Ross discovered how the parasites of malaria, after an analogous dependence on the mosquito for transport and sustenance, are injected into their human host by the insect intermediary, it being, however, "Man-

son's theory, and no other, which actually solved the problem" of the mode of transmission of this disease.

In these and similar instances the insect is a go-between, safeguarding the transfer of a specifically "human" parasite from one human being to another. But many blood-sucking insects are normally infected with seemingly innocuous endoparasites of their own, and some maintain that such insects may inject their own parasites into the human body where they may not remain innocuous; and it is to be noted that surmise of the same still unsatisfied kind has been awakened by the recent discovery in the normal intestine of certain insects, particularly bugs and lice, of bodies similar to the minute Rickettsia-bodies isolated, in 1916, by Rocha Lima from typhus fever cases and regarded by him as specifically morbific.

Recent developments in medical entomology may be summarized thus:

Diseases Specifically Attributable to Mosquito Agency.—To filariasis, malaria and yellow fever, the parasite of which last was in 1918 determined by Noguchi as a *Leptospira*, must be added dengue fever, shown to be transmitted in Australia (Cleland and others) by *Stegomyia fasciata*, and in Syria (Graham) by *Culex fatigans*.

Diseases Specifically Attributable to Sandfly Agency.—In entomological company with phlebotomus fever will probably have to be placed oriental sore (Sergent brothers: Aragão), and also kala-azar, the natural history of which seems to be definitely associated with *Phlebotomus argentipes* (*see* KALA-AZAR and SANDFLY FEVER).

Diseases Attributable to Gad-fly (Tabanidae).—The details of the post-embryonic development of *Filaria* (*Loa*) *loa* in the course of its transmission from man to man by *Chrysops dimidiata* and *salacea* were described in 1921 by Dr. and Mrs. Connal. (Tularaemia, a recently recognized septic fever of American rabbits, may be imparted from rabbits to man by *Chrysops discalis*, but merely mechanically, since the infection may also pass to man without any insect intervention.)

Diseases Specifically Attributable to Tsetse-fly Agency.—Besides the notorious *Glossina palpalis* and *morsitans* several other common species of *Glossina* are now known to be intermediary in the spread of the trypanosomes of African sleeping sickness.

Diseases Specifically Attributable to Flea Agency.—Hirst, in Ceylon, and Cragg, in India, have produced good evidence that not all the three species of rat-fleas of the *Xenopsylla* genus are equally formidable in spreading bubonic plague, and that plague does not rage as an epidemic in places where *Xenopsylla astia* is the only flea infesting the local rats. The evidence of the intermediation of the dog-flea in the transmission of infantile kala-azar is still obscure.

Diseases Attributable to Bugs (Rhynchota).—The parasite of South American trypanosomiasis (Chagas's disease) is now known to be transmissible by several species of reduviid bugs—and also, experimentally, by other blood-sucking insects—and is believed to be imparted to man in the insects' excrement. An original natural source of infection is said to exist in armadillos and opossums.

Diseases Attributable to Lice.—In company with typhus and relapsing fever the war disease "trench-fever" is to be included. In all three instances the virus is inoculated by contamination. The lousy person as he scratches himself rubs the infective juice or excrement of the infected insects into the abrasions of his skin. Another and unpleasant complaint thus engendered is Pediculosis.

Diseases Attributable to Ticks.—Several species of *Ornithodorus* are now suspected of transmitting the spirillum of relapsing fever, and *O. talaje* in tropical America has been shown to be as dangerous in this respect as the African *O. moubata*. The virus of Rocky Mountain spotted fever, conveyed to man by *Dermatocentor venustus*, is declared by Wolbach to be a *Rickettsia*. Another tick of this genus, *D. andersoni*, has been found infected with the bacillus of tularaemia. In these tick-borne infections the parent tick, becoming infected, transmits the infection to its offspring.

Diseases Specifically Attributable to the Agency of Harvest Mites (Trombidiid larvae).—Besides Japanese river fever, the virus of which is inoculated by the *akamushi* mite, there are other local and seasonal epidemic fevers that have a similar causation. Among them is the pseudotyphus of Sumatra.

Diseases Specifically Attributable to Crustacean Agency.—Small freshwater copepods of the genus *Cyclops* have been known from the time of Fedshenko to be intermediary hosts of the guinea-worm (*Dracunculus medinensis*); and in 1917 Janicki and Rosen discovered, in *Cyclops strenuus* and the near-related *Diaptomus gracilis*, the long-sought first intermediary hosts of the larval ribbon worm (*Bothriocephalus latus*). Japanese workers have shown that species of river crabs play an intermediary part in the post-embryonic development of the lung-fluke.

Diseases Attributable to Fortuitous Insect Agency.—We must consider also the odious assistance lent by domestic insects—houseflies, cockroaches, cellar-beetles, ants, fish-insects and by the ubiquitous fauna—moth and beetle-larvae, booklice, food-mites—of granaries, provision stores, warehouses etc., in the indiscriminate and mainly mechanical dissemination of morbific material of various kinds. Houseflies are the most assuredly dangerous of these disturbers of the public health. Fibiger found that in rats infected with a filarial worm of the genus *Gongylonema*, through feeding on infected cockroaches, cancerous growths started from the lesions caused in the rat by the worm.

Although the insects here very briefly reviewed are dangerous to public health, it is beginning to be realised that the peril is conditional. In an environment unmodified by sanitation, such as prevails in extensive areas in the tropics, these insects are a constant danger and, at the present time, must be attacked with energy and with resource based upon a study of their life-history, seasons and habits. But in countries having settled standards of personal and domestic hygiene and an efficient sanitary administration these insects have ceased to be a standing menace to the public health, as is exemplified by the history of plague, typhus and malaria in England since the establishment of a sanitary régime.

See A. Alcock, *Entomology for Medical Officers* (1920).

(A. W. A.)

ENTOMOSTRACA, a term now obsolete but formerly used in zoology to denote collectively all the Crustacea (*q.v.*) except the Malacostraca (*q.v.*). The word is misleading, as the groups thus brigaded together have no special relationship to one another.

ENTR'ACTE, the interval between the acts of a dramatic performance, or between the different items of a miscellaneous entertainment; *entr'acte* music being that intended to be played during this period. "Act-tune" was an earlier term, now quite obsolete.

ENTRAGUES, CATHERINE HENRIETTE DE BALZAC D' (1579–1633), marquise de Verneuil, mistress of Henry IV., king of France, was the daughter of Charles Balzac d'Entragues and of Marie Touchet, mistress of Charles IX. She induced Henry IV. to promise to marry her after the death of Gabrielle d'Estrées, a promise which led to bitter scenes at court when shortly afterwards Henry married Marie de Medici. She was deeply compromised in the conspiracy of Marshal Biron against the king in 1606; and in 1608 Henry actually took her back into favour. She seems then to have been involved in the Spanish intrigues which preceded the death of the king in 1610.

See H. de la Ferrière, *Henri IV. le roi, l'amoureux* (1890).

ENTRECASTEAUX, JOSEPH-ANTOINE BRUNI D' (1739–1793), French navigator, was born at Aix, and entered the navy at the age of fifteen. In the war of 1778 he commanded a 32-gun frigate, and successfully convoyed a fleet of merchant vessels from Marseille to the Levant, though they were attacked by two pirate-vessels, each of which was larger than his own. In 1785 he was put in command of the French fleet in the East Indies, and in 1787 he was made governor of Mauritius and the Isle of Bourbon. While in command of the East India fleet he made a voyage to China, and in 1791 he was given command of an expedition to search for La Pérouse, lost since Feb. 1788.

The expedition comprised the "Recherche" and "L'Esperance," with Captain Huon de Kermadec as second in command. No tidings were obtained of La Pérouse, but in the course of his search Entrecasteaux made important geographical discoveries. He traced the outlines of the east coast of New Caledonia, made surveys of the Tasmanian coast, and touched at several places on the south coast of New Holland. The two ships entered Storm bay, Tasmania, on April 21, 1792, and remained there until May 16, surveying and naming d'Entrecasteaux channel, the entrances to the Huon and Derwent rivers (the latter they called Rivière du Nord), Bruni island, and other places. They then sailed for the East Indies, and near Java Entrecasteaux died of scurvy on July 20, 1793.

See M. de Rossel, *Voyage de Dentrecasteaux* (1808).

ENTRE MINHO E DOURO (popularly called *Minho*), a province of northern Portugal; bounded on the N. by Galicia in Spain, E. by Traz-os-Montes, S. by Beira and W. by the Atlantic ocean. Pop. (1920) 1,304,461; area 2,790 sq.m. Of the mountain ranges the most important are the Serra da Peneda (4,728 ft.), between the rivers Minho and Lima; the Serra do Gerez (4,357 ft.), on the Galician border; the Serra da Cabreira (4,021 ft.), immediately to the south; and the Serra de Marão (4,642 ft.), in the extreme south-east. As its name implies, the province is bounded by two great rivers, the Douro (*q.v.*) on the south, and the Minho (Spanish *Miño*) on the north. There are three other large rivers which, like the Minho, flow west-south-west into the Atlantic. The Limia or Antela (Spanish *Linia*) rises in Galicia, and reaches the sea at Vianna do Castello; the Cavado forms, at its mouth, the small harbour of Espozende; and the Ave descends from its sources in the Serra da Cabreira to Villa do Conde. A large right-hand tributary of the Douro, the Tamega, rises in Galicia, and skirts the western slopes of the Serra de Marão.

The climate is mild, except among the mountains, and such plants as heliotrope, fuchsias, palms, and aloes thrive in the open throughout the year. Wheat and maize are grown on the plains, and other important products are wine, fruit, olives and chestnuts. As the province is occupied by a hardy and industrious peasantry, and the density of population (467·6 per sq.m.) is more than twice that of any other province on the Portuguese mainland, the soil is very closely cultivated. Small quantities of coal, iron, antimony, lead and gold are mined; granite and slate are quarried; and there are mineral springs at Monção, which is on the river Minho. The Oporto-Corunna railway traverses the western districts and crosses the Spanish frontier at Tuy; its branch lines give access to Braga, Guimarães and Povoa de Varzim; and the Oporto-Salamanca railway passes up the Douro valley. The chief towns are separately described; they include Oporto, one of the greatest wine-producing cities in the world; Braga, the seat of an archbishop who is primate of Portugal; the seaports of Povoa de Varzim and Vianna do Castello; and Guimarães.

ENTREPÔT, a storehouse or magazine for the temporary storage of goods; also a place where goods, which are not allowed to pass into a country duty free, are stored under the superintendence of the custom-house authorities till they are re-exported. Any town which has a considerable distributive trade is called an *entrepôt.*

ENTREPRENEUR. In economics, a term describing the person who assembles the various means of production, and by mobilizing them, renders them operative and useful. He is a promoter or initiator of production. The derivation is from Fr. *entre,* between; *prendre,* to take.

By making the factors of production operative, the entrepreneur earns a profit. What he needs in his operations are: (1) the use of land (a site) for which he pays rent; (2) the use of capital, for which he pays interest; (3) labour, for which he pays wages. By organizing the use of these to advantage, he seeks to make his own remuneration. What he buys for his operations constitutes the cost of production; that cost, plus his profit, amounts to the expenses of production.

The function of the entrepreneur is thus of the first importance. He may or may not be a landlord; he may or may not use in his operations his own capital; his essential function is that of industrial organizer. The owner of a site may or may not know how to use it; the owner of capital may or may not know how to make it fruitful; the worker with hand or brain may or may not know how to use his energies to advantage; it is the special business of the entrepreneur to know how best to make use of site, capital and labour. His is the function of enterprise, and in functioning he causes land, capital and labour to function. (*See* ECONOMICS.)

ENTRE RÍOS, an eastern province of the Argentine Republic lying between 30° and 34° S. lat. and 58° and 61° W. longitude. It is bounded north by the province of Corrientes, east by Uruguay river which separates it from Uruguay and south and west by the Paraná river which separates it from the provinces of Buenos Aires and Santa Fe. Pop. (1914) 425,373; 1925 estimate, 549,118 or 18·1 per square mile. The chief foreign groups were from Uruguay, Russia and Italy.

The province has an area of approximately 30,240 sq.m., consisting for the most part of an undulating, well watered and partly wooded plain with low hills bordering on the two great flanking rivers and a swampy district of limited extent in the angle between them. The great forest of Monteil occupies an extensive region in the north, estimated at nearly one-fifth the area of the province. Its soil is exceptionally fertile and the natural pasture lands are excellent for stock grazing. Its climate is mild and healthy. Entre Ríos is sometimes called the "garden of Argentina" and its agricultural development makes the reason evident. Its agricultural acreage for the year 1925–26 included 1,132,200 ac. of wheat; 1,495,000 ac. of linseed; 556,000 ac. of alfalfa; 209,000 ac. of oats; 189,000 ac. of maize (Indian corn); 24,700 ac. of potatoes; and 15,600 ac. of peanuts. Grapes are an important crop along the Uruguay river. Entre Ríos is one of the chief live stock producing provinces of the nation. Its live stock, according to the census of 1921, was as follows: cattle, 2,714,000; sheep, 2,710,000; horses 509,000; swine, 79,000. The manufacturing interests of the province are almost wholly dependent on agricultural and pastoral products. The chief exports are live cattle, jerked, chilled and tinned beef, beef extracts, mutton, wool, dairy products, wheat, linseed, fruits and a limited quantity of forest products. Lime and gypsum are the principal minerals. The Paraná and Uruguay rivers provide exceptional facilities for the shipment of produce and a network of 1,527 m. of railway operated by the Entre Ríos and the Argentine North Eastern railways, affords ample transportation facilities to the ports and to the provinces lying to the north and to the south.

The capital and chief city of the province is Paraná, a busy port on the Paraná river, with a population of 36,089 in 1914 and 47,000 (estimated) in 1926. Other important centres, with their population in 1926, are Concordia (27,680), Gualeguaychú (21,-622), Concepción de Uruguay (18,076), all important ports on the Uruguay; and Gualeguay (16,484) and Victoria (15,757). Entre Ríos, in its early history, suffered severely from political disorder and civil war. Comparative quiet reigned from 1842 to 1870 under the autocratic rule of Gen. J. J. Urquiza. After his assassination in 1870 these partisan conflicts were renewed for two or three years, and then the province settled down to a life of comparative peace, followed by an extraordinary development in her pastoral and agricultural industries. Educational and cultural institutions have increased to a remarkable degree during this era of peace and prosperity.

ENVER PASHA (1881–1922), leader of the Young Turks, was born at Apana, on the Black Sea coast, where his father was a bridge keeper and his mother followed the despised profession of laying out the dead. His father was Turkish, his mother Albanian and he had a Circassian grandmother. He entered the Turkish Army as a subaltern, and was sent to Salonika, where he came into touch with the leaders of the Young Turk movement. In 1908 as aide-de-camp of General Hussein Hilmi, he, with Niazi Bey, raised the flag of revolution in Macedonia, originally with the object of restoring the constitution of 1876, which had been disregarded by Abdul Hamid, but also to save himself from a threatened arrest. Abdul Hamid professed to yield, and Enver

entered Constantinople as a fêted hero. He then went to Berlin as major and military attaché, and there pursued his military studies, 1909–11. His stay was only once interrupted, when, in the year 1909, he hastened to Salonika, and with Mahmud Shevket undertook a brief and victorious campaign against the reactionaries.

After the deposition of Abdul Hamid, Enver returned to Berlin. He took command at Benghazi in the Italo-Turkish War and wrote a book called *Tripoli* (German version, 1918) dealing with this period. The Peace of Lausanne brought his work in Africa to an end, and he returned to Constantinople to find Turkey in the midst of the Balkan war. During the December armistice Enver, then a lieutenant-colonel, was made chief-of-staff of the X Army Corps, of which he soon was virtually in command. His attempt at a landing at Sharköi (in the east of the Gallipoli peninsula), on Feb. 8, 1913, miscarried. During the peace negotiations, when Kiamil, as the Grand Vizier, took the course of deferring to the wishes of the British, Enver with his friends arrived in front of the Sublime Porte, shot the War Minister, Nazim Pasha, turned out Kiamil, forced himself upon the Sultan, and in collusion with the Young Turk Committee filled all the offices with Young Turks. The new Vizier, Mahmud Shevket, was assassinated in June 1913, and this further enraged the Committee against the Old Turks and the Union Libérale. The body of the state was purged of all elements which would not blindly carry out the policy of the Committee. More than 1,200 officers, among them 153 generals and colonels, were dismissed by Enver in one day. In July 1913 he made a triumphal entry into Adrianople, which had already been evacuated by the Bulgarians. On Jan. 3, 1914, he promoted himself Minister of War.

When the World War broke out, Enver began to cherish strategical ambitions. In the winter of 1914–15 he led an entire Turkish Army in the disastrous offensive in the snow-covered mountains on the Russo-Turkish border. With Liman von Sanders, the chief of the German military mission in Constantinople, his relations were strained, and the situation was not improved by certain Germans who flattered Enver and intrigued against Liman von Sanders. He became a megalomaniac to whom no one offered advice, and though he had no share in the Dardanelles defence, he took all the credit for it. In internal politics he became, by degrees, the absolute ruler of the country, but when the Turkish collapse came he fled by way of Odessa to Germany. In 1919 he was condemned to death at Constantinople *in contumaciam*. In the same year, after a brief exile among friends in Germany, he fled to Russia. There at first he helped Denikin to maintain the independence of the Caucasus, but when Denikin approached the Entente Powers, Enver left him, stayed for a short time in Azerbaijan, and was mixed up in adventures in Asia Minor and with the Asiatic propaganda of the Soviet Government.

Finally he turned against the Soviet Government and leading an unsuccessful insurrection against them in the mountains of Russian Turkistan—a revival of the "Pan-Turanian" ambitions which he cherished during the War—he was killed at Douchembe, in Bukhara, on Aug. 4, 1922.

ENVOY, a diplomatic agent of the second rank. The word *envoyé* came first into general use in the 17th century, as a translation of the Lat. *ablegatus* or *missus* (*see* DIPLOMACY). Hence the word envoy is commonly used of anyone sent on a mission.

ENZELI LANGUAGE: *see* PAHLAVI.

ENZINAS, FRANCISCO DE (DRYANDER) (*c.* 1520–*c.* 1553), Spanish theologian, was born at Burgos and educated at Louvain. While in Wittenberg he was advised by Melanchthon to translate the New Testament from Greek into Spanish. This was published at Antwerp in 1543. Imprisoned in Brussels for heresy, he managed to escape about 1545, and returned to Wittenberg, where he wrote *The State of the Netherlands and of the Religion of Spain,* published first in Latin, then in French (Geneva, 1558). On Cranmer's invitation he came to England in 1548, and was made professor of Greek at Cambridge. Two years later he returned to the Continent. He died at Geneva.

ENZIO (*c.* 1225–1272), king of Sardinia, was a natural son of the emperor Frederick II., and married, in 1238, Adelasia, widow of Ubaldo Visconti and heiress of Torres and Gallura in Sardinia. Enzio took at once the title of king of Torres and Gallura, and in 1243 that of king of Sardinia, but his sovereignty existed in name alone. In July 1239 he was appointed imperial vicegerent in Italy, and sharing in his father's excommunication in the same year, took a prominent part in the war which broke out between the emperor and the pope. He commenced his campaign by subduing the march of Ancona, and in May 1241 commanded the forces which defeated the Genoese fleet at Meloria. Later he fought in Lombardy. He was wounded and taken prisoner by the Bolognese at Fossalta on May 26, 1249, and remained a captive until his death on March 14, 1272. His marriage with Adelasia had been declared void by the pope in 1243; he left one legitimate, and probably two illegitimate daughters.

See F. W. Grossman, *König Enzio* (Göttingen, 1883); and H. Blasius, *König Enzio* (Breslau, 1884).

ENZYMES. There are many chemical reactions which proceed alone at a very slow rate. By the addition of minute quantities of certain inorganic substances, termed catalysts, the rate of such reactions can be tremendously increased. Enzymes may be regarded as catalysts of biological origin which are formed in all living cells. They enable the cell to carry out the chemical processes necessary for its existence at a sufficient speed and at temperatures much below those which would be required in the laboratory.

It is now realized that most of the changes going on in the living cell are due to constituents similar to the zymase of the yeast cell, which brings about the fermentation of sugar. In many cases the enzymes act within the cell, but in others the enzymes are discharged from the cells which formed them and carry out their particular changes outside the cells. Thus the enzyme ptyalin, elaborated in the salivary gland cells, is discharged into the mouth, where it commences its action on the starch of the food.

The action of all enzymes shows certain characteristic features which closely resemble those shown by inorganic catalysts. The chemical reactions in which enzymes play a part are, so far as is known, reversible in type. In such reactions, an equilibrium point is reached at which the rate of the forward or breakdown process equals that of the reverse or synthetic process. In the presence of an enzyme the same equilibrium point is reached much more rapidly. Since the actual point of equilibrium reached depends solely on the ratio of the velocities of the forward and reverse reactions, the enzyme must accelerate both reactions equally. Thus enzymes are capable of increasing the rate of synthetic as well as breakdown processes. Which change will predominate depends on the concentration of the molecules involved and is not determined by the enzyme.

Enzymes show great specificity—a given enzyme will act only on a single substance or group of closely related substances. In the case of enzymes acting on carbohydrates this specificity is so extreme that it has been suggested that there must be a "lock and key" relationship between the enzymes and the molecule on which it acts—the substrate.

The activity of enzymes is influenced in a remarkable degree by factors such as temperature, acidity or alkalinity, and the presence of certain metallic salts. There is an optimum temperature for the action of an enzyme; above this temperature the enzyme is rapidly destroyed and its activity diminishes. Owing to this sensitiveness to external factors, an enzyme is frequently able to change only a limited amount of substrate, for the products of its activity accumulate and by their accumulation gradually inhibit the activity of the enzyme.

Enzymes are active in extremely minute amounts. Thus the enzyme invertase can hydrolyse one million times its weight of cane sugar without appreciable loss of activity. The majority of the reactions in which enzymes take part are hydrolytic, and involve the addition of the elements of water. Thus the enzymes of the alimentary canal break down the foodstuffs by hydrolysis. There are other types of enzyme action which are important, notably those concerned with oxidation processes. Enzymes accelerating such processes are known as oxidases, and to enzymes of

this class are due the colour changes seen when a cut potato or apple is exposed to the air.

The chemical structure of enzymes is not yet known. They were formerly regarded as proteins, but according to Euler and others they are not proteins, but are in colloidal combination with the cell proteins. Their sensitiveness to heat and other factors depends probably on this association. Willstätter conceives the molecule of an enzyme as consisting of a colloidal carrier and of a purely chemical active group. Complete separation of these is not yet possible. There is no doubt that, owing to its close association with a colloid, the enzyme molecule has an extensive surface area, and it appears certain that one of the first stages in the action of an enzyme is the concentration of molecules of the substrate on this surface by the physical process of adsorption. Whether a chemical combination between enzyme and substrate occurs has yet to be demonstrated.

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EOCENE, in geology, the name suggested by Sir Charles Lyell in 1833 for the earliest period of the Tertiary era. The term was intended to convey the idea that this was the period which saw the dawn of the recent or existing forms of life, because it was estimated that among the fossils of this period only 3½% of the species are still living. Since Lyell's time much has been learned about the fauna and flora of the period, and many palaeontologists doubt if any of the Eocene *species* are still extant, unless it be some of the lowest forms of life. Nevertheless, the name is a convenient one and is in general use. The Eocene as originally defined was not long left intact, for E. Beyrich in 1854 proposed the term "Oligocene" for the upper portion, and later, in 1874, K. Schimper suggested "Palaeocene" as a separate appellation for the lower portion. The Oligocene division has been generally accepted as a distinct period, but "Palaeocene" is not so widely used. In the present article we shall include also the "Palaeocene" deposits. Although in Germany the Oligocene deposits are transgressive and cover wide areas from which the Eocene is absent, in France and southern England there is little or no break between the Eocene and Oligocene and it is much more logical to include the whole of the lower Tertiary in a single period. This is the tendency among modern stratigraphers and the names "Palaeogene," "Nummulitic" or "Older Tertiary Period" (in opposition to Neogene or Newer Tertiary Period) are widely used to embrace the Palaeocene, Eocene and Oligocene. As a whole, the Palaeogene System is characterized by the almost exclusive occurrence of *Nummulites* (a few early forms have been recorded from the highest Cretaceous); further, its stratigraphic unity is ensured since the upper and lower limits are marked each by periods of marine regression whose effects are traceable over practically the whole of Europe. There are, in fact, very few areas indeed where sedimentation proceeded uninterruptedly on the one hand from the Cretaceous to the Palaeogene and on the other hand from the Palaeogene to the Neogene.

The stratigraphy of the Eocene was first worked out in detail in the basins of Paris, Belgium, Hampshire and London with the result that the Anglo-Franco-Belgian basin has become the type area. This is unfortunate, since the deposits there, both in the Eocene and Oligocene periods, were laid down in a large but shallow gulf affected by a succession of secondary oscillations of level which have resulted in a complex series of alternating marine and continental deposits. A continuous succession of marine deposits is found in the Mediterranean area—laid down in the Tethys or Mediterranean sea of Eocene times which stretched from Italy to India and in which were evolved the series of Nummulites by which the subdivisions of the period are dated.

Conditions During the Eocene.—When, after the great regression at the end of the Cretaceous, the sea once more invaded Europe there was but little change in the structure of the continent as a whole. On the north and north-west lay the North Atlantic continent—represented to-day by the ancient massifs of Scandinavia, Scotland, Ireland, Wales and Cornubia. Running through the heart of Europe was an important land mass, the remnants of which are found to-day as the Bohemian massif, the Ardennes, Vosges and Black Forest, Central Plateau of France and the massif of Brittany. Between these two land masses lay the Northern sea, from which a broad gulf or "epicontinental sea" formed the Anglo-Franco-Belgian basin. To the west lay the Tertiary Atlantic ocean with gulfs covering south-west France and north-east Spain as the basins of Aquitaine and Aragon. To the south-east of Central Europe lay the Tethys, the great Mediterranean sea of early Tertiary times, covering the area where the Alps were yet to rise. The Tethys extended over Italy and most of south-eastern Europe, stretched across Asia Minor and Syria into Persia and India. Marginal seas and gulfs covered most of the Atlas region and stretched into Egypt, wide gulfs occupied Assam, Burma and much of the East Indies. In North America Eocene deposits are found in a succession of basins which fringed the Pacific ocean and covered parts of the present west coast. Eocene seas stretched over the Gulf of Mexico and the present West Indies, the south-eastern States and parts of Central America. Continental Eocene deposits cover a wide area in the heart of the continent. In South America, Africa and Australia the continental masses were beginning to assume their present form and the Eocene deposits are again found mainly in fringing basins. We are scarcely affected by the problem of whether these continental masses occupied the same position relatively to one another or whether they have drifted apart as envisaged in Wegener's theory of continental drift.

It is towards the centres of the larger Tertiary seas that Eocene sedimentation succeeds without a break that of the Cretaceous and where the boundary line is difficult to draw. This is the case in parts of Egypt, Denmark, some areas in northern India, as well as in the continental region of central North America. In the classical localities of England and France a great gap in time separates the Tertiary from the Mesozoic deposits, though the angular discordance between the Cretaceous and Eocene is usually but slight.

Associated, no doubt, with the slight crustal movements which closed the Cretaceous and inaugurated the Eocene period there were local and intermittent manifestations of volcanic activity throughout the period. Intrusive rocks are found in the Eocene of the central and northern Apennines. Tuffs, basalts and other igneous rocks appear also in many of the Rocky Mountain States, in Central America, the West Indies and South America.

It has been very generally assumed by geologists, mainly upon the evidence of plant remains, that the Eocene period opened with a temperate climate in the northern latitudes, later becoming almost subtropical. The frequent admixture of temperate forms with what are now tropical genera makes it difficult to speak with certainty as to the degree of warmth experienced. The meteorological researches of Dr. C. E. P. Brooks (*Climate through the Ages*, London, 1926) have tended to confirm the belief in the existence of a warmer climate over Europe in early or middle Eocene times, becoming cooler towards the close of the period. The difference in the character of the faunas of the Tethys and the Northern sea points fairly conclusively to the differentiation of climate-zones in Europe comparable to those of the present day.

Life of the Period.—By far the most abundant and characteristic marine organisms were the foraminifera which flourished in the warm seas in countless myriads. Foremost among these are the *Nummulites,* which by their extraordinary numerical development and great size, as well as by their wide distribution, demand special recognition. Many other genera are of almost equal importance as rock builders—*Orthophragmina, Lepidocyclina, Operculina, Assilina, Orbitolites, Miliola, Alveolina.* The Nummulites, together with the Orthophragmines and Lepidocyclines, are the best fossils on which to base wide range correlation. Their centre of evolution and dispersal was in the Mediterranean province, where they are abundant at all levels in such a way that "zonal assemblages" may be determined. Whilst the determination of species is very difficult and possible only to the

specialist, the following broad groups are easily recognizable and can be utilized by the field geologist:—

Oligocene—small nummulites and lepidocyclines.
Upper Eocene—small nummulites and orthophragmines.
Middle Eocene—large and small nummulites, orthophragmines and assilines.
Lower Eocene—small nummulites and orthophragmines.

It was only at certain periods that a temporary connection was established between the Eocene Mediterranean and such areas of the Northern sea as the Paris basin, hence it is only isolated species and not phylogenetic series which are found in the latter areas. Thus whilst sedimentation was continuous in the Anglo-Franco-Belgian basin there are marked faunal breaks with a sudden influx of new forms.

In the northern province only isolated corals occur but in the Mediterranean reef-building forms of modern genera flourished. This is strong evidence of the differentiation into climatic zones as at present with a warm Mediterranean and a cold Northern sea.

In the marine mollusca the most noteworthy change is the entire absence of ammonoids, the group which throughout the Mesozoic era had taken so prominent a place, but disappeared completely with the close of the Cretaceous. Nautiloids were more abundant than they are at present, but as a whole the Cephalopods took a more subordinate part than they had done in previous periods. On the other hand, gastropods and pelecypods found in the numerous shallow seas a very suitable environment, flourished exceedingly, and their shells are often perfectly preserved and in enormous numbers. Of the gastropod genera *Cerithium* with its estuarine and lagoonal forms is very characteristic and the series of mutations have been of great service in studying the detailed stratigraphy of the Paris basin. *Rostellaria, Voluta, Fusus, Pleurotoma, Conus* may also be cited. *Cardium, Venericardia, Crassatella, Cytherea, Lucina, Anomia, Ostrea* are a few of the many genera of pelecypods abundantly represented. Echinoderms are especially important in the Tethys and the warmer seas and include the sea urchins *Linthia, Conoclypeus,* etc.

Crustacea were fairly abundant and most of the orders as well as numerous families of modern insects were represented.

When we turn to the higher forms of life, the reptiles and mammals, we find a remarkable contrast between the fauna of the Eocene and those periods which preceded and succeeded it. The great groups of reptiles, whose members had held dominion on land and sea during most of the Mesozoic time, had almost entirely disappeared by the beginning of the Eocene; in their place placental mammals made their appearance and rapidly became the dominant group. Among the early Eocene mammals no trace can be found of the numerous and clearly-marked orders with which we are familiar to-day; instead we find obscurely differentiated forms, which cannot be fitted without violence into any of the modern orders. The early placental mammals were generalized types (with certain non-placental characters) with potentialities for rapid divergence and development in the direction of the more specialized modern orders. Thus, the Creodonta foreshadowed the Carnivora, the Condylarthra presaged the herbivorous groups; but before the close of this period, so favourable were the conditions of life to a rapid evolution of types, that most of the great orders had been clearly defined, though none of the Eocene genera are still extant. Among the early carnivores were *Arctocyon, Palaeonictis, Amblyctonus, Hyaenodon, Cynodon, Provivera, Patriofelis.* The primitive dog-like forms did not appear until late in the period, in Europe; and true cats did not arrive until later, though they were represented by *Eusmilus* in the Upper Eocene of France. The primitive ungulates (Condylarths) were generalized forms with five effective toes, exemplified in *Phenacodus.* The gross Amblypoda, with five-toed stumpy feet (*Coryphodon*), were prominent in the early Eocene; particularly striking forms were the *Dinoceratidae, Dinoceras,* with three pairs of horns or protuberances on its massive skull and a pair of huge canine teeth projecting downwards, *Tinoceras, Uintatherium, Loxolophodon* etc. These enormous creatures, whose remains are so abundant in the Eocene deposits of western America, died out before the close of the period. The divergence of the hoofed mammals into the two prominent divisions, the odd-toed and even-toed, began in this period, but the former did not get beyond the three-toed stage. The least differentiated of the odd-toed group were the Lophiodonts: tapirs were foreshadowed by *Systemodon* and similar forms (*Palaeotherium, Palaplotherium*); the peccary-like *Hyracotherium* was a forerunner of the horse, *Hyrachyus* was a primitive rhinoceros. The evolution of the horse through such forms as *Hyracotherium, Pachynolophus, Eohippus,* etc., appears to have proceeded along parallel lines in Eurasia and America, but the true horse did not arrive until later. Ancestral deer were represented by *Dichobune, Amphitragulus* and others, while many small hog-like forms existed (*Diplopus, Eohyus, Hyopotamus, Homacodon*). The primitive stock of the camel group developed in North America in late Eocene time and sent branches into South America and Eurasia. Certain very generalized forms (Gandodonta) are commonly considered to be ancestral edentates, while the Tillodonta, whose affinities are still uncertain, are often grouped with the rodents, though far larger than any modern members of this group. The Insectivores had Eocene forerunners, and the Lemuroids—probable ancestors of the apes—were forms of great interest. The Cetaceans were well represented by *Zeuglodon* and others.

The non-placental mammals although still numerous were taking a secondary place; *Didelphys,* the primitive opossum, is noteworthy on account of its wide geographical range.

Among the birds, the large flightless forms, *Eupterornis, Gastornis,* were prominent, and many others were present, such as the ancestral forms of our modern gulls, albatrosses, herons, buzzards, eagles, owls, quails, plovers. Reptiles are represented solely by still surviving orders; they are not very common, though the remains of crocodilians, tortoises, turtles and some large snakes are locally plentiful.

The flora of the Eocene period, although full of interest, does not convey the impression of newness that is afforded by the fauna. The reason for this difference is this: the newer flora had been introduced and had developed to a considerable extent in the Cretaceous period, and there is no sharp break between the flora of the earlier and that of the later period. The reason for this difference is that the flora of modern aspect, characterized by the dominance of the flowering plants, had already come into being in the Cretaceous period; hence in general facies there is no sharp line of demarcation between Cretaceous and Eocene floras. Early Eocene floras are tropical or sub-tropical in character but in post Ypresian times there is evidence of cooling climatic conditions. (*See* PALAEOBOTANY.)

Eocene Stratigraphy.—The lower limit of the Eocene (including the Paleocene) is, generally speaking, well defined. There is general agreement that the Danian stage forms the highest Cretaceous and that the Eocene commences with the Montian. In the Montian there are no longer *Rudistes* or *Ammonites* but, on the other hand, a series of *Cerithium,* decidedly Tertiary in aspect, appears. The upper limit of the Eocene is far from clearly defined; it is usually taken at the summit of the Bartonian stage (including the Ludian).

The type area for Eocene stratigraphy is the Anglo-Franco-Belgian basin. At the opening of the Eocene period a broad gulf advanced from the Northern sea (roughly from the area occupied by the North sea of to-day) and covered most of south-eastern England, north-eastern France, Belgium and Holland. The deposits laid down in that gulf are now found confined mainly to four tectonic basins—the basins of London, Hampshire, Paris and Belgium. Occasional outliers or relict blocks serve to connect these areas and to indicate the original extent of the beds. The Eocene sea advanced intermittently, more or less towards the south in the Paris basin, more or less towards the west in England. In the intervals between the marine phases and on the borders of the gulf, lacustrine, fluviatile and estuarine deposits were laid down. Sediment was poured into the basin by rivers flowing from the west in England and from the south in France.

The multiple variations in facies have led to the distinction of a crowd of stages and a very complex nomenclature. Many of the beds and stages separated have a purely local significance. The marine faunas reflect the variations in facies, it is very difficult to separate faunal differences due simply to changes in facies from those due to evolution and immigration. It was only at certain periods that the gulf was in direct communication via the Atlantic coast with the Mediterranean area, so that only at times is there a marked influx of species from the southern seas.

The very varied deposits are most simply grouped into six or seven stages. Each stage commenced with a marine invasion, followed by a shallowing of the sea and then by continental conditions, the whole abruptly terminated by the next marine invasion. The deposits of each stage correspond to a "cycle of sedimentation." It will be clear also that the deposits are predominantly marine towards the centre of the old gulf; predominantly continental towards its margins. The arrangement of the wedges of strata is illustrated in the annexed diagrams.

The *Montian Stage* (Mons, Belgium) marks the first episode in the invasion of the Tertiary sea. During the long period of emergence which separated the Cretaceous and Tertiary periods in this part of Europe, the Chalk of the Parisian region and Belgium had been carved into hills and valleys and the earliest Tertiary deposits occupy valleys invaded by the sea and consist of limestones very localized in their occurrence—in a trough near Mons, at Meudon near Paris, Laversines near Beauvais and at Vertus near Épernay. The Montian is absent in England. The *Landenian Stage* (Landen in Belgium) is marked by a widespread marine invasion, the deposits no longer confined to old valleys. Generally the lower Landenian deposits consist of glauconitic sands resting on a plane of marine denudation on the Chalk surface. At the base there is generally a layer of green coated flints in a clayey, glauconitic matrix (the Bullhead Bed of English geologists). This is succeeded by a series of sands (Thanet Sands of the London basin, Sables de Bracheux of the Paris basin, Lower Landenian of Belgium). In some parts of Belgium the lowest beds are pure white chalky marls (Heersian) with plant remains.

In the London basin a thin bed of rounded pebbles separates the Thanet sands from the glauconitic sands of the Woolwich Bottom Bed (the oldest Tertiary found in the Hampshire basin). Over nearly the whole of the old gulf the marine sands are succeeded by a series of freshwater sands and mottled clays (the Reading Beds of England, Upper Landenian of Belgium, Argile plastique of France) or by a series of estuarine clays and sands often crowded with brackish-water fossils such as *Cyrena* and *Cerithium*. These are the Woolwich Beds of England, the Lignites du Soissonnais of France. The lower marine base of the Landenian is often referred to as the Thanetian Stage; the upper continental stage as the Sparnacian. Only in East Kent—towards the centre of the old gulf—is there Landenian marine throughout. In the sandy beds of the Upper Landenian masses of sand consolidated by a siliceous cement are common which, when weathered out and left on the surface form "sarsens." The *Ypresian Stage* is marked by a still more widespread marine invasion. At the base are often beds of well rounded black flint pebbles with or without a sandy matrix (Blackheath Beds of England, Sinceny Beds of France). The fauna of the pebble beds consists of survivors from the Woolwich phase mixed with new marine invaders common to the overlying deposits. In East Kent purely marine, sandy equivalents of these beds are known as the Oldhaven Beds. In England and Belgium the principal member of the Ypresian Stage is a thick mass of dark blue clay—reaching nearly 500 feet in thickness in parts of the London basin. This is the famous London Clay—the Argile des Flandres or Argile Yprésien of Belgium—which is the most characteristic Tertiary formation of the London basin and in addition occupies large areas in the Hampshire basin. It is so well contrasted with all the underlying sandy beds in the London basin that the latter are often grouped together as the "Lower London Tertiaries." In the Paris basin the place of the London Clay is taken by a group of sands, richly fossiliferous—the Sands of Cuise from which the name Cuisian is derived and often used instead of Ypresian. The characteristic fossil of the sandy phase of the Ypresian is *Nummulites planulatus-elegans*. Towards the south-east in Belgium the clay passes upwards into some extremely fine sands—the Upper Ypresian or Sands of Mons-en-Pevèle. In England the sandy upper part of the London Clay is known as the Claygate Beds which pass up into the continental phase, the Bagshot Beds. On the hills of Essex the Bagshot Beds are represented by beds of shingle; south-west of London by a series of coarse, false-bedded sands which give rise to a delightful stretch of heathland for which the county of Surrey is well known. In the Hampshire basin the Bagshot Beds are very important and include the well known Alum Bay Leaf Beds, Bournemouth Leaf Beds and the Pipe Clays of Poole. They are there a succession of false-bedded sands with lenticular clay and pebble beds, all often highly charged with vegetable matter. In the Paris basin the continental Ypresian is represented by the "Sables à Unios" and at Ay near Épernay have furnished important mammalian remains.

The *Lutetian Stage* (Lutetia = Paris) in general marks the widest extent of the Eocene marine invasion. The Paris basin was undoubtedly thrown into communication with the Mediterranean area and enormous numbers of *Nummulites laevigatus-Lamarcki* swarmed into the basin and formed the most characteristic fossil of the stage. The Lutetian Stage is particularly well developed in the Paris basin and there, apart from the basal sandy beds, consists mainly of beds of limestone, the famous Calcaire grossier. Many beds, especially of the middle division, afford excellent building stone which has been widely quarried throughout the Paris basin. It is the presence of the Calcaire grossier which has given rise to the characteristic scenery of the Paris basin—wooded limestone plateaux intersected by steep sided valleys where the limestone has been cut through. The upper part of the Calcaire grossier is estuarine (caillasses) and represents the continental phase. In Belgium the Flanders Clay, in the Plain of Flanders, passes up into a group of glauconitic clays and sands—the "Paniselian" of Belgian geologists (from Mont Panisel near Mons). The contemporaneity of this series with the Lutetian is generally agreed, though some geologists regard the Paniselian as equivalent rather with the upper part of the London Clay. It does not yield *Nummulites laevigatus*. In the heart of Belgium the Ypresian sands are succeeded by white marine sands (Bruxellian) with this fossil and it is difficult to prove the contemporaneity of the Bruxellian and the Paniselian which are, however, probably two facies of the same deposit. The Bruxellian is well seen round Brussels. In England the Lutetian is represented by the lower part of the Bracklesham Beds, a group of sands, clays and carbonaceous sands well developed in the Hampshire basin and there yielding *Nummulites laevigatus*. Eocene beds, younger than the Bagshot Sands, are found in the London basin only over a small area in Surrey, and fossils are scarce.

The *Ledian* or *Auversian Stage* (Lede in Belgium; Auvers in the Paris basin) is represented in the Paris basin by a series of sands (Sables de Beauchamp, or the Sables moyens of the older geologists) in which the characteristic fossil is *Nummulites variolarius-Herberti*. A similar but thin group of sands overlies the Bruxellian in Belgium, whilst in the Hampshire basin this stage is represented by the upper part of the Bracklesham Beds with the same fossil. Fresh-water limestones occur on the borders of the Paris basin belonging to the upper part of the Auversian.

The *Bartonian Stage* (Barton, Hampshire in England) is not quite so clearly defined in its upper limits as the preceding stages and there is still more than one interpretation commonly accepted. In England the richly fossiliferous Barton clay of the Hampshire basin has near its lower limits a bed with *Nummulites prestwichii*. The clays pass up into marine sands (Barton Sands and Headon Hill Sands) and then into brackish and freshwater clays and sands fading gradually into the Lower Headon Beds. The limit of the Eocene in Hampshire is drawn sometimes at the base of the Lower Headon Beds—a line difficult to define—but more naturally at the base of the succeeding marine Middle Headon Beds. In the Paris basin, the marine Bartonian is thin (Sables de Marines or Marinesian) but the continental phase is well represented by the freshwater St. Ouen Limestone with *Planorbis, Limnaea,* etc.

Succeeding this, however, are the famous Montmartre gypsum deposits and the thin band of marl with stunted marine fossils (Ludian). The Paris basin seems to have been cut off from the sea at this period and to have formed a salt water lagoon in which the Ludian fauna was evolved *in situ* and the gypsum deposited. On the evidence of mammalian remains, the limit of Eocene and Oligocene must be drawn in or at the top of the main mass of gypsum. In Belgium the Ludian is followed by fine sands with *Nummulites wemmelensis* (=*N. prestwichii*) known as Wemmelian, but a higher thin stage of sandy clays, rarely seen, constitutes the Asschian of the Ludian of the Paris basin.

In England the famous Eocene sections are at either end of the Isle of Wight, the cliffs of the mainland from the Isle of Purbeck to the Solent and in the London basin in very numerous inland sections. Reference should be made especially to *Geology in the Field* (1910) and the *Proceedings of the Geologists' Association.*

In Denmark, Scandinavia and northern Germany the Eocene is for the most part poor in fossils and is usually hidden under the Quaternary. The interest of the first two regions lies in the continuous sequence which exists from the Cretaceous upwards. Over the large area in central Europe which separated the Northern sea of Eocene times from the Mediterranean, the Eocene deposits are very localized and consist of fluviatile sands and clays, red earths and lacustrine limestones.

As already mentioned the Atlantic of Eocene times extended over parts of south-west France and north-east Spain as broad gulfs. There are the small gulfs of Basse Loire with Lutetian deposits and the large gulf of Aquitaine. The latter had its greatest extent in Lutetian times; the oldest recognizable beds along the northern borders of the old gulf are Ypresian, along the south border in the beautiful cliff sections of Biarritz they are Lutetian. Elsewhere in the basin there is a complete series of deposits from the Cretaceous upwards. On the borders, as in the Paris basin, are continental deposits. There is no doubt that the chain of the Pyrenees existed in a rudimentary form even in the Eocene and separated the Aquitaine gulf from the Eocene area of the Ebro valley.

The deposits which were laid down in the Eocene geosyncline now represented by the Alps are very different from those of the northern basins. Thicknesses are measured by thousands of feet rather than by dozens; the beds are intensely folded and even metamorphosed; the principal beds are nummulitic limestones, often hard and crystalline, with thin marls and nummulitic sandstones. Such rocks are not only found in southern Europe, including all the Alpine tracts, the Balkans and southern Russia, but they are well developed in northern Africa, Asia Minor, Palestine and may be followed through Persia, Baluchistan and India to China and Tibet. Locally, as in Italy between Vicenzia and Verona (the Vicentin), one finds a littoral phase of the Alpine geosyncline with a complete series of Eocene deposits, except the Landenian, richly fossiliferous. In Italy the term "Priabonian" is often used instead of Bartonian and Ludian.

While the foraminiferal limestones were being formed over most of southern Europe, a series of clastic beds were in course of formation in the Carpathians and the northern Alpine region—viz. the Flysch (*q.v.*) and the Vienna sandstone. Some portions of this Alpine Eocene are coarsely conglomeratic, and in places there are boulders of non-local rocks of enormous dimensions included in the argillaceous or sandy matrix. The Flysch is sparingly fossiliferous and difficult to correlate. In Egypt one finds the Eocene deposits transgressive over a continent which lay to the south of the old ocean; the "Libyan" of older authors includes the highest Cretaceous and lower Eocene; the Mokattam—including the famous limestones with huge nummulites so well known near Cairo—represents the middle and upper Eocene. In the north of India, the Eocene has been divided into the Ranikot (Landenian-Ypresian), Laki (Lutetian) and Kirthar (Lutetian and Bartonian). Exact correlation with Europe is extremely difficult. The first of the three stages in the Himalayan uplift took place in the middle Eocene and even in early Eocene times there existed round the fringes of Asia a series of basins in which sediments were deposited in much the same way as in the Anglo-Franco-Belgian basin. Two excellent examples exist in the Gulf of Assam and the twin gulf of Burma. Unlike the northern European deposits the beds in the Burma gulf are upwards of 10,000 feet in thickness; the deposits towards the landward end of the gulf are predominantly continental—sands and fresh-water to estuarine clays; towards the seaward end of the gulf they are predominantly marine.

Broadly it may be said that the same is true of the Tertiary gulfs which fringe the North and South American continents. The deposits of the Atlantic and Gulf Coast tracts belong definitely to the epicontinental non-folded type; the deposits of the West Indies and the Pacific coastal chains are rather of the geosynclinal type, whilst the deposits in the interior of the continent are of continental type. On the Atlantic coast there are no nummulites and correlation with Europe is difficult. Alabama is typical of the Gulf Coast Eocene; the succession is:—

Upper—Jacksonian—Limestone with Orthophragmina.
Middle { Claibornian with a rich fauna of mollusca. / Chickasawan Sands and Lignites.
Lower—Midwayan or Clayton Limestones.

On the Pacific coast marine formations are found in California and Oregon; such are the Tejon series with lignite and coal; the Escondido series of southern California (7,000ft.), part of the Pascadero series of the Santa Cruz mountains; the Pulaski, Tyee, Arago and Coaledo beds—with coals in Oregon. In the Puget formation of Washington we have a great series of sediments, largely of brackish water origin, and in parts coal-bearing. The total thickness of this formation has been estimated at 20,000ft. (it may prove to be less than this), but it is probable that only the lower portion is of Eocene age. The most interesting of the North American deposits are those of the Rocky mountains and the adjacent western plains, in Wyoming, Nevada, Nebraska, Colorado, etc.; they are of terrestrial, lacustrine or aeolian origin, and on this account and because they are not strictly synchronous, there is considerable difficulty in placing them in their true position in the time-scale. The main divisions or groups are generally recognized as follows:—

Stages		*Mammalian fauna*
Uinta Stage (Ludian)		*Diplacodon*
Bridger Stage, upper (Bartonian)		*Telmatotherium*
Bridger Stage, lower (Upper Lutetian)		*Uintatherium*
Wind River Stage, upper (Lower Lutetian)		
Wind River Stage, lower (Ypresian)		*Bathyopsis*
Wasatch Stage	Landenian	*Coryphodon*
Torrejon Stage	Landenian	*Pandolambda*
Puerco Stage	Landenian	*Polymastodon*

See A. de Lapparent, *Traité de géologie* vol. iii. (5th ed., 1906) which contains a good general account of the period with numerous references to original papers. Also M. Gignoux *Géologie stratigraphique* (1926) for a more modern general account; L. D. Stamp, *Stratigraphy* (1923), for the British Isles, with references; P. Lemoine, *Géologie du Bassin de Paris;* H. F. Osborn, *The Age of Mammals* (1910) for the American mammalian horizons. (L. D. S.)

EOHIPPUS, the "four-toed horse," the earliest known stage in the ancestry of the horse, found in the Lower Eocene formations of the western United States. A number of skeletons and many skulls, jaws or other fragmentary specimens are preserved in American museums. The closely-related *Hyracotherium* of western Europe is known from a skull and a number of jaws. The species range from the size of a fox to that of a cat. The fore foot has four well-developed toes, the hind foot three, with tiny splints representing the first and fifth digits; the third digit in manus and pes is only slightly larger than the others. The radius and ulna are complete and separate, also the tibia and fibula. The incisors are small, spatulate; canines larger, pointed; molars with low rounded cusps partly converted into crests; premolars smaller and simpler than molars. The animal appears to have been digitigrade, walking upright upon the padded toes like the dog or cat, not resting only upon the hoof as do later modern horses. The progressive changes from *Eohippus* to the existing horses are shown in a series of intermediate stages in the American Tertiary formations (*see* EQUIDAE).

EOLITHS. The term Eoliths is used of those objects which belong to the dawn (Eos) of the stone (Lithos) age. It does not

denote naturally chipped stones of any age which appear, at first sight, to be human artefacts. True Eoliths are of Tertiary age. At a congress held in Paris in 1867 it was claimed that certain chipped flints found in Tertiary deposits at Thenay, near Orleans, were humanly fashioned. Many eolithic discoveries have been described, notably as follow: from upper Miocene lacustrine beds at Otta near Madrid, by Carlo Ribeiro in 1872; from the upper Miocene at Puy Courny near Aurillac (France), by J. B. Rames in 1877; from the gravels of the Kent plateau, by B. Harrison in 1899; and from the middle Oligocene at Boncelles (Belgium), by E. de Munck in 1907.

The opponents of the human origin theory for these objects considered (and consider) that natural forces can produce similar specimens (*see* FLINTS). Monsieur Boule has described flints which had passed through a cement-making machine at Mantes, near Paris, which seemed very similar to the Eoliths. Again, Monsieur l'Abbé Breuil showed that well-trimmed edges due solely to earth pressure flaking had been formed on flints collected from the base of the Eocene deposits in the Paris basin. The same phenomenon can be seen in the "Bull Head" beds of Essex and elsewhere. Some few years ago Reid Moir produced specimens from the Tertiary gravel and sand exposures near Ipswich. The finds included scraper-like and awl-like objects and a new type named by him the Rostrocarinate, a chipped flint, shaped like the inverted end of a Canadian canoe, flat underneath with a keel above. At first these finds too were rejected on the same grounds as before. It was further demonstrated that frequently several shades of patina were present; all the chipping could not therefore have been contemporary. Lately, however, specimens which comply with the necessary criteria for humanly fashioned tools (*see* FLINTS) have been unearthed—at one site in what appear to be definite "floors."

In East Anglia the more important Eolith sites so far discovered are near Ipswich in gravel pits at Fox Hall, at Thorington Hall, at Bramford, and at Bolton and Laughlin's pit. The Tertiary deposits were laid down over the lower parts of East Anglia at a time when the land stood at a low level, and shelly sands of Marine origin were formed in the shallow sea. When these deposits, or "Crags" as they are called, arose above high-water level for any length of time they supported a sparse vegetation, and, as it would seem, some of the earliest members of the human race. The Eoliths are associated, for the most part with a bone bed at the base of the "Red Crag." That the Eoliths cannot be of later age than the crags is clear, for the patina on them is that of the pebbles composing the gravels, which are dated by the included Tertiary fauna. Nor can it be claimed that natural forces had by grinding pebbles together chipped them at some earlier date and then washed them into the Crag during the process of its formation. For at Thorington Hall the material is mainly sand, with rare pebbles, and natural flaking due to differential movement of the gravels is thus precluded. Further, just above the implements were found bivalve shells with their delicate hinges unbroken. Had earth movement occurred, other than on a continent-building scale involving without contortion the whole countryside, the hinges would certainly have been smashed. Again there are at Fox Hall two distinct "floors" where implements have been found, both chips and also larger tools occurring together. This could not have occurred had there been a washing-in of older objects from a distance, for the selective action of water would have separated the heavier objects from the lighter chips. We must, therefore, be prepared to accept the fact of the existence of a tool-making animal, probably man, as long ago at least as the late Tertiary period.

BIBLIOGRAPHY.—For an account with bibliography see *Ancient Hunters* 3rd ed., by W. J. Sollas, chap. iii. (M. C. B.)

ÉON DE BEAUMONT, CHARLES GENEVIÈVE LOUISE AUGUSTE ANDRÉ TIMOTHÉE D' (1728–1810), commonly known as the CHEVALIER D'ÉON, French political adventurer, was born near Tonnerre in Burgundy on Oct. 7, 1728. He qualified as an advocate and contributed to Fréron's *Année littéraire*. Sent by Louis XV. to Russia on a secret mission (1755) he adopted a woman's dress, in order to become reader to the Empress Elizabeth. He was sent on a second mission to Russia, and was frequently employed on diplomatic errands during the Seven Years' War. He also served in the French army, and was wounded. In 1762 he was sent to London as agent, then as minister plenipotentiary. He was superseded, involved in legal disputes with his successor, and raised gossip by his *Les Loisirs du Chevalier d'Eon* (Amsterdam, 1774). Bets were laid on his sex, and when he returned to France the king decreed that he must wear woman's dress, which he did to the end of his life, though he frequently figured in fencing matches. He died in London on May 22, 1810. During the closing years of his life he is said to have enjoyed a small pension from George III. A post-mortem examination of the body conclusively established the fact that d'Eon was a man.

The best modern accounts are in the duc de Broglie, *Le Secret du roi* (1888); J. B. Telfer, *Strange Career of the Chevalier d'Eon* (1888); A. E. Vizetelly, *The True Story of the Chevalier d'Eon* (1895); O. Homberg and F. Jousselin, *Le Chevalier d'Éon* (1904); and A. Lang, *Historical Mysteries* (1904).

EOSINES, brilliant pink dyestuffs which are brominated or iodinated derivatives of fluorescein. (*See* DYES, SYNTHETIC.)

EÖTVÖS, JOZSEF, BARON (urt'vursh), Hungarian writer and statesman (1813–1871), was born at Buda on Sept. 13, 1813. He spent many years in western Europe, where he became acquainted with western liberal ideas and with the leaders of the Romantic movement. In the diet of 1839–40 he advocated Jewish emancipation, and in the columns of the *Pesti Hirlap* he put forward a plea for responsible government, without which, he maintained, the necessary reforms in Hungary could not be carried out. His novel, *The Village Notary* (1844–46), which is a Hungarian classic, was liberal and progressive in tendency, as were the romance *Hungary in 1514* and the comedy *Long Live Equality*. After the February revolution of 1848 he was minister of education in the first responsible Hungarian Government. On the retirement of the prime minister Batthyány, Eötvös retired to Munich for a time, and therefore took no active part in the War of Independence. But he served the cause of freedom by his *Influence of the Ruling Ideas of the 19th Century on the State* (Pest, 1851–54; German ed. Vienna and Leipzig, simultaneously). After his return to Hungary in 1851 he held aloof from politics. In 1859 he published his *Guarantees of the Power and Unity of Austria* (German ed., Leipzig, 1859), in which he sought a compromise in the monarchy which would permit of responsible government. In the diets of 1861, 1865 and 1867 he gave loyal and effective support to Deák. In the Andrássy cabinet of 1867 he was minister of education, the only one of the ministers of 1848 to return to office. He established the system of national education in Hungary. Good Catholic though he was (in matters of religion he had been the friend and was the disciple of Montalembert), Eötvös disliked the proclamation of the dogma of papal infallibility, promulgated in 1870, and when the bishop of Fehérvár proclaimed it, Eötvös cited him to appear at the capital *ad audiendum verbum regium*. He was a constant defender of the *Ausgleich* with Austria, and during the absence of Andrássy presided over the council of ministers. He died on Feb. 2, 1871.

Eötvös occupied as prominent a place in Hungarian literature as in Hungarian politics. The best of his verses are to be found in his ballads, but his poems are insignificant compared with his romances. It was *The Carthusians*, written on the occasion of the floods at Pest in 1838, that first took the public by storm. The Magyar novel was then in its infancy, being chiefly represented by the historico-epics of Jósiká. Eötvös modernized it, giving prominence in his pages to current social problems and political aspirations. The famous *Village Notary* came still nearer to actual life, while *Hungary in 1514*, in which the terrible Dozsa *Jacquerie* (*see* DOZSA) is so vividly described, is especially interesting because it rightly attributes the great national catastrophe of Mohács to the blind selfishness of the Magyar nobility.

Eötvös's works were collected in 17 vols. (1901–13). There is a good English version (London, 1850) and numerous German versions of *The Village Notary*, while *The Emancipation of the Jews* has been translated into Italian and German (Pest, 1841–42), and a German translation of *Hungary in 1514*, under the title of *Der Bauernkrieg in Ungarn* was published at Pest in 1850.

See Zoltan Ferenczi, *Baron Joseph Eötvös* (Hung.) (Budapest, 1903); this is the best biography.

EÖTVÖS, ROLAND VON, Baron (1848–1919), Hungarian physicist, son of Baron Josef Eötvös, was born in Budapest July 27, 1848. He studied at Budapest and Heidelberg, and in 1872 he was appointed professor of physics in the University of Budapest. In the following year he was elected member, and in 1889 president, of the Hungarian Academy of Sciences. From 1894–95 he was Minister of Public Instruction. His first scientific studies were connected with capillarity; in 1885 he published the result of these investigations in which he deduced the law connecting the variations of surface tension with temperature. From 1890 onwards he examined the phenomena connected with the problems of gravitation and of terrestrial magnetism. He constructed a number of magnetic instruments. Later he constructed the double-armed torsion balance. This so-called Eötvös-balance is an extremely delicate instrument for determining the variations of gravity quickly and accurately; it became an essential instrument for the location of subterranean materials. In a treatise which won him the Benecke prize from Göttingen university in 1909, Eötvös demonstrated with great exactitude that the attraction of bodies is independent of the quality of the substance. Towards the end of his life he studied the variations of the gravitation (*q.v.*) of bodies moving on the earth. He demonstrated by experiments that if a body moves towards the east it loses in weight. Eötvös showed the rotation of the earth by means of a slowly rotating gravity balance. He died in Budapest on April 8, 1919.

EÖTVÖS BALANCE: *see* Balance: *Torsion Balance.*

EPACRIDACEAE, a large family of dicotyledonous shrubs and trees, chiefly Australian, but also represented in India, New Zealand, South America and the Hawaiian islands. There are 30 genera and some 400 species. In Australia they fill the place occupied elsewhere by the Ericaceae (*q.v.*) or heath family. The flowers are usually white or red, symmetrical and pentamerous. The fruit is a capsule or a drupe. *Astroloma* is the Australian, *Lissanthe* the Tasmanian, cranberry. Species of *Epacris* are cultivated for ornamental flowers.

EPAMINONDAS (Epameinondas, Ἐπαμεινώνδας) (*c.* 418–362), Theban general, was born about 418 B.C. He was educated by Lysis of Tarentum, a Pythagorean philosopher in exile. In 385 he was fighting on the Spartan side in the attack on Mantineia, where he saved the life of Pelopidas. In 371 he represented Thebes at the congress at Sparta, and by his refusal to surrender the Boeotian cities under Theban control prevented the conclusion of a general peace. In the ensuing campaign he commanded the Boeotian army that met the Peloponnesian levy at Leuctra, and by a brilliant victory, due mainly to his innovations in tactics, at once established the predominance of Thebes among the land-powers of Greece.

These innovations were substantially the use of a 50-deep phalanx as a striking head, with the centre and left *en échelon* behind it, in close co-operation with cavalry on the flank. In 370, in support of the new Arcadian league, he took a large army into Laconia; here he dealt a lasting blow at Sparta's predominance in the Peloponnese by liberating the Messenians and rebuilding Messene. In 369 he forced the isthmus lines and secured Sicyon for Thebes; it was probably in this campaign that he founded Megalopolis, the centre of the Arcadian league. Somewhere about this time he seems to have been put on trial on some charge connected with his command; the evidence is conflicting: Plutarch says it was after the 370 campaign, that the charge was of exceeding his term, and that he was acquitted.

Diodorus' account is that it was after the 369 campaign, that the charge was laxity, and that he was removed from the command. Plutarch's account is to be preferred, but Diodorus may be right about the charge.

In the following year he served as a common soldier in Thessaly, and upon being reinstated in command contrived the safe retreat of the Theban army from a difficult position. Returning to Thessaly next year at the head of an army he procured the liberation of Pelopidas from the tyrant Alexander of Pherae without striking a blow. In his third expedition (366) to Peloponnesus, Epameinondas again eluded the isthmus garrison and won over the Achaeans to the Theban alliance. When subsequent complications threatened the position of Thebes in Peloponnesus he again mustered a large army in order to crush the newly formed Spartan league (362). After some masterly operations between Sparta and Mantineia, by which he nearly captured both these towns, he engaged in a battle on the latter site. His tactics (*see* Mantineia) were similar to those of Leuctra. His death on the field converted what was practically a complete victory into an unprofitable draw.

His title to fame rests mainly on his brilliant qualities both as a strategist and as a tactician; his influence on military art in Greece was of the greatest. For the purity and uprightness of his character he likewise stood in high repute; his culture and eloquence equalled the highest Attic standard. In politics his chief achievement was the final overthrow of Sparta's predominance in the Peloponnese; as a constructive statesman he displayed no special talent, and the lofty pan-Hellenic ambitions which are imputed to him at any rate never found a practical expression.

Cornelius Nepos, *Vita Epaminondae;* Diodorus xv. 52–88; Xenophon, *Hellenica*, vii.; L. Pomtow, *Das Leben des Epaminondas* (Berlin, 1870); von Stein, *Geschichte der spartanischen und thebanischen Hegemonie* (Dorpat, 1884), pp. 123 *sqq.;* H. Swoboda in Pauly-Wissowa, *Realencyclopädie*, v. pt. 2 (Stuttgart, 1905), pp. 2674–2707; also Army; History, N. Cay in *Classical Quarterly*, xviii. (1924) 182.

EPARCH, an official, a governor of a province of Roman Greece, ἔπαρχος, whose title was equivalent to, or represented that of the Roman *praefectus*. The area of his administration was called an eparchy (ἐπαρχία). The term survives as one of the administrative units of modern Greece, the country being divided into nomarchies, subdivided into eparchies, again subdivided into demarchies (*see* Greece: *Local Administration*). "Eparch" and "eparchy" are also used in the Russian Orthodox Church for a bishop and his diocese respectively.

EPAULETTE, properly a shoulder-piece (from Fr. *épaule*, a shoulder), and so applied to the shoulder-knot of ribbon to which a scapulary was attached, worn by members of a religious order. The epaulette was first used merely as a shoulder-knot to fasten the baldric, and the application of it to mark distinctive grades of rank was begun in France at the suggestion, it is said, of Charles Louis Auguste Fouquet, duc de Belle-Isle, in 1759. In modern times it always appears as a shoulder ornament for military and naval uniforms. At first it consisted merely of a fringe hanging from the end of the shoulder-strap or cord over the sleeve, but towards the end of the 18th century it became a solid ornament, consisting of a flat shoulder-piece, extended beyond the point of the shoulder into an oval plate, from the edge of which hangs a thick fringe, in the case of officers of gold or silver. The epaulette is worn in the British navy by officers above the rank of sub-lieutenant; in the army it ceased to be worn about 1855. It is worn by officers in the United States navy above the rank of ensign; since 1872 it is only worn by general officers in the army. In most other countries epaulettes were worn by officers until the World War. In the French army until 1914 they were worn by the men also, with a fringe of worsted, various distinctions of shape and colour being observed between ranks, corps and arms of the service. The "scale" is similar to the epaulette, but has no fringe.

ÉPÉE, CHARLES-MICHEL, Abbé de l' (1712–1789), French educationist famous for his work on behalf of the deaf and dumb, was born at Paris on Nov. 25, 1712, being the son of the king's architect. He became a canon of Troyes, but was deprived of his ecclesiastical functions on account of his Jansenist leanings. He then began to instruct two deaf mutes. The Spaniard Pereira was then in Paris, and it has been affirmed that it was from him that Épée obtained his manual alphabet. In any case there can be no doubt that he attained far greater success than Pereira or any of his predecessors, and that the whole system now followed in the instruction of deaf mutes virtually owes its origin to his intelligence and devotion. In 1755 he founded at his own expense a school for deaf mutes, which afterwards was succeeded

by the "Institution Nationale des Sourds Muets à Paris," founded by the National Assembly in 1791. He died on Dec. 23, 1789. He wrote *La Véritable Manière d'instruire les sourds et muets, confirmée par une longue expérience* (1784). His *Dictionnaire général des signes* was completed by his successor the abbé Sicard.

ÉPÉE-DE-COMBAT is a weapon still used in France for duelling and there and elsewhere (blunted, of course) for exercise and amusement in fencing. It has a sharp-pointed blade, about 35in. long, without any cutting edge, and the guard, or shell is bowl-shaped, having its convexity towards the point. The *épée* is the modern representative of the small-sword, and both are distinguished from the older rapier, by being several inches shorter and much lighter in weight. The small-sword (called thus in opposition to the heavy cavalry broadsword), was worn by gentlemen in full dress throughout the 18th century, and it still survives in the modern English court costume.

Methods of foil-fencing after the introduction of the fencing mask are described in the article. Jacob, a Parisian fencing-master, was the first to establish in the last quarter of the 19th century a definite method of the épée, which differed essentially from all its forerunners. He was soon followed by Baudry, Spinnewyn, Laurent and Ayat. The methods of the four first-named, not differing much *inter se,* are based on the perception that in the real sword fight, where hits are effective on all parts of the person, the "classical" bent-arm guard, with the foil inclining upwards, is hopelessly bad. It offers a tempting mark in the exposed sword-arm itself, while the point requires a movement to bring it in line for the attack, which involves a fatal loss of time. The épée is really in the nature of a short lance held in one hand, and for both rapidity and precision of attack, as well as for the defence of the sword-arm and the body behind it, a position of guard *with the arm almost fully extended, and épée in line with the forearm,* is far the safest. Against this guard the direct lunge at the body is impossible, except at the risk of a mutual or double hit (*le coup des deux veuves*). No safe attack at the face or body can be made without first binding or beating, opposing or evading the adverse blade, and such an attack usually involves an initial forward movement. Beats and binds of the blade, with retreats of the body, or counter attacks with opposition, replace the old foil-parries in most instances, except at close quarters. And much of the offensive is reduced to thrusts at the wrist or forearm, intended to disable without seriously wounding the adversary. The direct lunge (*coup-droit*) at the body often succeeds in tournaments, but usually at the cost of a counter hit, which would be fatal with sharp weapons.

Ayat's method, as might be expected from a first-class foil-player, is less simple. Indeed for years, too great simplicity marked the most successful épée-play, because it usually gained its most conspicuous victories over those who attempted a foil defence, and whose practice gave them no safe strokes for an attack upon the extended blade. But by degrees the épéists themselves discovered new ways of attacking with comparative safety, and at the present day a complete épée-player is master of a large variety of movements, both of attack and defence.

It was mainly by amateurs that this development was achieved. Perhaps the most conspicuous representative of the new school was J. Joseph-Renaud, a consummate swordsman, who had also been a champion foil-player. Lucien Gaudin, Alibert and Edmond Wallace may be also mentioned as among the most skilful amateurs, Albert Ayat and L. Bouche as professors—all of Paris. Belgium, Italy and England have also produced épéists quite of the first rank. The épée lends itself to competition far better than the foil, and the revival of the small-sword soon gave rise in France to "pools" and "tournaments" in which there was the keenest rivalry between all comers.

In considering the épée from a British point of view, it may be mentioned that it was first introduced publicly in London by C. Newton-Robinson at an important assault-at-arms held in the Steinway Hall on May 4, 1900. Professor Spinnewyn was the principal demonstrator, with his pupil, the late Willy Sulzbacher. The next day was held at the Inns of Court R. V. School of Arms, Lincoln's Inn, the first English open épée tournament for amateurs. It was won by W. Sulzbacher, C. Newton-Robinson being second, and Paul Ettlinger, a French resident in London, third. This was immediately followed by the institution of the Épée Club of London, which, under the successive presidencies of a veteran swordsman, Sir Edward Jenkinson, and of Lord Desborough, subsequently held annual open international tournaments. In 1906, the Amateur Fencing Association recognized the best-placed Englishman, Edgar Seligman (the actual winner), as the English épée champion.

Épée practice became popular among Belgian and Dutch fencers about the same time as in England, and this made it possible to set on foot international team-contests for amateurs, which have done much to promote good feeling and acquaintanceship among swordsmen of several countries. In 1903 a series of international matches between teams of six was inaugurated in Paris. Up to the year 1909 the French team uniformly won the first place, with Belgium or England second. In 1906 a British épée team of four, consisting of Lord Desborough, Sir Cosmo Duff-Gordon, Bart., Edgar Seligman and C. Newton-Robinson, with Lord Howard de Walden and Theodore Cook as reserves (the latter acting as captain of the team), went to Athens, to compete in the international match at the Olympic games. After defeating the Germans rather easily, the team opposed and worsted the Belgians. It thus found itself matched against the French in the final, the Greek team having been beaten by the French and the Dutch eliminated by the Belgians. After a very close fight the result was officially declared a tie. In fighting off the tie, however, the French were awarded the first prize.

In the Olympic games of London, 1908, the Épée International Individual Tournament was won by Alibert (France), but Montgomerie, Haig and Holt (England), took the 4th, 5th and 8th places in the final pool. In the International Team competition the English representatives, Daniell, Haig, Holt, Montgomerie and Amphlett, took second place to the French. Egerton Castle was captain of the English team.

The method of ascertaining the victor in épée tournaments as indeed with all three weapons, is by dividing the competitors into "pools," usually of six or eight fencers. Each of these fights an assault for first hit only, with every other member of the same pool, and he who is least often hit, or not at all, is returned the winner. If the competitors are numerous, fresh pools are formed out of the first two, three or four in each pool of the preliminary round, and so on until a small number are left for a final pool, the victor in which is the winner of the tournament.

An average épée weighs, complete, about a pound and a half, while a foil weighs approximately one-third less. The épée blade is triangular in section and almost exactly like that of the old small-sword after the abandonment of the *colichemarde* form, in which the *forte* of the blade was greatly thickened. In length from guard or shell to point it measures about 35in., and in width at the shell about $\frac{1}{2}\frac{3}{8}$in. From this it gradually and regularly tapers to the point. There is no cutting edge. The side of the épée which is usually held uppermost is slightly concave, the other is strengthened with a midrib, nearly equal in thickness and similar in shape to either half of the true blade. The material is tempered steel. There is a haft or tang about 8in. long, which is pushed through a circular guard or shell (*coquille*) of convex form, the diameter of which is normally 5in. and the convexity $1\frac{3}{4}$in. The shell is of steel or aluminium, and if of the latter metal, sometimes fortified at the centre with a disk of steel the size of a crown piece. The insertion of the haft or tang through the shell may be either central or eccentric to the extent of about 1in., for protection of the outside of the forearm.

After passing through the shell, the haft of the blade is inserted in a grip or handle (*poignet*), averaging 7in. in length and of quadrangular section, which is made of tough wood covered with leather, india-rubber, wound cord or other strong material with a rough surface. The grip is somewhat wider than its vertical thickness when held in the usual way, and it diminishes gradually from shell to pommel for convenience of holding. It should have a slight lateral curvature, so that in executing circular movements the pommel is kept clear of the wrist. The pommel, usually of

steel, is roughly spherical or eight-sided, and serves as a counter-balance. The end of the haft is riveted through it, except in the case of *épées démontables,* which are the most convenient, as a blade may be changed by simply unscrewing or unlocking the pommel. An épée is well balanced and light in hand when, on poising the blade across the forefinger, about 1in. in advance of the shell, it is in equilibrium.

For practice, the point is blunted to resemble the flat head of a nail, and is made still more incapable of penetration by winding around it a small ball of waxed thread, such as cobblers use. This is called the "button." In competitions various forms of *boutons marqueurs,* all of which are unsatisfactory, are occasionally used. The *pointe d'arrêt,* like a small tin-tack placed head downwards on the flattened point of the épée, and fastened on by means of the waxed thread, is, on the contrary, most useful, by fixing in the clothes, to show where and when a good hit has been made. The point need only protrude about $\frac{1}{16}$th of an inch from the button. There are several kinds of *pointes d'arrêt.* The best is called, after its inventor, the "Leon Sazie," and has three blunt points of hardened steel each slightly eccentric. The single point is sometimes prevented by the thickness of the button from scoring a good hit. A mask of wire netting is used to protect the face, and a stout glove on the sword hand. It is necessary to wear strong clothes and to pad the jacket and trousers at the most exposed parts, in case the blade should break unnoticed. A vulnerable spot is just under the sword-arm.

Recent Developments in Great Britain.—All that has been written under foil-fencing (*q.v.*) with regard to the increase in popularity and the more general appeal of the art to all classes, applies with even greater force to the épée. This is very natural for it is easier to become a moderate épée fencer, good enough to extract great enjoyment from the play, with far less time and study than to reach an equal degree of skill with the foil. Some of the many clubs which sprang up after the World War confined themselves to foil-fencing—all honour to them. Others, after a start with the foil, took up both épée and sabre later; some frankly discarded the foil and devoted themselves to the épée from the start. Given a good teacher of épée play pure and simple, it is quite possible for an adaptable pupil to reach a high degree of excellence with that weapon without preliminary training with the foil, a fact that is borne out by the history of the Grosvenor Fencing Club, a club formed towards the end of 1922, by Mr. G. M. Burt, who won the Épée championship of that year. By keenness and sheer hard work the members of this club made such steady improvement that in 1927 they won the Savage Shield, from a field that included all the leading clubs of London and the provinces. On the other side of the picture it must be noticed that the épée fencer, who has no original grounding with the foil, will rarely make a good foil or sabre fencer. A good foil fencer on the other hand can easily become a firstrate épée fencer, Mr. R. Montgomerie being a striking example.

The épée has been popularized not only in London and at the provincial Salles, it has even spread to the villages. Thanks to Mr. W. Godden, a veteran international fencer, a club for village lads was started in Buckinghamshire in 1926, and aroused much local enthusiasm. All the London hospitals have clubs, which fight with all three weapons, but specialize in épée play.

One feature of épée fencing which has arisen in latter years is to be deplored. Assaults with that weapon are now decided in international events by two hits out of three instead of by a single hit. There appear to be three good and sufficient arguments against this practice: (a) where the target is the whole body, such concentration is required that a single hit is quite sufficient to determine the issue; (b) the knowledge that a single hit is not fatal tends to carelessness over the first hit; (c) a fencer who has won the first hit can win the encounter equally with a good second hit or a *coup double,* and anything which tends to exploit the *coup double* is much to be deprecated.

The principal épée events held annually in London, in addition to the Amateur Championship, are the Épée competition of the Amateur Fencing Association, corresponding to the Foil competition, which is limited to fencers who have never reached the final pool of the Épée championship, nor competed in an international match, and the inter-Salle competition with teams of four for the Savage Shield. Épée Champions since 1910 are:—

1910	E. M. Amphlett	1922	G. M. Burt
1911	J. P. Blake	1923	M. D. V. Holt
1912	R. Montgomerie	1924	C. H. Biscoe
1913	C. G. M. Vereker	1925	Major C. B. Notley
1914	R. Montgomerie	1926	Hon. I. D. Campbell-Gray
1915–1919	No competition	1927	Major C. B. Notley.
1920	M. D. V. Holt		
1921	Captain H. F. S. Huntingdon		

(*See* also FENCING.) (C. E. N. R.; A. R. H.)

EPERJES: *see* PREŠOV.

ÉPERNAY, a town of northern France, capital of an arrondissement in the department of Marne, 88 m. E.N.E. of Paris on the main line of the Eastern railway to Châlons-sur-Marne. Pop. (1926), 19,067. The town stands on the left side of the valley of the Marne, where it receives the Cubry. Épernay (*Sparnacum*) belonged to the archbishops of Reims from the 5th to the 10th century, when it passed to the counts of Champagne. It suffered severely during the Hundred Years' War and was burned by Francis I. in 1544. It was captured by Henry of Navarre in 1592. In 1642, along with Château-Thierry, it was erected into a duchy and assigned to the duke of Bouillon.

In the central and oldest quarter the streets are narrow and irregular; the suburbs, especially that of La Folie, on the east, contain handsome villas. The town has also extended to the right bank of the Marne. One of its churches preserves a portal and stained-glass windows of the 16th century. Épernay is the principal *entrepôt* of the Champagne wines, which are bottled and kept in extensive vaults in the chalk rock on which the town is built. The manufacture of the apparatus and material used in the champagne industry occupies many hands, and the Eastern Railway Company has important workshops there. Épernay is the seat of a sub-prefect and has tribunals of first instance and of commerce.

ÉPERNON, a town of northern France in the department of Eure-et-Loir, at the confluence of the Drouette and the Guesle, 17 m. N.E. of Chartres by rail. Pop. (1926) 2,067. It belonged originally to the counts of Montfort, who, in the 11th century, built a castle here of which the ruins are still left, and granted a charter to the town. In the 13th century it became an independent lordship, which remained attached to the crown of Navarre till, in the 16th century, it was sold by King Henry (afterwards King Henry IV. of France) to Jean Louis de Nogaret, for whom it was raised to the rank of a duchy in 1581. The new duke of Épernon was one of the favourites of Henry III., who were called *les Mignons;* the king showered favours upon him, giving him the posts of colonel-general in the infantry and of admiral of France. Under the reign of Henry IV. he made himself practically independent in his government of Provence. He died in 1642. After the death of his second son Bernard (1661) the title of duke of Épernon was borne by the families of Goth and of Pardaillan.

EPHEBEUM, in architecture, a hall of an ancient Greek palaestra (buildings for exercise and meeting), reserved for the exercises of youths from 16 to 18 years old.

EPHEBI, a name given, in Athens and other Greek towns, to a class of young men from 18 to 20 years of age, who formed a sort of college under State control. On the completion of his 17th year the Athenian youth attained his civil majority, and, provided he belonged to the first three property classes and passed the scrutiny (*dokimasia*) as to age, civic descent and physical capability, was enrolled on the register of his deme. He thereby at once became liable to military training and duties. After admission to the college, the ephebus took the oath of allegiance and was sent to Munychia or Acte to form one of the garrison. At the end of the first year of training, the ephebi were reviewed, and, if their performance was satisfactory, were provided by the State with a spear and a shield, which, with the *chlamus* ("cloak") and *petasos* ("broad-brimmed hat"), made up their equipment. In their second year they were transferred to other garrisons in Attica,

patrolled the frontiers, and on occasion took an active part in war. During these two years they were free from taxation, and were not allowed to appear in the law courts as plaintiffs or defendants. During the Eleusinia they fetched the sacred objects from Eleusis and escorted the image of Iacchus on the sacred way (*see* MYSTERY).

After the end of the 4th century B.C. enrolment ceased to be obligatory, lasted only for a year, and the limit of age was discontinued; with the admission of foreigners the college lost its national character. The military element was no longer all-important, and the *ephēbia* became a sort of university for well-to-do young men of good family, whose social position has been compared with that of the Athenian "knights" of earlier times. The institution lasted till the end of the 3rd century A.D.

BIBLIOGRAPHY.—A whole chapter (42) of the Aristotelian *Constitution of Athens* is devoted to the subject. *See* also Daremberg and Saglio's *Dictionnaire des antiquités*, which contains further bibliographical references; G. Gilbert, *The Constitutional Antiquities of Athens* (Eng. trans., 1895); G. Busolt, *Die griechischen Staats- und Rechtsaltertümer* (1892); T. Thalheim and J. Ohler in Pauly-Wissowa, *Realencyklopädie der classischen Altertumswissenschaft*, v. pt. 2 (1905); L. Whibley, *Companion to Greek Studies* (1916).

EPHEDRA: *see* GYMNOSPERMS.

EPHEDRINE, an alkaloid (*see* ALKALOIDS) first prepared by Nagai (1887) from the Chinese drug "Ma Huang," since then found in other species of Ephedra, and having the composition $C_{10}H_{15}ON$. The naturally occurring laevo form has been synthesized and shown to be $CH_3{\cdot}NH{\cdot}CH(CH_3){\cdot}CH(OH){\cdot}C_6H_5$. It melts at 40° C, has a specific rotation $[\alpha]_D - 6{\cdot}3°$, and forms well defined salts. Ephedrine has become important, since 1925, as a partial substitute for adrenalin (*q.v.*), particularly in the treatment of asthma. (*See* EPHEDRA; JOINT-FIRS.)

EPHEMERIS. An ephemeris is a table giving, for stated points of time, the position or other numerical particulars of one or more of the heavenly bodies. Such tables are essential to the navigator, whose observations of the sun, moon, and stars would be valueless without a knowledge of their exact positions; to the astronomer who wishes to direct his telescope to a particular celestial object, or to check the time-keeping of his clock; and to the computer who predicts eclipses or the return of comets. The word ephemeris is frequently applied to a collection of such tables embodied in the form of an almanac, and it is used in that sense in the following remarks.

National Ephemerides.—The oldest of the five principal astronomical ephemerides is the *Connaissance des Temps ou des Mouvements Célestes,* founded by J. Picard in 1679 and published at Paris under the auspices of the Bureau des Longitudes. Its most distinguished superintendent was Le Verrier, immortalized as the co-discoverer with Adams of the planet Neptune.

The *Nautical Almanac,* which first appeared in 1766 for the year 1767, owes its existence to the initiative of Nevil Maskelyne, then Astronomer Royal. At that time no wholly satisfactory method of determining longitude at sea existed. The method of Lunar Distances, destined to become the standard method during the nineteenth century, but since discarded, was then impracticable because of the inaccuracy of the existing lunar tables, and because special knowledge and long and tedious computation were necessary in their use. When the tables of Tobias Mayer, of Göttingen, came into the hands of Maskelyne, he quickly realized their value to navigation. To make them practically useful, however, it was necessary to prepare from them an ephemeris of the moon for every noon and midnight, which should be published and made available to seamen. Maskelyne's representations to the Board of Longitude resulted in the establishment of the *Nautical Almanac* under his superintendence.

After the death of Maskelyne in 1811 the *Nautical Almanac* fell into disrepute and became notorious for its errors. As a result of many attacks made on it, principally by Francis Baily and Sir James South, the Admiralty appealed to the Royal Astronomical Society in 1830. The society appointed a strong committee, whose many recommendations were accepted in their entirety and embodied in the *Almanac* for 1834. Apart from improvements in the basic data from which the ephemerides are constructed, and a few changes made in 1896 at the suggestion of the Royal Astronomical Society, the form of the *Almanac* remained substantially unaltered until the issue of that for 1923, when the volume was completely re-cast. Changes necessitated by the alteration in 1925 of the beginning of the astronomical day from noon to midnight were made and consideration was given to the changed requirements of modern astronomers and of computers equipped with calculating machines.

As the greater part of the *Nautical Almanac* is not of interest to the seaman, the issue was commenced in 1914 of *The Nautical Almanac, Abridged for the Use of Seamen,* in which the material required for navigation was set up afresh, but only to the lesser degree of accuracy required by that science, Right Ascensions, for instance, being given to the nearest second only.

The third great national ephemeris emanated from Berlin, under the editorship of J. E. Bode. The first volume appeared in 1774, with the title *Astronomisches Jahrbuch oder Ephemeriden für das Jahr 1776.* In 1830 J. F. Encke changed the title to *Berliner Astronomisches Jahrbuch.* It is now produced by the Astronomisches Rechen-Institut, and is highly valued because of its presentation of data in a form adapted to the needs of workers in dynamical astronomy. A supplementary annual volume entitled *Kleine Planeten* contains opposition ephemerides of over 1,000 of the minor planets.

The *Almanaque Nautico y Ephemerides Astronomicas,* adapted to the Naval Observatory of San Fernando, near Cadiz, in Spain, appeared first in 1827 for the year 1830.

Finally the *American Ephemeris and Nautical Almanac* was first published at Washington in 1852 for the year 1855, the editor being Admiral C. H. Davis. Later, under the superintendence of Simon Newcomb, this ephemeris stepped into the front rank and became the best of the national ephemerides.

In addition to the ephemerides already enumerated, nearly every other country publishes one of its own, based on one or more of the above mentioned almanacs. The reason for this is the necessity for having the explanation and directions for use in the language of the country concerned, rather than any special requirements of its astronomers and navigators.

International Co-operation.—Although five extensive national ephemerides are printed they are not all computed independently. Conferences of the directors were held at Paris in 1896 and 1911, while more recently opportunities for co-operation have been afforded by the triennial meetings of the International Astronomical Union, one of whose "commissions" is devoted to ephemerides. The *Nautical Almanac* is responsible for the ephemerides of the sun and planets, using the tables prepared by Newcomb and G. W. Hill for the *American Ephemeris,* and of the moon, using the tables of E. W. Brown, which, since 1923, have replaced those of P. A. Hansen. The *Connaissance des Temps* prepares independent ephemerides of the sun and planets from the Le Verrier-Gaillot tables, and of the moon from Radau's tables based on Delaunay's theory. In addition it produces the apparent places of circumpolar stars, predictions of eclipses, and data for the four great satellites of Jupiter, based on the tables of R. A. Sampson. The *American Ephemeris* is charged with the production of elements of eclipses and occultations from the sun and moon data supplied by the *Nautical Almanac,* of sunrise, sunset, moonrise and moonset tables, and of tables relating to the satellites, and to physical observations of the sun, moon, and planets. The *Berliner Jahrbuch* undertakes the heavy task of preparing asteroid ephemerides, and also tables for the satellites of Saturn, from the elements of H. Struve. The *Almanaque Nautico* shares with the other ephemerides the work of producing apparent places of over 1,000 stars.

Tables of Heavenly Bodies.—Some reference has already been made to the tables used in producing the ephemerides. When a theory of the motion of a heavenly body has been evolved by a master of celestial mechanics, the available observations are used to supply the numerical constants of the theory. Then tables are formed by means of which the position of the body may be found for any desired date. These tables allow for every known gravitational effect acting on the body; for in-

stance, the effect of the attractions of other members of the solar system, and of changes in the size, shape, plane, and orientation of the orbit of the body. In Brown's *Tables of the Moon* no fewer than 1,400 terms are included, and the determination of a single position, which involves the use of 180 tables, is a good day's work for a computer.

Ephemerides of the apparent positions of stars are based on catalogues produced by combining all available observations of these stars and on a knowledge of the motions of the earth, which give rise to precession, nutation and aberration.

In the making of the observations from which these all-important tables and catalogues are formed, the national observatories have, of course, played a leading part; and in several of the ephemeris offices much work has been done in the analysis of these observations, in preparation of the numerical material on which the predictions are based, and in the production of working trigonometrical and other tables.

Computation of an Ephemeris.—The production of an ephemeris involves very heavy computing and careful checking, though it may perhaps be a matter for surprise that a calculation is rarely repeated. The principal check employed is known as differencing, and depends on the fact that the quantities are tabulated for equal intervals of time, and should exhibit a certain smoothness of progression. As a simple illustration of checking by differences, a column of numbers and their cubes may be considered. The process consists in subtracting each cube from the one following and setting down the result as the first difference. Similarly the second, third and higher differences may be found.

		Differences					Differences		
No.	Cube	First	Second	Third	No.	Cube	First	Second	Third
1	1				1	1			
		7					7		
2	8		12		2	8		12	
		19		6			19		6
3	27		18		3	27		18	
		37		6			37		5
4	64		24		4	64		23	
		61		6			60		9
5	125		30		5	124		32	
		91		6			92		3
6	216		36		6	216		35	
		127		6			127		7
7	343		42		7	343		42	
		169		6			169		6
8	512		48		8	512		48	
		217					217		
9	729				9	729			

In the table on the left the third differences are uniformly 6. In the other table 5^3 or 125 has been replaced by 124, with the result that the smoothness of the third difference is interrupted. The effect of an error of even a single unit in the last figure of a function is seen to be a considerable distortion of the smoothness of the final order of differences. Not only does the process of differencing provide a most powerful method of detecting accidental errors but it also enables the computer to locate the erroneous value and to determine the sign and magnitude of the error.

Calculating Machines.—Until the early part of this century tables of logarithms formed the chief tools of the computer, but the tendency now is to employ mechanical calculators whenever possible. The simplest of these is the adding machine, in which addition is performed by the depression of numbered keys. In the lunar and planetary tables, which consist of periodic sine or cosine terms, a constant is usually added to each table so that no negative numbers occur, and after adding perhaps 30 or 40 terms from as many tables a simple subtraction of the sum of the constants is made. Thus a Comptometer or other adding machine relieves the computer of the tedium of much mental addition, and, moreover, reduces the possibility of error.

Still more important are machines for multiplication and division. These are as a rule faster, more accurate, and less fatiguing than logarithms. Electrically driven machines such as the Monroe or Mercedes are particularly efficient in heavy work, while hand machines, such as the Nova-Brunsviga, are no less valuable for casual computations. Two special advantages possessed by calculating machines are that they will add products while forming them, and that they avoid the writing of intermediate figures.

The summation of a large number of the positive terms in Brown's *Tables of the Moon* is now done very efficiently by means of the Hollerith tabulating machine. Here the same numbers are used repeatedly, but never twice with the same partners. The numbers are, therefore, punched on to cards, which are arranged in the correct order and passed through the machine. The machine performs the necessary additions and prints the required results, while the cards are automatically re-sorted to be used again.

A mechanical integrator can be of the greatest assistance in ephemeris work. Quantities are frequently computed for every fourth or eighth day, and the intervening values obtained by the process known as interpolation. In the form usually employed this process is the reverse of that previously described as differencing, and in carrying it out the second differences of the new quantities are first obtained and then the column of values is formed by repeated summation. The ideal mechanical integrator would produce and print these new values and their differences. In 1908 a machine was built by Herr Hamann, and successfully used by Bauschinger and Peters for the production of 8-figure logarithm tables; but as this machine was subsequently stolen, and the plans used are lost, it cannot be reproduced.

In 1927 two commercial machines appeared, not specifically designed for mechanical integration, but able to perform the work very satisfactorily. One, the Brunsviga-Dupla, is a hand machine with a capacity of 15 figures, but no printing device. The other, an electric Burroughs machine with two distinct adding mechanisms, will add and print 13 figures, together with four figures of the argument, while all carriage and spacing movements are performed automatically. In addition to its use in the production of ephemerides such a machine lends itself readily to the computation of extensive mathematical and trigonometrical tables.

(L. J. C.)

EPHEMEROPTERA, an order of insects (*q.v.*), comprising the may-flies (*q.v.*) and their allies.

EPHESIANS, EPISTLE TO THE. This book of the New Testament, the most general of all the Pauline epistles and the one having least apparent reference to an immediate occasion, may be described as a solemn contemplation of the lofty privilege into which God's eternal purpose has brought believers in Christ, followed by an exhortation to conduct worthy of this high calling. Beneath this simple structure of the epistle and pervading the whole is the fully developed conception of Christ as central in the universe and in history. God's purpose from eternity was in the fulness of times to unite in Christ the Jews (to whom had been given the covenants of promise), and so to bring human history to its goal, the one New Man, the measure of the stature of the fulness of Christ. Those who have believed in Christ, that is the Church, represent the result of this redemptive work; and a clear knowledge of the purpose itself, the secret of the ages, has now been revealed to men. The theme of the epistle has often, but not quite adequately, been described as the Unity and Divinity of the Church.

The writer's exposition of Christian privilege takes the form of a great expanded use of the conventional introductory paragraphs of congratulation and prayer seen in other epistles of Paul as also in the Greek letters of simple people. In it, packed full of thought as it is, the writer touches on many profound aspects of his great conception (i. 3–ii. 10), then (ii. 11–iii. 13) points out the significance of the readers' position as Gentile believers, with a long digression (iii. 1–13) declaring his own (Paul's) commission by God's grace to preach to the Gentiles. This first half of the epistle closes with a renewed prayer for the strengthening of the readers in character and in the understanding of their great privilege (iii. 14–19) and with an ascription of eternal glory to almighty God (iii. 20–21).

In the second half the writer turns with a characteristic and impressive "therefore" to an exposition (iv.–vi.) of the responsibilities which the privilege entails, especially the preservation within the Church of unity in peace, on which, in harmony with his underlying theme, he enlarges in a notable passage (iv. 3–16).

Detailed warning against obvious vices (iv. 17–v. 14) merges in an exhortation to specific virtues (v. 15–vi. 9); and here in a series of paragraphs on the duties of wives, husbands, children, parents, slaves and masters Paul seems to be striving to find in the common relation of Christians to the Lord the principle of a new and specifically Christian (as distinguished from Jewish or Stoic) ethics. The power of moral achievement comes from God (vi. 10–18a). With an entreaty that the readers will pray for other Christians and for Paul himself, and with a note regarding Tychicus, the bearer of the letter, and a farewell benediction (vi. 18b–24) the epistle closes.

Title.—The title and opening verse of the epistle present a problem. Except for the edition of Marcion (*c.* A.D. 150), in which (possibly by an inference of identification from Col. iv. 16) it was entitled "To the Laodiceans," the epistle has in all periods (including the 2nd century) borne the title "To the Ephesians." But probably as early as the 2nd century, certainly in the 3rd and 4th centuries and subsequently, there were in circulation excellent copies (including our Codices Vaticanus and Sinaiticus of the 4th century) which omitted the words "in Ephesus" from the first verse. The most natural explanation is that these words were lacking in the original and were later added to the verse from the title which the epistle had received when the collection of Paul's epistles was adapted for church use. To this would correspond the absence of reference in the epistle to the members and conditions of any single Gentile church; and altogether the book is best understood as a circular letter intended for a considerable group of churches, of which that at Ephesus may have been one. As a letter addressed to the church at Ephesus alone, where in a long period of years Paul had acquired uncounted friendly connections and of which he must have had abundant knowledge, the epistle would be incomprehensible. That it is, however, "the letter (to be got) from Laodicea" mentioned in Col. iv. 16 is not improbable.

Resemblance to Colossians.—The relationship, both literary and theological, between the Epistle to the Ephesians and that to the Colossians (*q.v.*) is very close. Many of the prominent ideas of the two writings are the same, especially the developed view of the central position of Christ in the whole universe; the conception of the Church as Christ's body, of which He is the head; the thought of the great Mystery, once secret, now revealed. There is further resemblance in the formal code of morals, similarly arranged by classes of persons and having much the same contents in the two epistles (Eph. v. 22–vi. 9; Col. iii. 18–iv. 1). In both cases Tychicus carries the letter, and in almost identical language the readers are told that he will by word of mouth give fuller information about the apostle's affairs (Eph. vi. 21–22; Col. iv. 7–8). Moreover, in a great number of characteristic phrases and even whole verses the two are alike. *See*, for instance, Eph. i. 7, Col. i. 14; Eph. i. 10, Col. i. 20; Eph. i. 21, Col. i. 16; Eph. i. 22, 23, Col. i. 18, 19; Eph. ii. 5, Col. ii. 13; Eph. ii. 11, Col. ii. 11; Eph. ii. 16, Col. i. 20; Eph. iii. 2, 3, Col. i. 25, 26, and many other parallels (very fully set forth in Moffatt's *Introduction*, pp. 375–381). Only a comparison in detail can give a true impression of the extraordinary degree of resemblance. Yet the two epistles do not follow the same course of thought, and their contents cannot be successfully exhibited in a common synoptical abstract. Each has its independent occasion, purpose, character and method; but the two draw on a common store of thought and use common means of expression.

Genuineness.—The earliest evidence of use of Ephesians (1 Peter [not later than *c.* 100 A.D.], Ignatius, Polycarp and Hermas), and of the general 2nd-century acceptance of its claim to be by Paul (Irenaeus, Tertullian, Clement of Alexandria, Muratorian Canon), is as complete as the remains of early Christian literature reasonably permit; but on internal grounds objections to the genuineness of the epistle have been pressed since the early part of the 19th century. In recent years a certain, but by no means universal, tendency among critics to accept Ephesians as genuine has followed the somewhat stronger reaction in favour of Colossians. As a matter of fact the question of authorship is less important to the student of the history of Christian thought than in the case of other Pauline epistles, because of the lack in Ephesians of specific allusions to the situation. The place of its ideas in Christian history is not very different whether they were those of Paul in his later years or of an otherwise unknown great writer in profound sympathy with Paul's thought but living in the period following the apostle's death.

The objections to the genuineness of the epistle consist partly of literary observations and points of detail, and these have on the whole not proved convincing. (1.) The style has a slow and cumbrous movement; but parallels can be found elsewhere in Paul (*e.g.*, Rom. iii. 23–26), while many positive traits of Pauline style can be pointed out in Ephesians. (2.) The vocabulary is not more distinctive than, for instance, that of Galatians. (3.) Such phrases as "the devil" (iv. 27, vi. 11, as in the Pastoral epistles, instead of "Satan" as in Paul's other epistles), "his holy apostles and prophets" (iii. 5, *cf.* ii. 20), "mystery" (v. 32) in a sense not exactly the same as any of the other various meanings of the word in Paul, with other similar considerations often adduced, are not sufficient to prove that another than Paul was the author. (4.) The relation to Colossians is to some a ground of suspicion, but to others seems best explained by accepting a common Pauline authorship for both epistles. Holtzmann's ingenious theory (1872) that our Epistle to the Colossians, while based on a genuine shorter letter of Paul, is the product of expansion by the same later hand which created Ephesians has gained but limited support from recent scholars.

The more serious objections come from the advanced Christology and the terms of Alexandrian philosophy used in stating it, together with the developed conception of the Church as undivided and as the body of Christ. These ideas, however, do not seem to lie beyond the possibility of inclusion within Paul's horizon, and Colossians, if accepted as genuine, provides Pauline parallels for most of them. That the thought of the epistle implies the atmosphere and situation of the 2nd century is a position which cannot be sustained.

On the other hand, Ephesians shows profound and subtle agreement with the distinctive modes of thought, ruling interests, and religious language of Paul. So full an understanding and complete a resemblance in thought on the part of another writer would be without a parallel in that period (even 1 Peter is far less close). Highly significant is the strong pride of Jewish race exhibited in Eph. ii. 11–22 combined with the writer's extreme satisfaction in the opening of salvation in Christ to the Gentiles to whom the epistle is addressed.

Date and Place.—If Ephesians was written by Paul, it was composed during the period of his imprisonment, either at Caesarea or at Rome (iii. i.; iv. 1; vi. 20). The theory lately advanced of an imprisonment at some time during the three years' stay at Ephesus is improbable. At very nearly the same time he must have written Colossians and Philemon; all three were sent by Tychicus. There is no strong reason for supposing that the three were written from Caesarea. In favour of Rome are the greater probability of the metropolis as the place where a fugitive slave would hide himself, the impression given in Colossians of opportunity for active mission-work (Col. iv. 3, 4; *cf.* Acts xxviii. 30, 31), and the fact that Philippians, which in a measure belongs to the same group, was pretty certainly written from Rome. Ephesians is not intended merely for Gentile Christians at large, for Tychicus carries the letter to the readers, Paul has some general knowledge of their circumstances (i. 15), and they are explicitly distinguished from "all the saints" (iii. 18, vi. 18). We may most naturally think of them as the members of the churches of Asia.

BIBLIOGRAPHY.—Besides general works on New Testament Introduction, the Apostolic Age, and the Life of Paul, and the treatises on Paul's theology, *see* H. Holtzmann, *Kritik der Epheser- und Kolosser-briefe* (1872); F. J. A. Hort, *Prolegomena to St. Paul's Epistles to the Romans and the Ephesians* (1895). Commentaries. In English: H. A. W. Meyer (4th ed. 1867; Eng. trans. 1880); T. K. Abbott (Internat. Crit. Comm., 1897); J. Armitage Robinson (1903, 2nd ed. 1904). In German: Hermann von Soden (Hand-Commentar zum N.T., 1891); M. Dibelius (Handbuch zum N.T., 2nd ed., 1927). (J. H. Rs.)

EPHESUS, an ancient Ionian city on the west coast of Asia

Minor. In historic times it was situated on the lower slopes of the hills, Coressus and Prion, which rise out of a fertile plain near the mouth of the river Caÿster, while the temple and precinct of Artemis or Diana, to the fame of which the town owed much of its celebrity, were in the plain itself, E.N.E. at a distance of about a mile. But there is reason to think both town and shrine had different sites in pre-Ionian times, and that both lay farther south among the foot-hills of Mt. Solmissus. The situation of the city was such as at all times to command a great commerce. Of the three great river basins of Ionia and Lydia, those of the Hermus, Caÿster and Maeander, it commanded the second, and had already access by easy passes to the other two.

HISTORY

The earliest inhabitants assigned to Ephesus by Greek writers are the "Amazons," with whom we hear of Leleges, Carians and Pelasgi. In the 11th century B.C., according to tradition (the date is probably too early), Androclus, son of the Athenian king Codrus, landed on the spot with his Ionians and a mixed body of colonists; and from his conquest dates the history of the Greek Ephesus. The deity of the city was Artemis; but we must guard against misconception when we use that name, remembering that she bore close relation to the primitive Asiatic goddess of nature, whose cult existed before the Ionian migration at the neighbouring Ortygia, and that she always remained the virgin-mother of all life and especially wild life, and an embodiment of the productive power of the earth. The well-known monstrous representation of her, as a figure with many breasts, swathed below the waist in grave-clothes, was probably of late and alien origin. In early Ionian times she seems to have been represented as a natural matronly figure, sometimes accompanied by a child, and to have been a more typically Hellenic goddess than she became in the Hellenistic and Roman periods.

Croesus and the Persians.—Twice in the period 700–500 B.C. the city owed its preservation to the interference of the goddess; once when the Cimmerians overran Asia Minor in the 7th century and burnt the Artemision itself; and once when Croesus besieged the town in the century succeeding, and only retired after it had solemnly dedicated itself to Artemis, the sign of such dedication being the stretching of a rope from city to sanctuary. Croesus presented most of the columns required for the restoration of the temple of Artemis, as well as some cows of gold. To counteract, perhaps, the growing Lydian influence, Athens, the mother-city of Ephesus, despatched one of her noblest citizens, Aristarchus, to restore law on the basis of the Solonian constitution. The labours of Aristarchus seem to have borne fruit. It was an Ephesian follower of his, Hermodorus, who aided the Decemviri at Rome in their compilation of a system of law about the middle of the 5th century B.C. And in the same generation Heraclitus, probably a descendant of Codrus, quitted his hereditary magistracy in order to devote himself to philosophy, in which his name became almost as great as that of any Greek. Poetry had long flourished at Ephesus. From very early times the Homeric poems found a home and admirers there; and to Ephesus belong the earliest elegiac poems of Greece, the war songs of Callinus, who flourished in the 7th century B.C. and was the model of Tyrtaeus (*q.v.*). The city seems to have been more than once under tyrannical rule in the early Ionian period; and it fell thereafter first to Croesus of Lydia, and then to Cyrus, the Persian, and when the Ionian revolt against Persia broke out in the year 500 B.C. under the lead of Miletus, the city remained submissive to Persian rule. When Xerxes returned from the march against Greece (478 B.C.), he honoured the temple of Artemis, although he sacked other Ionian shrines, and even left his children behind at Ephesus for safety's sake. After the final Persian defeat at the Eurymedon (466 B.C.), Ephesus for a time paid tribute to Athens, with the other cities of the coast, and Lysander first and Agesilaus afterwards made it their headquarters. To the latter fact we owe a contemporary description of it by Xenophon. In the early part of the 4th century it fell again under Persian influence, and was administered by an oligarchy.

From Alexander to the Romans.—Alexander the Great was received by the Ephesians in 334, and established democratic government. Soon after his death the city fell into the hands of Lysimachus, who introduced fresh Greek colonists from Lebedus and Colophon and renamed the city after his wife Arsinoë; but the old name was soon resumed. Ephesus was very prosperous during the Hellenistic period, and is conspicuous both then and later for the abundance of its coinage, which gives us a more complete list of magistrates' names than we have for any other Ionian city. The Roman coinage is remarkable for the great variety and importance of its types. After the defeat of Antiochus the Great, king of Syria, by the Romans, Ephesus was handed over by the conquerors to Eumenes, king of Pergamum, whose successor was Attalus Philadelphus. The third Attalus of Pergamum bequeathed Ephesus with the rest of his possessions to the Roman people, and it became for a while the chief city, and for longer the first port, of the province of Asia, the richest in the empire.

Henceforth Ephesus remained subject to the Romans, save for a short period, when, at the instigation of Mithridates Eupator of Pontus, the cities of Asia Minor revolted and massacred their Roman residents. The Ephesians even dragged out and slew those Romans who had fled to the precinct of Artemis for protection, notwithstanding which sacrilege they soon returned from their new to their former masters, and even had the effrontery to state, in an inscription preserved to this day, that their defection to Mithridates was a mere yielding to superior force. Sulla, after his victory over Mithridates, brushed away their pretexts, and inflicted a very heavy fine. In the civil wars of the 1st century B.C. the Ephesians twice supported the unsuccessful party, giving shelter to, or being made use of by, first Brutus and Cassius, and afterwards Antony.

The Christian Period.—All this time the city was gradually growing in wealth and in devotion to the service of Artemis. The story of St. Paul's doings there illustrates this fact, and the sequel is very suggestive—the burning, namely, of books of sorcery of great value. Addiction to the practice of occult arts had evidently become general in the now semi-orientalized city. The Christian Church which Paul planted there was governed by Timothy and John, and is famous in Christian tradition as a nurse of saints and martyrs. According to local belief, Ephesus was also the last home of the Virgin, who was lodged near the city by St. John and there died. But later events show that the pagan tradition of Artemis continued very strong and perhaps never became quite extinct in the Ephesian district. The city was proud to be termed *neocorus* or servant of the goddess.

Ephesus contested stoutly with Smyrna and Pergamum the honour of being called the first city of Asia; each city appealed to Rome, and we still possess rescripts in which the emperors endeavoured to mitigate the bitterness of the rivalry. One privilege Ephesus secured; the Roman governor of Asia always landed and first assumed office there: and it was long the provincial centre of the official cult of the emperor, and seat of the Asiarch. The Goths destroyed both city and temple in A.D. 262, and although the city revived and the cult of Artemis continued, neither ever recovered its former splendour. A general council of the Christian Church was held there in 431 in the great double church of St. Mary, which is still to be seen. On this occasion Nestorius was condemned, and the honour of the Virgin established as *Theotokus*, amid great popular rejoicing, due, doubtless, in some measure to the hold which the cult of the virgin Artemis still had on the city. Thereafter Ephesus seems to have been gradually deserted owing to its malaria; and life transferred itself to another and higher site (Ayassoluk) near the Artemision. The ruins of the Artemision, after serving as a quarry to local builders, were finally covered deep with mud by the river Caÿster, or one of its left bank tributaries, the Selinus, and the true site remained unsuspected until 1869.

EXCAVATIONS

The first light thrown on the topography of Ephesus was due to the excavations conducted by the architect, J. T. Wood, on behalf of the trustees of the British Museum, during the years

1863–1874. He first explored the Odeum and the Great Theatre situate in the city itself, and in the latter place found an inscription which indicated in what direction to search for the Artemision. Following up this clue, Wood lighted first on a ruin which he believed to be the tomb of Androclus, and afterwards on an angle of the wall of the time of Augustus. Soon afterwards he struck the actual pavement of the Artemision on the last day of 1869.

Excavation of the Artemision.—Wood removed the whole stratum of superficial deposit which overlay the huge area of the temple, and exposed to view not only the scanty remains of the latest edifice, built after 350 B.C., but the platform of an earlier temple, now known to be that of the 6th century to which Croesus contributed. Below this he did not find any remains. He sent to England parts of several sculptured drums of the latest temple, and archaic sculptures from the drums and parapet of the earlier building. He also made a plan of the Hellenistic temple, found many inscriptions and a few miscellaneous antiquities, and had begun to explore the Precinct, when the trustees of the British Museum suspended his operations in 1874. The site lay desolate till 1904, when the trustees sent D. G. Hogarth to re-examine the remains. Wood's "earliest temple" was re-cleared and planned, remains of three earlier shrines were found beneath it, a rich deposit of offerings, etc., belonging to the earliest shrine was discovered, and tentative explorations were made in the Precinct. This deep digging, however, resulted in the permanent flooding of the site.

History of the Artemision.—The history of the Artemision, as far as it can be inferred from the remains, is as follows. (1) There was no temple on the plain previous to the Ionian occupation, the primeval seat of the nature-goddess having been in the southern hills, at Ortygia (near mod. *Arvalia*). Towards the end of the 8th century B.C. a small shrine came into existence on the plain. This was little more than a small platform of green schist with a sacred tree and an altar, and perhaps later a wooden image, the whole enclosed in a *temenos*. But this early shrine was presently enriched by Greeks with many and splendid offerings of Hellenic workmanship. The whole treasure can be dated to a period considerably anterior to the reign of Croesus. This treasure is now divided between the museums of Constantinople and London. (2) Within a short time, perhaps after the Cimmerian sack (? 650 B.C.), this shrine was restored, slightly enlarged, and raised in level, but not altered in character. (3) About the close of the century the shrine was replaced by a temple of regular Hellenic form. The latter was built in relation to the earlier central statue-base, but at a higher level than either of its predecessors, doubtless for dryness' sake. There is now no certain evidence of its architectural character; but it is very probable that it was the early temple in which the Ionic order is said to have been first used, after the colonists had made use of Doric in their earlier constructions; and that it was the work of the Cnossian Chersiphron and his son, Metagenes, always regarded afterwards as the first builders of a regular Artemision. Their temple is said by Strabo to have been made bigger by another architect. (4) The latter's work must have been the much larger temple, exposed by Wood, and usually known as the Archaic or Croesus temple. This overlies the remains of No. 3, at a level higher by about a metre, and the area of its *cella* alone contains the whole of the earlier shrines. Its central point, however, was still the primitive statue-base, now enlarged and heightened. About half its pavement, parts of the *cella* walls and of three columns of the peristyle, and the foundations of nearly all the platform, are still in position. The visible work was all of very fine white marble. Fragments recovered show that the workmanship and Ionic style were of the highest excellence, and that the building presented a variety of ornament, rare among Hellenic temples. The whole ground-plan covered about 80,000 sq.ft. The height of the temple is doubtful. Judged by the diameter of the drums, the columns of the Croesus temple were not two-thirds of the height of those of the Hellenistic temple.

This fourth temple is, beyond question, that to which Croesus contributed, and it was, therefore, in process of building about 540 B.C. It took 120 years to complete. It was dedicated probably between 430 and 420 B.C., and the famous Timotheus, son of Thersander, carried off the prize for a lyric ode against all comers. Its original architects were, probably, Paeonius of Ephesus, and Demetrius, a priest of the shrine itself. Of this temple Herodotus speaks as existing in his day; and unless weight be given to an isolated statement of Eusebius, that it was burned about 395 B.C., we must assume that it survived until the night when one Herostratus, desirous of acquiring eternal fame if only by a great crime, set it alight. This is said to have happened in 356 B.C. on the October night on which Alexander the Great came into the world. But the exactness of this portentous synchronism makes the date suspect. (5) It was succeeded by what is called the Hellenistic temple, begun almost immediately after the catastrophe, according to plans drawn by the famous Dinocrates the architect of Alexandria. The platform was once more raised to a higher level by means of huge foundation blocks bedded upon the earlier structures. The new columns were of greater diameter than the old and over 60 ft. high; and from its great height the whole structure was regarded as a marvel, and accounted one of the wonders of the world. Since, however, other Greek temples had colonnades hardly less high, and were of equal or greater area, it has been suggested that the Ephesian temple had some distinct element of grandiosity, no longer known to us—perhaps a lofty sculptured parapet or some imposing form of *podium*. The fifth temple was once more of Ionic order, but the finish and style of its details as attested by existing remains were inferior to those of its predecessor. The great sculptured drums and pedestals, now in the British Museum, belong to the lower part of certain of its columns: but nothing of its frieze or pediments (if it had any) has been recovered. Begun probably before 350 B.C., it was in building when Alexander came to Ephesus in 334 and offered to bear the cost of its completion. It was probably finished by the end of the century. It stood intact, except for very partial restorations, till A.D. 262 when it was sacked and burned by the Goths: but it appears to have been to some extent restored afterwards, and its cult no doubt survived till the Edict of Theodosius closed the pagan temples (about 389).

THE CITY

After Wood's explorations, the city remained desolate till 1894, when the Austrian Archaeological Institute obtained a concession and began systematic excavation. This has been carried down no farther than the imperial stratum. The main areas of operation have been: (1) The *Great Theatre*. The stage buildings, orchestra and lower parts of the *cavea* have been cleared. In the process considerable additions were made to Wood's find of sculptures in marble and bronze, and of inscriptions. This theatre has a peculiar interest as the scene of the tumult aroused by the mission of St. Paul; but the existing remains represent a reconstruction carried out after his time. (2) The *Hellenistic Agora*, a huge square, surrounded by porticoes, lying S.W. of the theatre and having fine public halls on the S. It has yielded fine sculpture in marble and bronze and many inscriptions. (3) The *Roman Agora*, with its large halls, lying N.W. of the theatre. Here were found many inscriptions of Roman date and some statuary. (4) A street running from the S.E. angle of the Hellenic Agora towards the Magnesian gate. This was found to be lined with pedestals of honorific statues and to have on the west side a remarkable building, stated in an inscription to have been a library. (5) A street running direct to the port from the theatre. This was known as the Arcadiane after having been restored at a higher level than formerly by the emperor Arcadius (A.D. 395). It leaves on the right the great *Thermae* of Constantine, of which the Austrians have cleared out the south-east part. Part of the quays and buildings round the port were exposed, after measures had been taken to drain the upper part of the marsh. (6) The Double Church of the Virgin "Deipara" in the N.W. of the city, wherein the council of 431 was held. Here interesting inscriptions and Byzantine architectural remains were found. Besides these excavated monuments, the Stadion; the *enceinte* of fortifications erected by Lysimachus, which runs from the tower called

the "Prison of St. Paul" and right along the crests of the Bulbul (Prion) and Panajir hills; the round monument miscalled the "Tomb of St. Luke"; and the Opistholeprian gymnasium near the Magnesian gate, are worthy of attention.

The work done by the Austrians enables a good idea to be obtained of the appearance presented by a great Graeco-Roman city of Asia in the last days of its prosperity. It may be realized better there than anywhere how much architectural splendour was concentrated in the public quarters. But the restriction of the clearance to the upper stratum of deposit has prevented the acquisition of much further knowledge. Both the Hellenistic and, still more, the original Ionian cities remain for the most part unexplored. It should, however, be added that very valuable topographical exploration has been carried out in the environs of Ephesus by members of the Austrian expedition.

The Turkish village of Ayassoluk (the modern representative of Ephesus), more than a mile N.E. of the ancient city, is noteworthy for a splendid ruined mosque built by the Seljuk, Isa Bey II., of Aidin, in 1375, which contains magnificent columns: for a castle, near which lie remains of the pendentives from the cupola of the great cathedral of St. John, now deeply buried in its own ruins; and for an aqueduct, Turkish baths and mosque-tombs.

Bibliography.—E. Curtius, *Ephesos* (1874); C. Zimmermann, *Ephesos im ersten christlichen Jahrhundert* (1874); J. T. Wood, *Discoveries at Ephesus* (1877); E. L. Hicks, *Anc. Greek Inscr. in the Brit. Museum*, iii. 2 (1890); B. V. Head, "Coinage of Ephesus" (*Numism. Chron.*, 1880); J. Menadier, *Que condicione Ephesii usi sint*, etc. (1880); Sir W. M. Ramsay, *Letters to the Seven Churches* (1904); D. G. Hogarth, *Excavations at Ephesus: the Archaic Artemisia* (2 vols., 1908) with chapters by C. H. Smith, A. Hamilton Smith, B. V. Head, and A. E. Henderson. (D. G. H.)

EPHESUS, COUNCILS OF. Two church councils at Ephesus have acquired historic importance.

(*a*) In June 431 a council was convened here to deal with the Nestorian doctrine of the person of Christ. The councils of Nicea and Constantinople had asserted the full divinity and real humanity of Christ, without, however, defining the manner of their union. The attempt to solve the apparent incongruity of a perfect union of two complete and distinct natures in one person produced first Apollinarianism, which substituted the divine Logos for the human νοῦς or πνεῦμα of Jesus, thereby detracting from the completeness of his humanity; and then Nestorianism, which destroyed the unity of Christ's person by affirming that the divine Logos dwelt in the man Jesus as in a temple, and that the union of the two was in respect of dignity, and furthermore that, inasmuch as the Logos could not have been born, to call Mary θεοτόκος, "Godbearer," was absurd and blasphemous. The Alexandrians, led by Cyril, stood for the "monophysite" doctrine of the perfect union of two complete natures in one person, and made θεοτόκος the shibboleth of orthodoxy. The theological controversy was intensified by the rivalry of the two patriarchates, Alexandria and Constantinople, for the primacy of the East. As bishop of Constantinople Nestorius naturally looked to the emperor for support, while Cyril turned to Rome: but the Ephesian council of 431 condemned his doctrine and declared him excommunicate, and deposed. Cyril apparently regarded this as a declaration of the mind of the church in favour of the "monophysite" Christology.

(*b*) The so-called "Robber Synod" of Ephesus was held in 449. Eutyches, who held a form of the "monophysite" doctrine, had been deposed by his bishop, Flavianus of Constantinople, and had appealed to Dioscurus, successor of Cyril in the see of Alexandria, who restored him and moved the emperor Theodosius II. to summon a council which should "utterly destroy Nestorianism." The council, which was convened in August, 449, was entirely dominated by Dioscurus. Eutyches was acquitted of heresy and reinstated, Flavianus and other bishops deposed, the Roman legates insulted, and all opposition overborne by intimidation or actual violence. Leo I. of Rome refused to recognize the council, excommunicated Dioscurus, and demanded a new and greater council. The death of Theodosius II. removed the main support of Dioscurus, and cleared the way for the council of Chalcedon (*q.v.*), which deposed the Alexandrian and condemned Eutychianism.

See Monophysites, Nestorians and references there given, and the general histories of Dogma (especially Harnack and Loofs) and the general Church Histories on the Christological controversies of the 5th century.

EPHOD, a Hebrew word of uncertain meaning. In the post-exilic priestly writings the ephod forms part of the ceremonial dress of the high-priest (*see* Ex. xxix. 5 *seq.* and especially Eccles. xlv. 7–13). It was a richly decorated object worn outside the robe and kept in place by a girdle, and by shoulder-pieces (?), from which hung the "breastplate" (or rather pouch) containing the sacred lots, Urim and Thummim. The somewhat involved description in Ex. xxviii. 6 *sqq.*, xxxix. 2 *seq.* leaves it uncertain whether it covered the back, encircling the body like a kind of waistcoat, or only the front; at all events it was not a garment in the ordinary sense, and its association with the sacred lots indicates that the ephod was used for divination (*cf.* Num. xxvii. 21), and had become the distinguishing feature of the leading priestly line (*cf.* 1 Sam. ii. 28). From other passages it seems that the ephod had been a familiar object whose use was by no means so restricted. Like the teraphim (*q.v.*) it was part of the common stock of Hebrew cult; it is borne by persons acting in a priestly character (Samuel at Shiloh, priests of Nob, David), it is part of the worship of individuals (Gideon at Ophrah), and is found in a private shrine with a lay attendant (Judg. xvii. 5; *see*, however, vv. 10–13). Nevertheless, while the prophetical teaching came to regard the ephod as contrary to the true worship of Yahweh, the priestly doctrine of the post-exilic age has retained it.

An intricate historical problem is involved in the ephod which the priest Abiathar brought to David after the massacre of the priests of Nob. The ostensible intention is to narrate the transference of the sacred objects to David (*cf.* 2 Sam. i. 10), and henceforth he regularly inquires of Yahweh in his movements (1 Sam. xxiii. 9–12, xxx. 7 *seq.*). It is possible that the writer (or writers) desired to trace the earlier history of the ephod through the line of Eli and Abiathar to the time when the Zadokite priests gained the supremacy (*see* Levites); but elsewhere Abiathar is said to have borne the ark (1 Kings ii. 26), and this is noteworthy by reason of the confusion in the text of 1 Sam. xiv. 3, 18.

On one view, the ark in Kirjath-jearim was in non-Israelite hands (1 Sam. vii. 1 *sq.*); on the other, Saul's position as king necessitates the presumption that his sway extended over Judah and Israel. There are some fundamental divergencies in the representations of the traditions of both David and Saul (*qq.v.*), and there is indirect evidence which makes 1 Kings ii. 26 not entirely isolated. Here it must suffice to remark that the ark was also an object for ascertaining the divine will.

For the form of the earlier ephod the classic passage is 2 Sam. vi. 14, where David girt in (or with) a linen ephod dances before the ark at its entry into Jerusalem. Relying upon the known custom of performing certain observances in a practically, or even entirely, nude condition, it seems plausible to infer that the ephod was a scanty wrapping, perhaps a loin-cloth. (On the question of nudity [*cf.* 1 Sam. xix. 24] *see* Robertson Smith, *Rel. Sem.* 3 pp. 161, 450 *seq.* 687, *Ency. Bib. s.vv.* "girdle," "sack-cloth"; and M. Jastrow, *Journ. Am. Or. Soc.* xx. 144, xxi. 23.)

The favourite view that the ephod was also an image rests partly upon 1 Sam. xxi. 9, where Goliath's sword is wrapped in a cloth in the sanctuary of Nob *behind the ephod.* But it may have hung on a nail in the wall, and in any case the text is uncertain. Again, in the story of Micah's shrine parallel narratives have been used (the graven and molten images of Judg. xvii. 2–4 corresponding to the ephod and teraphim of ver. 5) and the finale refers only to the graven image of Dan (xviii. 30 *seq.*, *see* 1 Kings xii. 28 *seq.*). But the combination of ephod and teraphim (as in Hos. iii. 4) is noteworthy. Finally, according to Judg. viii. 27, Gideon made an ephod of gold and "put" it in Ophrah.

This object was probably once harmlessly associated with the cult of Yahweh (*cf.* Calf, Golden), and the term "ephod" may be due to a later hand. The passage is the only one which appears to prove that the ephod was an image.

Archaeological evidence for objects of divination and parallels from the Oriental area, can be readily cited in support of any of the above explanations of the ephod, but naturally cannot prove the form which it took in Palestine. If the ephod was a loin-cloth, its use as a receptacle and the known evolution of the article find useful analogies. Finally, if there is no decisive evidence for the view that it was an image (Judg. viii. 27), or that as a wrapping it formed the sole covering of the officiating agent (2 Sam. vi.), it can safely be said that it was used in divination and presumably did not differ radically from the ephod of post-exilic age.

See further, T. C. Foote in *Journ. Bibl. Lit.* xxi. 1902, 1 *seq.*, the articles in Hastings's *Dict. Bible* (by S. R. Driver), *Ency. Bib.* (by G. F. Moore), and *Jew. Ency.* (L. Ginsburg).

EPHOR the title of the highest magistrates of Sparta. It is uncertain when the office was created and what was its original character. We may regard it as an immemorial Dorian institution, or accept the tradition that it was founded during the first Messenian War, which necessitated a prolonged absence from Sparta on the part of both kings. The ephors seem to have had from the outset judicial or police functions. Gradually they extended their powers, aided by the jealousy between the royal houses, which made it almost impossible for the two kings to co-operate heartily.

In historical times the ephors were five in number, the first of them giving his name to the year, like the eponymous archon at Athens. Where opinions were divided the majority prevailed. The ephors were elected annually by the people; they had an official residence (*ephoreion*) in the Agora. Every full citizen was eligible.

The ephors summoned and presided over meetings of the Gerousia and Apella (*qq.v.*) and formed the executive responsible for carrying out decrees. In their dealings with the kings they represented the people. The kings swore to rule according to the laws; the ephors undertook on this condition to maintain the royal authority. They alone might remain seated in a king's presence, and had power to try and even to imprison a king. Two of them accompanied the army in the field, not interfering with the king's conduct of the campaign, but prepared, if need be, to bring him to trial on his return. The ephors shared the criminal jurisdiction of the Gerousia and decided civil suits. The administration of taxation, the distribution of booty, and the regulation of the calendar devolved upon them. They were responsible for protecting the State against the helots, upon whom they formally declared war on entering office, so as to be able to kill any whom they regarded as dangerous without violating religious scruples. The ephors were supreme in questions of foreign policy. They enforced, when necessary, the alien acts (*xenēlasia*), negotiated with foreign ambassadors, instructed generals and sent out expeditions.

Bibliography.—G. Gilbert, *Constitutional Antiquities* (Eng. trans. 1895); A. H. J. Greenidge, *Greek Constitutional History* (1896); article "Ephoroi" in Pauly-Wissowa, *Realencyklopädie*, v. 2860 ff.; L. Whibley, *Companion to Greek Studies* (1916).

EPHORUS (*c.* 400–330 B.C.), of Cyme in Aeolis, in Asia Minor, Greek historian. The tradition that, together with Theopompus, he was the pupil of Isocrates, and turned to the study of history at the suggestion of his master, seems to be unhistorical. His chief works were Ἱστορίαι in 29 books, the first universal history, beginning with the return of the Heracleidae to Peloponnesus. The work was edited by his son Demophilus, who added a 30th book, containing a summary description of the Social War and ending with the taking of Perinthus (340) by Philip of Macedon (*cf.* Diod. Sic. xvi. 14 with xvi. 76). Ephorus was the first historian to divide his work into books, to each of which he wrote a preface. He treated his material κατὰ γένος (according to subject), and not according to years. Ephorus was used as a source by Diodorus, who makes chronological blunders in trying to reproduce him in annalistic form. Polybius (xii. 25 g), while crediting him with a knowledge of naval warfare conditions, ridicules his description of the battles of Leuctra and Mantineia as showing ignorance of the nature of land operations. He usually (though not always) distinguished clearly between the mythical and historical (Strabo ix. p. 423); he even recognized that detail, though it corroborates accounts of recent events, is ground for suspicion in reports of far-distant history. His style was artificial, and he frequently sacrificed truth to rhetoric effect. Other works attributed to him were:—*A Treatise on Discoveries; Respecting Good and Evil Things; On Remarkable Things in Various Countries* (it is doubtful whether these were separate works, or merely extracts from the *Histories*); *A Treatise on my Country*, on the history and antiquities of Cyme, and an essay *On Style*. It has also been maintained (*e.g.*, by Judeich, E. M. Walker) that he is the author of a historical fragment discovered at Oxyrhynchus. *See* E. M. Walker, *Hellenica Oxyrhynchia* (1913).

Fragments in C. W. Müller, *Fragmenta historicorum Graecorum*, i., with critical introduction on the life and writings of Ephorus; *see* J. A. Klügmann, *De Ephoro historico* (1860); C. A. Volquardsen, *Untersuchungen über die Quellen der griechischen und sicilischen Geschichten bei Diodor, xi.–xvi.* (1868); and specially J. B. Bury, *Ancient Greek Historians* (1909); E. Schwartz, in Pauly-Wissowa, *Realencyklopädie s.v.*; and article Greece: *History:* Ancient Authorities.

EPHRAEM SYRUS (Ephraim the Syrian) (d. 373), a saint famous as a poet and commentator, was born early in the 4th century at or near Nisibis, of pagan parents. He became a ward of St. James, the famous bishop of Nisibis, was baptized and probably ordained a deacon. During the war begun by Shapur II., in which the city was thrice unsuccessfully besieged by the Persians (in 338, 346 and 350), Ephraem played an important part. When Nisibis surrendered in 363, he left with other Christians, and finally settled at Edessa where he devoted himself to writing, teaching and refuting heresies. He died there probably on June 9, 373. There is no ground for the statements that he spent eight years in Egypt refuting Arianism and that he wrote the funeral panegyric on Basil, though he might well have known Basil.

Of Ephraem's many works, written in Syriac, numerous early versions in Greek, Armenian, Coptic, Aratic and Ethiopic are still extant. They include commentaries on the Scriptures, homilies and hymns. Except for the commentaries on Genesis and on a large portion of Exodus, his O.T. commentaries are accessible only in the form they had assumed in the *Catena Patrum* of Severus (compiled in 861), and in quotations by later Syriac commentators. His commentary on the Gospels is of great importance in connection with N.T. textual history, for the text on which it was based was that of the Diatessaron. Only the ancient Armenian version survives, and was published at Venice in 1836 with the commentary on the Pauline epistles (also only extant in Armenian) and other works. A Latin version of the Armenian Diatessaron commentary was made by Aucher and Mösinger (Venice, 1876). His homilies are expository, controversial and hortatory. His hymns, which greatly impressed his countrymen, deal with such subjects as the Nativity, the Epiphany, Paradise, free-will and hymns against heretics and against sceptics. Of the 72 hymns known as *Carmina Nisibena*, the first 20 were written at Nisibis between 350 and 363 during the Persian invasions and the remaining 52 at Edessa between 363 and 373. The former tell us much of the incidents of the frontier war.

Ephraem had an immense reputation for sanctity. As an exegete he inclined strongly towards the Antiochene school; as a theologian he defended Nicaean orthodoxy and regarded it as his special task to combat the views of Marcion, Bardaison and Mani. His poetry, though prolix and wearisome, possesses a certain richness of diction and skill in the use of metaphors and illustrations.

A full list of the many editions of Ephraem's works is given in Herzog's *Realencyklopädie*. The most important are:—(1) the folio edition in 6 vols. (3 of works in Greek and 3 in Syriac) containing a Latin version (Rome, 1732–46); (2) The *Commentary on Acts* ed. F. C. Conybeare (1926); (3) the Prose Refutations of Mani, Marcion and Bardaisan ed. C. W. Mitchell, 2 vols. (1912–21); (4) *Carmina Nisibena*, ed. with a Latin trans. by G. Bickell (Leipzig, 1866); (5) *Hymni et Sermones*, ed. with a Latin trans. by T. J. Lamy (4 vols., Malines, 1882–1902). Many selected homilies have been edited or translated (*cf.* Wright, *Syriac Literature*, 1894); a selection of the *Hymns* was translated by H. Burgess, *Select Metrical Hymns of Ephraem Syrus* (1853); further selections in Pusey's *Library of the Fathers*, and in *The Library of Nicene and Post-Nicene Fathers*. See J. R. Harris, *Fragments of the Commentary of Ephraem Syrus upon the Diatessaron* (1895); F. C. Burkitt, "Ephraim's Quotations from the Gospels" in *Texts and Studies*, vol. 7 (Cambridge, 1901); and C. Emereau, *S. Ephrem le Syrien, Son oeuvre Litt. Grecque* (1919).

EPHRAIM, the stronger of the two tribes into which the house of Joseph was divided (*cf.* Gen. xlviii. 8–16). The territorial boundary between the two in west Palestine (east of Jordan we find Manasseh alone) seems to have been uncertain, but Ephraim included the famous sites of Shechem, Shiloh, Timnath-Heres and Samaria, while Bethel belonged to the allied tribe of Benjamin.

During the period of the monarchy, Ephraim was so much the dominant tribe in the northern kingdom, that its name is sometimes used as synonymous with Israel. Its early settlements were made in the central hill country, and the tribe may have owed its superior position to the comparative purity of its descent from the Aramaean invaders to whom Israel traced their ancestry.

EPHTHALITES or **WHITE HUNS.** This many-named and enigmatical tribe was of considerable importance in the history of India and Persia in the 5th and 6th centuries, and was known to the Byzantine writers, who call them 'Εφθαλῖται, Εὐθαγῖται, Νεφθαλῖται, or 'Αβδελοί. The last of these is an independent attempt to render the original name, which was probably something like Aptal or Haptal, but the initial N of the third is believed to be a clerical error. They were also called Λευκοί, Οὖννοι or Χοῦνοι, White (that is fair-skinned) Huns. Ephthalite is the usual orthography, but Hephthalite is perhaps more correct.

Our earliest information about the Ephthalites comes from the Chinese chronicles, in which it is stated that they were originally a tribe of the great Yue-Chi (*q.v.*), living to the north of the Great Wall, and in subjection to the Jwen-Jwen, as were also the Turks at one time. Their original name was Hoa or Hoa-tun. Before the 5th century A.D. they began to move westwards, for about 420 we find them in Transoxiana and for the next 130 years they were a menace to Persia, which they continually and successfully invaded, though they never held it as a conquest. The Sassanid king, Bahram V., fought several campaigns with them and succeeded in keeping them at bay, but they defeated and killed Peroz (Firūz), A.D. 484. The Persians were not quit of the Ephthalites until 557, when Chosroes Anushirwan destroyed their power with the assistance of the Turks.

The Huns who invaded India appear to have belonged to the same stock as those who molested Persia. The headquarters of the horde were at Bamian and at Balkh, and from these points they raided south-east and south-west. Skandagupta repelled an invasion in 455, but the defeat of the Persians in 484 probably stimulated their activity, and at the end of the 5th century their chief Toromana penetrated to Malwa in central India and succeeded in holding it for some time. His son Mihiragula (*c.* 510–540) made Sakāla in the Punjab his Indian capital, but the cruelty of his rule provoked the Indian princes to form a confederation and revolt against him about 528. He took refuge in Kashmir, where after a few years he seized the throne. He died (*c.* 540), and shortly afterwards the Ephthalites collapsed under the attacks of the Turks. They were probably gradually absorbed in the surrounding populations. Their political power perhaps continued in the Gurjara empire, which at one time extended to Bengal in the east and the Nerbudda in the south, and continued in a diminished form until A.D. 1040. These Gurjaras appear to have entered India in connection with the Hunnish invasions.

Our knowledge of the Indian Hūnas is chiefly derived from coins, from a few inscriptions distributed from the Punjab to central India, and from the account of the Chinese pilgrim Hsüan Tsang, who visited the country just a century after the death of Mihiragula. The Greek monk Cosmas Indicopleustes, who visited India about 530, describes the ruler, Gollas, as a White Hun king.

The accounts of the Ephthalites, especially those of the Indian Hūnas, dwell on their ferocity and cruelty. Their invasions shook Indian society and institutions to the foundations, but unlike the earlier Kushans, they do not seem to have introduced new ideas into India nor have acted as other than a destructive force. Many of Mihiragula's coins bear the Nandi bull (Śiva's emblem); and the king's name is preceded by the title *śahi* (shah), which had previously been used by the Kushan dynasty. Toramana's coins are found plentifully in Kashmir, which, therefore, probably formed part of the Hūna dominions before Mihiragula's time.

Greek writers give a more flattering account of the Ephthalites; Procopius says they were far more civilized than the Huns of Attila. The Chinese writers say their customs were like those of the Turks; that they had no cities, lived in felt tents, were ignorant of writing, and practised polyandry. Nothing whatever is known of their language, but some scholars explain the names Toramana and Jauvla as Turkish.

For the possible connection between the Ephthalites and the European Huns *see* HUNS.

See (original authorities) Procopius, Menander Protector, Cosmas, Indicopleustes (trans. McCrindle, Hakluyt Society, 1897); the Kashmir chronicle, *Rajatarangini* (trans. Stein, 1900, and Yüan Chwang).
See also Drouin, *Memoire sur les Huns Ephthalites* (1895); Ujfalvy, *Memoire sur les Huns Blancs* (1898); O. Franke, *Beiträge aus chinesischen Quellen zur Kenntnis der Türkvölker und Skythen* (1904); A. Stein, *White Huns and Kindred Tribes* (1905); articles by Vincent Smith, Specht, Drouin, and E. H. Parker in the *Journal of the Royal Asiatic Society, Journal asiatique, Revue numismatique, Asiatic Quarterly*, etc.

EPI, the French architectural term for a small finial (*q.v.*), generally of metal, but sometimes of terra-cotta, forming the termination of a spire or the angle of a roof.

EPICENE, a term in Greek and Latin grammar denoting nouns possessing one gender only, but used to describe animals of either sex. In English grammar there are no true epicene nouns, but the term is sometimes used instead of *common gender.* "Epicene" is sometimes also applied as an adjective to persons having the characteristics of both sexes, and hence is occasionally used as a synonym of "effeminate."

EPICHARMUS (*c.* 540–450 B.C.), Greek comic poet, was born in Cos. Early in life he went to Megara in Sicily, and after its destruction by Gelon (484) removed to Syracuse, where he lived at the court of Hieron till his death at the age of 90 or (according to a statement in Lucian, *Macrobii,* 25) 97. The inhabitants set up a statue in his honour with an inscription by Theocritus (*Epigr.* 17). Epicharmus was the chief representative of the Sicilian or Dorian comedy. Of his works 35 titles and a few fragments have survived. In the city of tyrants it would have been dangerous to present political comedies, like those of Aristophanes at Athens; Epicharmus' plays, therefore, are either mythological travesties (resembling the satyric drama of Athens) or character comedies. To the first class belong the *Busiris,* in which Heracles appears as a voracious glutton; the *Marriage of Hebe,* remarkable for a long list of dainties. The second class dealt with different classes of the population (the sailor, the prophet, the boor, the parasite). Some of the plays seem to have bordered on the political, as *The Plunderings,* describing the devastation of Sicily in the time of the poet. A short fragment has been discovered (in the Rainer papyri) from the 'Οδυσσεὺς αὐτόμολος, which told how Odysseus entered Troy disguised as a beggar and obtained valuable information. Another feature of his works was the large number of sentiments expressed in proverbial form; the Pythagoreans claimed him as a member of their school. The metres employed by Epicharmus were iambic trimeter, and especially trochaic and anapaestic tetrameter.

Epicharmus is the subject of articles in Suidas and Diogenes Laërtius (viii. 3). *See* A. O. Lorenz, *Leben und Schriften des Koers E.* (with account of the Doric drama and fragments, 1864); J. Girard, *Études sur la poesie grecque* (1884); Kaibel in Pauly-Wissowa's *Realencyklopädie,* according to whom Epicharmus was a Siceliot; for the papyrus fragment, Blass in *Jahrbücher für Philologie,* cxxxix., 1889.

EPIC POETRY or **EPOS,** the names given to the most dignified and elaborate forms of narrative poetry. The word *épopée* is used. When we first discover the epos in Greek literature, hexameter verse has already been selected for its vehicle. In this form epic poems were composed not merely dealing with war and personal romance, but with a didactic or religious purpose. The early epic poets, Lesches, Linus, Orpheus, Arctinus, Eugammon, are the veriest shadows, whose names often betray their symbolic and fabulous character. The *Iliad* and the *Odyssey* (*see* HOMER) form for us the type of the ancient epic; when we speak of epic poetry, we unconsciously measure it by the example of the *Iliad* and the *Odyssey.* It is quite certain, however, that these poems had not merely been preceded by a vast number of revi-

sions of the mythical history of the country, but were accompanied by innumerable poems of a similar character. When we pass from Homer and Hesiod, about whose actual existence critics will be eternally divided, we reach in the 7th century a poet, Peisander of Rhodes, who wrote an epic poem, the *Heracleia,* of which fragments remain. Other epic writers, who appear to be historic, are Antimachus of Colophon, who wrote a *Thebais,* Panyasis, who, like Peisander, celebrated the feats of Heracles; Choerilus of Samos; and Anyte, of whom we only know that she was an epic poetess, and was called "The female Homer." In the 6th and 5th centuries B.C. there was a school of philosophical epic, Xenophanes, Parmenides and Empedocles being the leaders.

From the dawn of Latin literature epic poetry seems to have been cultivated in Italy. A Greek exile, named Livius Andronicus, translated the *Odyssey* into Latin during the first Punic War, but the earliest original epic of Rome was the lost *Bellum Punicum* of Naevius, a work to which Virgil was indebted. A little later, Ennius composed, about 172 B.C., in 18 books, an historical epic of the *Annales*, dealing with the whole chronicle of Rome. Virgil began the most famous of Roman epics in the year 30 B.C., and when he died, nine years later, he desired that the ms. of the *Aeneid* should be burned, as it required three years' work to complete it. In the next generation, the *Pharsalia* of Lucan, of which Cato, as the type of the republican spirit, is the hero, was the principal example of Latin epic. Statius, under the Flavian emperors, wrote several epic poems, of which the *Thebaid* survives. In the 1st century A.D. Valerius Flaccus wrote the *Argonautica* in eight books, and Silius Italicus the *Punic War,* in 17 books; these authors show a great decline in taste and merit. At the close of the 4th century the style revived with Claudian, who wrote the *Rape of Proserpine.* With Claudian the history of epic poetry among the ancients closes.

In mediaeval times there existed a large body of narrative poetry to which the general title of Epic has usually been given. Three principal schools are recognized, the French, the Teutonic and the Icelandic. Teutonic epic poetry deals, as a rule, with legends founded on the history of Germany in the 4th, 5th and 6th centuries, and in particular with such heroes as Ermanaric, Attila and Theodoric. But there is also an important group in it which deals with English themes, and among these *Beowulf, Waldere, The Lay of Maldon* and *Finnesburh* are pre-eminent. To this group is allied the purely German poem of *Hildebrand,* attributed to *c.* 800. Among these *Beowulf* is the only one which exists in anything like complete form, and it is of all examples of Teutonic epic the most important. It is written, like all old Teutonic work of the kind, in alliterative unrhymed rhythm.

The surviving epical fragments of Icelandic composition are found thrown together in the *Codex Regius,* under the title of *The Elder Edda* (*see* EDDA), a most precious ms. discovered in the 17th century. The French mediaeval epics (*see* CHANSONS DE GESTE) are late in comparison with those of England, Germany and Iceland. They form a curious transitional link between primitive and modern poetry; the literature of civilized Europe may be said to begin with them. The existing masterpiece of this kind is the magnificent *Roland.* Of the progress and decline of the *chansons de geste* a fuller account is given elsewhere. To the *Nibelungenlied* (*q.v.*) also, detailed attention is given in a separate article.

What may be called the artificial or secondary epics of modern Europe, founded upon an imitation of the *Iliad* and the *Aeneid,* are more numerous than the ordinary reader supposes, although but few of them have preserved much vitality. In Italy the *Chanson de Roland* inspired romantic epics by Luigi Pulci (1432–87), whose *Morgante Maggiore* appeared in 1481, and is a masterpiece of burlesque; by M. M. Boiardo (1434–94), whose *Orlando Innamorato* was finished in 1486; by Francesco Bello (1440?–95), whose *Mambriano* was published in 1497; by Lodovico Ariosto (*q.v.*), whose *Orlando Furioso,* by far the greatest of its class, was published in 1516, and by Luigi Dolce (1508–68), as well as by a great number of less illustrious poets. The most splendid of all the epics of Italy, however, was, and remains, the *Jerusalem Delivered* of Torquato Tasso (*q.v.*). Early Portuguese literature is rich in epic poems; but all others are obscured by the glory of Camoens (*q.v.*), whose magnificent *Lusiads* had been printed in 1572, and forms the summit of Portuguese literature. In Spanish poetry, the *Poem of the Cid* takes the first place, as the great national epic of the middle ages; it is supposed to have been written between 1135 and 1175. Perhaps the finest modern epic in Spanish verse, is the *Araucana* (1569–90) of Alonso de Ercilla y Zúñiga (1533–95), "the first literary work of merit," as Fitzmaurice-Kelly remarks, "composed in either American continent." In France, the epic never flourished in modern times, and no real success attended even the *Henriade* of Voltaire. In English literature *The Faery Queen* of Spenser has the same claim as the Italian poems mentioned above to bear the name of epic, and Milton, who stands entirely apart, may be said, by his isolated *Paradise Lost,* to take rank with Homer and Virgil.

See Bossu, *Traité du poeme épique* (1675); Voltaire, *Sur la poésie épique;* Fauviel, *L'Origine de l'épopée chevaleresque* (1832); Léon Gautier, *Les Épopées françaises* (1865–68); W. von Christ, *Geschichte der griechischen Litteratur* (1879); Gaston Paris, *La Littérature française au moyen âge* (1890); W. P. Ker, *Epic and Romance* (1897), and *Essays in Mediaeval Literature* (1905); Gilbert Murray, *The Rise of the Greek Epic* (3rd ed. 1924). For works on the Greek epics *see* also GREEK LITERATURE and HOMERIC POEMS.

EPICTETUS (born *c.* A.D. 60), Greek philosopher, probably from Hierapolis, Phrygia. The name Epictetus is the Greek for "acquired" (from ἐπικτᾶσθαι); his original name is not known. As a boy he was a slave, but managed to attend the lectures of the Stoic Musonius Rufus, and subsequently became a freedman. He was lame and of weakly health. In 90 he was expelled with other philosophers by Domitian, who was irritated by the encouragement which the opposition to his tyranny found amongst the adherents of Stoicism. The rest of his life he spent at Nicopolis, in southern Epirus, not far from the scene of the battle of Actium. He wrote nothing; but much of his teaching was transmitted by his pupil Flavius Arrianus, the historian of Alexander the Great, in two treatises, four books of the larger, *Discourses of Epictetus* (Ἐπικτήτου Διατριβαί), being still extant. The other, the *Encheiridion* ("Handbook"), contains in an aphoristic form the main doctrines of the longer work.

The philosophy of Epictetus exhibits a high idealistic type of morality. The all important problem is how life is to be carried out well. True education lies in recognizing that there is only one thing which is fully our own,—that is, our will or purpose. God, acting as a good king and father, has given us a will which cannot be compelled or thwarted by anything external. We are not responsible for the ideas that present themselves to our consciousness, but we are absolutely responsible for the way in which we use them. "Two maxims," he says, "we must ever bear in mind—that apart from the will there is nothing good or bad, and that we must not try to anticipate or direct events, but merely to accept them with intelligence." We must, in short, believe that there is a God whose thought directs the universe.

Man is a member of a great system, which comprehends God and men. Each human being is firstly a citizen of his own commonwealth; but he is also a member of the great city of gods and men, whereof the city political is only a copy. All men are the sons of God, by virtue of rationality, and, kindred in nature with the divinity. Hence man can enter into the method of divine administration, and thus can learn—and it is the acme of his learning—the will of God, which is the will of nature. The natural instinct of animated life, to which man also is subject, is self-preservation and self-interest. But men are so constituted that the individual cannot secure his own interests unless he contributes to the common welfare. The aim of the philosopher therefore is to see the world as a whole, to grow into the mind of God and to make the will of nature our own.

The historical models to which Epictetus reverts are Diogenes and Socrates. But he frequently describes an ideal character of a missionary sage, perfectly unembarrassed in the service of God, not bound by the common ties of life, nor entangled by relationships.

The best editions of the works of Epictetus are by J. Schweig-

häuser (6 vols., Leipzig, 1799–1800) and H. Schenkl (Leipzig, 1894, 1898). An edition with an Eng. trs. by W. A. Oldfather in Loeb series (1926, Eng. trs. also by G. Long, 1848). *See* A. Bonhöffer, *Epiktet und die Stoa* (Stuttgart, 1890), *Die Ethik des Stoikers Epiktet* (1894) and *Epictetus u. das Neue Testament* (1911); E. M. Schranka, *Der Stoiker Epiktet und seine Philosophie* (Frankfort, 1885); T. Zahn, *Der Stoiker Epiktet und sein Verhältnis zum Christentum* (2nd ed. Erlangen, 1895); T. Colardeau, *Étude sur Épictète* (1903), and D. S. Sharp, *Epictetus and the New Testament* (1914). *See* also STOICS and Überweg, *Grund. der Gesch. der Phil.* pt. 1 (1926) for full bibliography.

EPICURUS (341–270 B.C.), Greek philosopher, was born in Samos, where his father, Neocles, an Athenian, had settled some ten years before. In 323 he came to Athens, but shortly after joined his father in Colophon (Diog. Laert., x. 1). Thereafter he taught in Mytilene and Lampsacus and in 306 returned to Athens, where he founded a school and established his permanent home. He taught and lived with his pupils near the Dipylon in a garden (κῆπος, Diog. Laert., x. 17, *Epicuri hortus,* Cic. *N.D.* i. 33; hence Cic. *N.D.* 43 Democritus . . . from whose waters Epicurus irrigated his gardens) which at his death he bequeathed to his school (*cf.* his will in Diog. Laert., x. 27). The society which he gathered round him included women as well as men, a circumstance which occasioned some scandalous legends. A more pleasant story is told of his unsurpassed kindness to all, as testified by his country and his friends (Diog. Laert., x. 9), and of the simplicity which characterized the regimen of his school (Diog. Laert. x. 11).

Writings.—Epicurus was a most prolific writer—πολυγραφώτατος Diog. Laert., x. 26, who there gives a list of his chief works. Diogenes has preserved three letters which give the gist of his teaching: (1) *To Herodotus,* dealing with physics; (2) *To Pythocles,* on meteorology; (3) *To Menoeceus,* on ethics and theology. Diogenes has further preserved his Κύριαι Δόξαι (Cic. *De Fin.*, ii. 7, 20 Epicuri Κυρίας Δόξας id est quasi maxime ratas. *id. N.D.* i. 30, 85 illis. selectis eius brevibusque sententiis, quas appellatis Κυρίας Δόξας *cf.* Plut. *adv. Coloten* 31 τῶν κυριωτάτων δοξῶν Lucian *Alexandr.* 47 Diod. xxv. *fr.* 1. Philodem. *de Ira,* col. xliii., etc.), a series of 40 short aphoristic statements of Epicurean doctrines. Some fragments of his great work Περὶ φύσεως (in 37 books) as well as of other writings are preserved in the rolls of Herculaneum. A series of 80 Epicurean aphorisms, partly identical with the Κύριαι Δόξαι, were discovered (1888) in a Vatican ms. (cod. Vat. gr. 1950) of the 14th century. In 1884 and subsequent years were discovered considerable fragments of letters and aphorisms of Epicurus, which Diogenes (2nd–3rd century A.D.) of Oenoanda in Lycia had caused to be inscribed on the wall of a portico for the instruction of his fellow citizens. Knowledge of Epicurus is further supplemented by quotations or references in later authors—Plutarch, Cicero, etc., and, above all, Lucretius, whose great poem *De Rerum Natura* is a passionate exposition of the teaching of Epicurus.

The philosophic outlook of Epicurus is fundamentally ethical and his interest in other studies seems to have been small (*cf.* Diog. Laert., x. 2; 6; 31.). Even his interest in physics is purely subsidiary to the ethical end, *i.e.*, to obtaining a theory of life which shall ensure "quietude of mind and a steadfast faith" (ἀταραξίαν καὶ πίστιν βέβαιον Diog. Laert., x. 85). According to Diog. Laert., x. 29 his philosophy is divided into three parts: *canonical, physical, ethical*; the first, dealing with "approaches (ἐφόδους) to the study," *i.e.*, with *criteria* of validity, being usually coupled with the physical.

Physics.—We are told by Diog. Laert., x. 2, that it was from the writings of Democritus that Epicurus received his first impulse to philosophy. Be that as it may, the doctrine of Democritus regarding the atoms and the void is the basis of the teaching of Epicurus.

Nothing is created out of nothing and nothing passes into nothing. The universe (τὸ πᾶν) was always such as it is now and always will be such, since there is nothing beyond the universe the entrance of which could effect a change. The universe consists of bodies (σώματα) and space (τόπος = τὸ κενόν, the void). The existence of bodies is testified by sense (αἴσθησις) and the existence of space is a necessary inference of reason (λογισμός); for, if the void did not exist, bodies could not move as, in fact, sense assures us that they do move. Besides these two—bodies and space—nothing can even be imagined. Again, bodies are either compound or the elements of which bodies are compounded. These elements are indivisible (ἄτομα, atoms) and unchangeable; for, when a compound is resolved into its elements, the elements must either pass into nothingness—which we held to be impossible—or remain as ultimate indissoluble entities. Again the universe is infinite; for the finite has an extremity (ἄκρον) which can only be observed against something else, which is *ex. hypothesi* impossible in the case of the universe. Having, then, no extremity it has no limit (πέρας). Also the number of atoms and the extent of the void are infinite; for if there were a limited number of atoms in unlimited void, the atoms could not remain anywhere but would drift, scattered through infinite void, not having atoms to support and place them by their collisions (ἀνακοπαί Diog. Laert., x. 42). If on the other hand the void were limited and the atoms unlimited, there would not be room for them.

The atoms are not all of one shape (σχῆμα). The number of atoms of any one shape is absolutely infinite (ἁπλῶς ἄπειροι), but the number of different shapes, though incomprehensibly large, is not absolutely infinite (οὐχ ἁπλῶς ἄπειροι ἀλλὰ μόνον ἀπερίληπτοι).

The atoms vary in size but are not of all sizes: otherwise some would be visible. Whatever their size, they are in perpetual motion, moving all with the same velocity, swift as thought (ἅμα νοήματι Diog. Laert., x. 61). Owing to an inherent "swerve" (παρέγκλισις, *clinamen,* Lucret., ii. 292—this, of course, is a necessary postulate, Lucret., ii. 243 Quare etiam atque etiam paulum inclinare necesse est Corpora. Plut. *Mor.* 964 C οὐδὲ γὰρ αὐτοὶ τῷ Ἐπικούρῳ διδόασιν . . . ἄτομον παρεγκλῖναι μίαν ἐπὶ τοὐλάχιστον) the atoms collide and rebound to a lesser or greater distance, thus forming compound bodies of greater or lesser density.

Psychology.—(1) The soul is a material body of fine parts (σῶμα λεπτομερές) and is distributed through the whole bodily structure. Compound bodies are of two sorts—those which are capable of holding together of themselves and those which cannot do so unless protected (στεγαζόμενα) by some more solid body. The soul belongs to the latter sort. So long as it is protected by the body, it is capable of sensation and of communicating sensation to the body. When it leaves the body, it is dissipated; the body, on the other hand, is no longer capable of sensation. (2) Sense-perception is a purely material process. From the surface of all bodies there are continually being discharged images (εἴδωλα Diog. Laert., x. 46, *simulacra* Lucret., iv. 99, *imagines* Lucret., iv. 101), hollow films (Diog. Laert., *l.c.* κοιλώματα) of exceedingly fine texture, which in shape are an exact replica of the body (τύποι ὁμοσχήμονες τοῖς στερεμνίοις Diog. *l.c.*). These, reaching the soul through the various organs of sense, originate sensation. (3) Sensation is the sole source of knowledge and all sensuous perceptions are true. Error can arise only when, beyond what is given in sensation, the mind forms an opinion which is afterwards contradicted or unconfirmed (Diog. Laert., x. 50. *cf. ibid.* 32; 146 f.).

According to Diog. Laert., x. 31 "In the *Canon* Epicurus says that the *criteria* of truth are the sensations (αἰσθήσεις) and concepts (προλήψεις) and the feelings" (πάθη); the Epicureans add "the imaginative apprehensions of the mind" (τὰς φανταστικὰς ἐπιβολὰς τῆς διανοίας). This passage, which should be compared with several passages in the *Letter to Herodotus* (Diog. Laert., x. 38; 50; 51; 62) and with K. Δ. xxiv. (Diog. Laert., x. 147), raises some difficulties. By sensations is meant that which is immediately given by the senses. By concepts is meant the general notion (*notities,* Lucret., v. 182; *anticipatio sive praenotio,* Cic. *N.D.* i. 17.43) formed by repeated sense-perceptions: Diog. Laert., x. 33 τὴν δὲ πρόληψιν λέγουσιν . . . καθολικὴν νόησιν ἐναποκειμένην, τουτέστι μνήμην τοῦ πολλάκις ἔξωθεν φανέντος, *cf. ibid.* 31; 72; 152 f., and especially 124, where we are told that "the assertions of the many about the gods are not conceptions (προλήψεις) but false suppositions (ὑπολήψεις ψευδεῖς)." By the retention of these in the mind we are able, not merely to perceive

an individual object as such, but to refer it to the general name. By feelings are meant apparently the "emotions," or, so to say, passive effects on the mind. Lastly the φανταστικὴ ἐπιβολὴ τῆς διανοίας seems best referred to the power of the mind to form mental images (φαντασίαι) intuitively. It would thus be equivalent to the ἐναργὴς γνῶσις by which the gods are known (*Letter to Menoeceus*, 123). The best commentary on the whole matter is K. Δ. xxiv. (Diog. Laert., x. 147), "If you reject any sensation absolutely and do not distinguish opinion in regard to that which awaits confirmation (τὸ δοξαζόμενον κατὰ τὸ προσμένον from that which is already given (τὸ παρόν) by sensation and feelings and every imaginative apprehension of the mind, you will confound all other sensations as well and so reject every criterion."

Ethics.—The criterion of good and evil is sensation: πᾶν ἀγαθὸν καὶ κακὸν ἐν αἰσθήσει (*Letter to Menoec.*, 124). Hence "we declare pleasure to be the beginning and end of the blessed life; for we recognize this to be our first and natural good, and from this we start in every choice and avoidance and this we make our goal, using feeling as the canon by which we judge every good" (*ibid.* 129). "But while every pleasure is in itself good, not all pleasures are to be chosen, since certain pleasures are produced by means which entail annoyances many times greater than the pleasures (K. Δ. viii.). Moreover, a right conception of pleasure itself conduces to right living, since it is not possible to live pleasantly without living wisely and well and righteously" (K. Δ. v.). In this light the declaration that "beauty, virtue, and the like are to be valued if they produce pleasure; if not, we must bid them farewell" (*ap.* Athen. 546 f.) is not so hedonistic as it sounds. Pleasure as contemplated by Epicurus is not so much active enjoyment as the absence of pain: Diog. Laert., x. 136 "Epicurus differs from the Cyrenaics as regards Pleasure; for they do not admit static (καταστηματικήν) but only active (τὴν ἐν κινήσει) Pleasure . . . But Epicurus in his work on *Choice* says: Quiet of mind (ἀταραξία) and absence of (bodily) pain (ἀπονία) are static pleasures, but joy and mirth are seen in activity" (*cf.* Plut. *Mor.* 1089 D).

The Gods.—Since happiness lies in quiet of mind (ἀταραξία Diog. Laert., x. 82; 85; 128 "all choice and avoidance are to be referred to health of body and quiet of mind, since this is the end of the blessed life") Epicurus is concerned to remove the two great disturbing ideas in human life—the fear of the gods and the fear of death (*Letter to Herod*, 81). He does not deny the existence of the gods—"their existence is known to us by immediate apprehension" (*Letter to Menoec.* 123, θεοὶ μὲν γὰρ εἰσίν ἐναργὴς γὰρ αὐτῶν ἐστιν ἡ γνῶσις.): only they are not such as is vulgarly supposed. Fashioned of finer stuff than we, they dwell afar in the intermundial spaces (μετακόσμια Plut. *Mor.* 731 D, 734 C, *intermundia* Cic. *N.D.* i. 8. The lucid interspace of world and world, Tennyson, *Lucretius*), neither troubling nor troubled by the affairs of humanity, neither rewarding virtue nor punishing sin in this life. And, as we have seen above, there is no life to come, since the soul is of such a nature that, when it leaves the body, it is immediately dissolved into the primordial atoms of which it was compounded.

The Epicurean School.—The Epicurean school survived until the 4th century A.D. Among his immediate disciples the most eminent were Metrodorus, Hermarchus, who succeeded Epicurus as head of the school, Colotes (*cf.* Plut. *adv. Coloten*=*Mor.* 1107 D.—1127 E). Later prominent Epicureans were Apollodorus (called κηποτύραννος King of the Garden, Diog. Laert., x. 25) in the second half of 2nd century B.C.; Zenon of Sidon (b. *c.* 150 B.C.), teacher of Cicero; and his pupil, Philodemus of Gadara, of whose works some fragments have been recovered from Herculanean rolls. His most eminent Roman disciple was, of course, Lucretius.

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(A. W. MA.)

EPICYCLE, in ancient astronomy, a small circle the centre of which describes a larger circle. It was especially used to represent geometrically the periodic apparent retrograde motion of the outer planets, Mars, Jupiter, and Saturn, which we now know to be due to the annual revolution of the earth around the sun.

EPICYCLOID: *see* CURVES, SPECIAL.

EPIDAURUS, the name of two ancient cities of southern Greece.

1. Epidaurus the Holy, a maritime city on the eastern coast of Argolis, on a rocky peninsula with a natural harbour on the northern side and an open bay on the southern. Its narrow but fertile plain is shut in except towards the sea by mountains, of which the most notable were Arachnaeon and Titthion. The conterminous states were Corinth, Argos, Troezen and Hermione. The commercial advantages of its position, and the fame of its temple of Asclepius made Epidaurus a place of some importance. It was occupied by a Carian colony, by Ionians and by Phlegyans from Thessaly. The Ionians were conquered by Dorians of Argos led by Deiphontes; and the city preserved its Dorian character. It colonized neighbouring islands, founded Aegina and took part with Argos and Troezen in settlements in Asia Minor. The monarchical government gave way to oligarchy, and oligarchy to a despotism. When Procles the tyrant was captured by Periander of Corinth, oligarchy was restored, and Epidaurus continued a close ally of Sparta. The governing body of 180 was chosen from certain influential families, and the executive was a committee of *artynae* (from ἀρτύνειν, to manage). The rural population, who had no share in the affairs of the city, were called κονίποδες ("dusty-feet"). The site of a temple of Hera is identified with the chapel of St. Nicolas; portions of the walls can be traced; and the name is preserved by the little village of Nea-Epidavros.

The *Hieron* (sacred precinct) of Asclepius, about 8 m. inland from the town, has been excavated by the Greek Archaeological Society. In addition to the sacred precinct, with its temples and other buildings, the theatre and stadium have been cleared; and baths, gymnasia and a hospital have been found. The sacred road from Epidaurus, flanked by tombs, approaches through a gateway. The chief buildings are grouped together, and include temples of Asclepius and Artemis, the Tholos, and the Abaton (portico), where the patients slept. Architecture and sculpture are of high merit, and inscriptions record cures attributed to the god.

The temple of Asclepius, which contained the gold and ivory statue by Thrasymedes of Paros, had six columns at the ends and eleven at the sides; it was approached by a ramp at the eastern front. An inscription records contracts for building this temple about 460 B.C. The sculptor Timotheus (who collaborated in the Mausoleum) undertook to make the acroteria, Nereids mounted on sea-horses, on the pediments, and models for the sculpture, some of which has been found. The great altar lay to the south of the temple, and beyond it a small temple of Artemis and a square Roman building. The Tholos, to the south-west of the temple of Asclepius, must have been one of the most beautiful buildings in Greece; the exquisite carving is only equalled by that of the Erechtheum at Athens. It consisted of a circular chamber, with Doric colonnade outside and Corinthian within: the architect was Polyclitus, probably the younger sculptor of that name. In contracts for its building it is called the Thymele; it was probably the idealized architectural representative of a primitive pit of sacrifice, such as may still be seen in the Asclepianum at Athens. The foundations consist of a series of concentric walls with doors and partitions that make a subterranean labyrinth. There is no evidence of a well or spring. North of the Tholos is the long portico described in inscriptions as the Abaton; on two different levels, the lower of which had two storeys. Here the invalids used to sleep when consulting the god, and the inscriptions record not only the method of consulting the god, but the manner of his cures. The patient sleeps in the Abaton, sees certain visions, and

comes forth cured. There are some surgical cases, and many examples resembling those at Lourdes or Tenos, where hysterical or other similar affections are cured by the influence of imagination or sudden emotion. It is, however, difficult to make scientific use of the records. Some are contemporary dedications; but others are long lists of cases, compiled by the priests from dedications or tradition. In later times the old faith-healing lost its efficacy and the priests substituted elaborate prescriptions as to diet, baths and regimen which must have made Epidaurus resemble a modern spa. Extensive buildings were provided for the accommodation of invalids (one by Antoninus Pius), great courtyards surrounded by colonnades and chambers. A large gymnasium was in later times converted to other purposes, a small odeum being built in the middle. In the stadium, the seats and goal are well preserved. A gutter surrounds the running ground, with basins at intervals, and a post at every hundred feet of the course. The goal resembles that at Olympia; a stone sill sunk level with the ground, with parallel grooves for the feet of the runners at starting, and sockets for posts that separated the competitors.

The theatre, as Pausanias says, is the most beautiful in Greece, almost every seat being still *in situ;* the complete circle of the orchestra is marked by a sill of white limestone. There are benches with backs not only in the bottom row, but above and below the diazoma. A speaker in the orchestra is heard throughout the auditorium without raising his voice. The stage buildings are not preserved much above their foundations, and show signs of later repairs; a long rectangular building has a column front almost at a tangent to the circle of the orchestra; at the middle and at either end are doors leading into the orchestra wings; the top of this proscenium is approached by a ramp running parallel to the parodi, but sloping up as they slope down. The proscenium was originally about 14 ft. high and 12 ft. broad, corresponding approximately to the Greek stage as described by Vitruvius.

See Pausanias i. 29; *Expédition de la Morée*, ii.; Curtius, *Peloponnesus*, ii.; *Transactions of Roy. Soc. of Lit.*, 2nd series, vol. ii.; Weclawski, *De rebus Epidauriorum* (Posen, 1854).

The excavations have been recorded in the Πρακτικά of the Greek Archaeological Society, especially 1881–84 and 1889, and in Ἐφημερὶς Ἀρχαιολογική, especially 1883 and 1885; *see* also Kavvadias, *Les Fouilles d'Épidaure* and Τὸ Ἱερὸν τοῦ Ἀσκληπιοῦ ἐν Ἐπιδαύρῳ καὶ ἡ θεράπεια τῶν ἀσθενῶν; Defrasse and Lechat, *Épidaure.*

2. Epidaurus Limera (either "The Well-havened" or "The Hungry"), a city of Peloponnesus on the east coast of Laconia, founded by the people of Epidaurus the Holy, but abandoned during the middle ages when its inhabitants took possession of the promontory of Minoa, turned it into an island, and built and fortified thereon the city of Monemvasia, which became the most flourishing of all the towns in the Morea, and gave its name to the well-known Malmsey or Malvasia wine. The ruins of Epidaurus are to be seen at Palaea Monemvasia.

EPIDEMIC. A term used adjectivally or as a noun to signify the sudden outbreak of an infectious disease, of which the case incidence rises to a peak with more or less rapidity and thereafter declines, usually less rapidly. The curve thus formed shows variations in different diseases and in epidemics of the same disease. The mortality curve in any epidemic bears a general relation to the incidence curve, but the mortality curves in different epidemics of the same disease, like the incidence curves, may vary much in height and shape. (*See* EPIDEMIOLOGY.)

EPIDEMIOLOGY. In recent years more study has been given to that branch of the science of medicine which, under the name of epidemiology, displays the general factors which operate upon populations or aggregates, and lead to the outbreak of a sickness affecting several persons within a short time. The unit of the epidemiologist is a population, of a physician an individual.

The Spread of Epidemics.—Modern epidemiology is based on the collections of statistics which began half way through the 19th century, and on the associated information which was obtained as to the causation and course of epidemics by careful local enquiry into all the conditions. Even before this some countries, such as Sweden, published the figures of the deaths from numerous infectious diseases for series of years; but, though very interesting, these figures reflect more or less special conditions. Since about 1840, especially in Europe, India and America, carefully collected information exists respecting many epidemics and epidemiological conditions. Sufficient evidence is now available to examine any theory which may be offered to account for the facts. Advance has been made on a number of lines: on the modes of spread of infection; on the theory of the course, recurrence and size of epidemics; on the relation of epidemics to climatic conditions and the cause of these relations; on the knowledge of the life history of the organisms which cause epidemics; on the conditions of living which favour the spread of infectious disease.

Aetiology.—With the discovery of the organisms (*see* BACTERIOLOGY; FILTER PASSING VIRUSES; PARASITOLOGY) which cause disease, and with careful observation in the field as to the manner in which disease spreads from person to person, new viewpoints have emerged. Most diseases have their special forms of spreading which account for practically all the cases. Thus measles (*see* INFECTIOUS FEVERS) and smallpox (*q.v.*) are exceedingly infectious from person to person. Typhoid fever (*q.v.*) is nearly always carried by contaminated water or contaminated food. Cholera (*q.v.*) is spread by water and flies. Other diseases have been found to be practically non-infectious from person to person unless by means of an intermediate parasite. Thus typhus (*see* INFECTIOUS FEVERS) and trench fever are carried by lice, while yellow fever (*q.v.*) and malaria (*q.v.*) require the intervention of the mosquito. The mode of spread of some diseases is still obscure. Among these scarlet fever must be placed. While direct infection undoubtedly takes place, a satisfactory elucidation of the problems of its dissemination has not yet been arrived at.

Infectivity and Virulence.—Disease-producing organisms possess two qualities: one, the power of causing the disease; and the second the power of producing a severe attack of disease. The first may be termed infectivity and the second virulence. These qualities must not be confused. In point of fact, they are not constantly associated. In certain diseases the height of the epidemic seems to be associated with severe disease, in others with that of milder type. The former at least holds for a certain number of large epidemics of measles of which the statistics have been investigated. The latter is the case both in Glasgow and London in regard to the autumnal prevalence of scarlet fever.

Incidence.—That an epidemic might possess a definite form capable of calculation seems to have been advanced first by Farr. In 1840 he graduated the decline of the great smallpox epidemic in England to the normal curve of error, and obtained a very close representation of the facts. He promised further discussion, but seems to have given none till 1867. In this year he returned to the subject in connection with the cattle plague, writing a letter to *The Daily News*, in which it was stated that though in the popular conception plague was advancing with such rapidity that all the cattle of the country might be destroyed, in reality the force of the epidemic was spent, and that if the form of the epidemic curve up to that point were taken as a basis of calculation the future course could be foretold. The prediction proved to be very near the truth.

The theory of the course of the epidemic, however, as a guide to the solution of the problem has unfortunately not proved so fertile as might have been hoped. Some facts are quite definite. The curve of the epidemic is often found to be symmetrical, the fall corresponding closely to the rise, though in some diseases the ascent is more rapid than the descent, and in some the reverse. The equation of the curve which describes the majority of epidemics, as found by trial apart from theory, is

$$y = \frac{a}{1 + \frac{t^2 n}{b^2}}$$

where y is the number of cases at time t, t being measured from the centre of the epidemic.

Curves closely resembling that given by the above equation arise on a number of hypotheses, of which two are discussed. First, the organism may be assumed to possess at the beginning of the disease a high degree of infectivity, which decreases as the epidemic goes on. If the loss of infectivity is according to geometric law, the normal curve of error already used by Farr is the result. It is sufficient to state that on various probable hypotheses regard-

ing exposure to infection, etc., the normal curve may be so modified as to take the form found by observation. Secondly, a similar type of curve arises if we consider an epidemic dies out from lack of susceptible persons. It is not possible to distinguish statistically these hypotheses from the consideration of the epidemic form alone. In one case, however, the second hypothesis can be tested. If the form of the epidemic be calculated by assuming different degrees of infectivity on the part of the organism, an infectivity which remains constant during the epidemic, it is found that this curve becomes flatter the smaller the degree of infectivity.

Now with regard to plague in India, among brown and black rats living more or less in the same circumstances, it is observed that many more brown rats are infected than black. In such circumstances the form of the epizoötic should be different in the two species if the decline is due to lack of susceptible individuals. As a matter of fact it is nearly identical: a fact which tells strongly in favour of the hypothesis that the epidemic ends because of loss of infectivity on the part of the organisms. This example would be crucial but for the fact that the flea on which the spread of the epizoötic depends has a law of seasonal prevalence of its own.

In many cases, however, the only feasible explanation of the course of an epidemic is that the organism loses the power of infecting as the epidemic proceeds. It is difficult to believe, for instance, with regard to the great epidemic of smallpox in London in 1901–02, that there were only 8,000 people susceptible out of a population of 6,000,000. As the course of this epidemic was typical, rising and falling in the manner found to be characteristic, it cannot be argued that the decline was due to the action of the health authorities; all they can have done was to limit the extent of the epidemic, leaving its course unchanged.

Periodicity.—The next point requiring consideration is the periodicity in the epidemics of infectious diseases. Taking measles as an example, the common explanation is that each epidemic ends from the exhaustion of the number of susceptible persons, and that it is only when a new population of susceptible children has accumulated that a further outbreak occurs. This explanation fails to account for many of the facts. Even after the very large epidemic of measles in Glasgow in 1906, it was found that nearly half of the children admitted to the fever hospitals immediately thereafter suffering from other diseases had not suffered from measles, so that there must have been, with the high infectivity of the epidemic, plenty of susceptible material. The disease subject to the most extensive enquiry hitherto has been measles. Using the method of the periodogram, the statistics of London and all the chief towns of the British Isles have been analysed. It is found that in almost no case is there only one period to be discovered. In London there are several, the chief of which is 97 weeks.

Periodicity in other diseases is well known. Thus in the city of Liverpool the epidemics of scarlet fever occurred at regular intervals of four years from 1850–78. On one occasion alone was there an exception, when the interval between two epidemics was three years in place of four. A similar periodicity of five years has been observed in Glasgow. There is one specially interesting example, namely, the occurrence of plague in Bombay. In many places, such as Hong Kong, the period between each epidemic is rigidly a year. In such a case the influence of the season of the year seems a sufficient explanation. But the case of Bombay is different. The first epidemic, in 1897, had its maximum about the 40th day of the year. From this point until the last year for which statistics are available (1918) the date of the maximum of the epidemic has steadily advanced into the year, advancing about 80 days in 20 years, or an average of four days a year. The conclusion must be arrived at that while some periodicities of disease are strictly seasonal others are not so, and require some further explanation.

A further important application of mathematics to epidemiology has been made by Sir Ronald Ross in his studies on malaria (*q.v.*). Here the factors influencing the spread of the disease are numerous. Rainfall and temperature, the number of persons carrying the organism in their blood, the number of mosquitoes and the proximity of the breeding-places of the mosquito to the abodes of men, are all capable of quantitative measurement, and of furnishing guidance for suitable administrative measures.

Climate and Weather.—The relationship of epidemics to climate has received much attention in recent years, though in many cases the cause of seasonal prevalence is elusive. Thus, why scarlet fever should be so regularly an autumnal disease is not at all clear. On many cases, however, much light has been thrown. The discovery, for instance, that malaria was carried by the mosquito elucidates the seasonal distribution of that disease. A temperature of a certain height associated with pools of water is necessary for the rapid development of the mosquito, and also a certain degree of temperature for the development of the parasite in the mosquito. In the same way the zone to which sleeping sickness is limited is a narrow region in which the climate and environment are suitable to the life history of one particular tsetse fly. Much light has been thrown on the epidemiology of plague by the discovery that it was carried to man from the rat by means of the flea. Humidity is necessary for the growth of the flea, and consequently epidemics of plague can hardly occur at seasons of the year when it is warm and dry. Thus the epidemics of plague in Bombay, which have advanced progressively later and later into the year, now occur when the flea is no longer at its greatest prevalence. With this change the number of cases and deaths has greatly diminished.

Effect of Organisms.—As to the relation of epidemics to the organism which causes them, why an organism should be capable at one time of causing a great epidemic and at another only a few sporadic cases of a disease has not yet been found out. That organisms do vary in the power of infecting in this manner is a truism to anyone who has administered in the health departments of a large city. At one time the merest contact with a case of smallpox, for instance, will give rise to a large number of cases. At another time a patient suffering from smallpox may even attend a theatre without giving rise to a case of infection.

A considerable amount of evidence has been accumulated that an organism, having found a suitable host, or succession of hosts, may have its virulence unusually exalted, and if the virulence can be exalted in this manner, it is probable that some similar conditions may give rise to a great increase in the power of infection.

Environment.—While an epidemic may in many cases be chiefly or even wholly due to the active condition of the causal organism, it is to be remembered that the vitality and environment of the persons affected must also play a part. Thus, for instance, typhus fever introduced into a crowded slum in which lice are plentiful will almost certainly cause considerable havoc, but even here the havoc will be determined to a certain extent by the season of the year. If the weather be cold the people are crowded together on account of the demand for warmth, and the chance of infection is increased. In addition, in the winter, food is often scarce, and consequently vitality is low. If, on the other hand, the invasion of the organism takes place during the summer, a large epidemic will be unlikely. But though these factors act, yet if an organism has an exalted state of activity an epidemic of the disease may occur at any season of the year, even the most unlikely. Plague, for instance, especially in temperate climates, is essentially a disease of the warmer part of the year, yet it has been known occasionally to occur in large epidemics in the middle of winter, while epidemics of typhus of considerable size have been recorded in the summer time. The great epidemic of influenza (*q.v.*) in the autumn of 1918 is a striking example, such a season being a very unusual one for an outbreak of this disease. What rôle special susceptibility on the part of the population had in this case is not known.

Some other influences also act. There is some evidence that fatigue predisposes to enteric fever, an army on the march drinking polluted water tending to have a larger number stricken than a similarly conditioned civil population. Further, it cannot be doubted that the accumulated effect of seasons may tend to depress health and increase susceptibility to certain diseases. The cumulative effect of winter cold may be, perhaps, traced in children in relation to death from whooping-cough, the average minimum temperature in the winter preceding the maximum number of deaths from whooping-cough by about six weeks, while the form of the two curves is very much the same. The deaths from whooping-cough are due very largely to broncho-pneumonia, yet the sea-

sonal distribution of whooping-cough is not identical with that of the latter disease. Thus scarlet fever, being an autumnal disease and following the hot summer, might in the same way be ascribed to depression produced by continued hot weather, making certain persons more susceptible to the disease. But as scarlet fever is a disease almost absent in warm climates this explanation can hardly be complete, and some other factor must be necessary. None of these questions have at present been sufficiently investigated.

Carriers.—Another point of importance requires special reference, and that is the problem of "carriers," as individuals infected with a disease and cured as regards themselves, but who yet continue to harbour and distribute the parasite, are called. Cholera follows the pilgrims' way, enteric fever the carrier cook, diphtheria the carrier school-teacher (*see* CARRIERS).

Experimental Verification.—Recently, investigators in several countries—Topley and his collaborators in England; Webster and others at the Rockefeller Institute, New York; Neufeld, Lange and others of the Robert Koch Institute in Berlin—have applied the experimental method to the study of epidemiological problems. The plan has been to study the course of an epidemic disease introduced into a herd of mice, its evolution under conditions better defined and more simple than obtain in nature. Greenwood and Topley, for instance, have watched the progress of a fatal infectious disease of mice due to an organism of the Pasteurella group in a population of mice replenished wholly by the addition of normal animals over a period of more than three and a quarter years—that is, through a period much longer than the length of an average generation of mice. They have shown that in these circumstances the prevalence of the disease exhibits wave-like movements, and that the intervals between successive exacerbations can be diminished merely by increasing the rate of immigration of normal animals. In infections of this type the regular immigration of healthy animals is sufficient to maintain the disease indefinitely.

Prophylaxis.—In field epidemiology much work has been done in developing a method of prophylaxis against diphtheria, rendered possible by the discovery that certain persons exhibit a peculiar skin reaction (the so-called Schick reaction) after the injection within the skin of a small quantity of the toxin produced by the bacillus of diphtheria (*see* INFECTIOUS FEVERS). It is thought that such persons are especially liable to develop the disease when exposed to infection, and that an outbreak may be controlled or prevented by the immunization of those who respond to this test. This immunization is obtained by the injection of small doses of a mixture of toxin and anti-toxin. The method has been employed on a large scale, particularly in America. It is, however, too early to express a decided opinion, since the statistical evidence which has been tendered has not always been free from ambiguity.

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(J. B.; M. GR.)

EPIDIORITE, in petrology, an altered basic igneous rock, consisting essentially of hornblende and plagioclase felspar, used in road-mending. The term is now restricted to those metamorphosed igneous rocks of gabbroic or doleritic composition in which either relict minerals or relict textures, or both, are preserved. The epidiorites thus constitute a connecting link in the transformation of basic igneous rocks to amphibolites (*q.v.*) and hornblende-schists in which recrystallization is typically complete. Though having the same general mineral composition as diorites, the epidiorites are distinctly more basic rocks. The usual mineralogical changes in the passage of dolerite or gabbro to epidiorite are the partial or complete conversion of augite to the fibrous hornblende known as uralite, with simultaneous production of sphene, and the rearrangement of the felspar molecule to form limpid grains of albite and a hydroxyl-bearing calcium-aluminium silicate, zoisite or epidote, this assemblage being known as saussurite. Other minerals such as prehnite and grossular are sometimes constituents of this saussuritic aggregate. The original ophitic or porphyritic textures of the igneous rock are usually not completely destroyed, and are strictly referred to as blastophitic and blastoporphyritic textures.

With advancing metamorphism the chemical changes are more fundamental. The albite felspar gradually becomes richer in anorthite at the expense of the epidote, but the development of the red iron-bearing garnet does not usually ensue till recrystallization is complete, when the rock is more strictly referred to as amphibolite or hornblende-schist. Epidiorites are the common products of basic igneous rocks subject to dynamic metamorphism, and as such appear in regions of comparatively low grades of metamorphism. Their chief development is in the form of small bosses, dikes and sills. Within the limits of one exposure all stages in the gradual transition from dolerite to amphibolite, through epidiorite, may frequently be studied, the cores of dikes and sills consisting of unaltered igneous rock while the margin is completely recrystallized to amphibolite or hornblende-schist.

Epidiorites are of widespread distribution occurring among slates, phyllites and schists, as in the Scottish Highlands, the Alps, the Harz, Brittany and the crystalline ranges of eastern North America, etc. Many so-called greenstones (*q.v.*) are in reality epidiorites. In many parts of the world they form the matrices of auriferous quartz veins, *e.g.*, in the Precambrian shield of western Australia. (C. E. T.)

EPIDOSITE, in petrology, a typical member of a family of metamorphic rocks composed mainly of epidote and quartz; they are pale or greenish yellow, hard, and somewhat brittle, and are derived from several kinds of rock. Some have been epidotic grits and sandstones; others are limestones which have undergone contact-alteration; but the majority are probably allied to epidiorite and amphibolite and are local modifications of rocks which were primarily basic intrusions or lavas. The sedimentary epidosites occur with mica-schists, sheared grits and granulitic gneisses; they often show, on minute examination, the remains of clastic structures. The epidosites derived from limestones may contain a great variety of minerals such as calcite, augite, garnet, scapolite, etc., but their source may usually be inferred from their close association with calc-silicate rocks in the field. The third group of epidosites may form bands, veins or irregular streaks and nodules in masses of epidiorite and hornblende-schist. In microscopic section they are often merely a granular mosaic of quartz and epidote with some iron oxides and chlorite, but in other cases they retain much of the structure of the original rock though there has been a complete replacement of the former minerals by new ones. Epidosites when streaked and variegated have been cut and polished as ornamental stones. They are translucent and hard, and hence serve for the simpler kinds of jewellery. These rocks occasionally carry gold in visible yellow specks.

EPIDOTE, a mineral species consisting of basic calcium, aluminium and iron orthosilicate, crystallizing in the monoclinic system. Well-developed crystals are of frequent occurrence: they

are commonly prismatic in habit, the direction of elongation being perpendicular to the single plane of symmetry. Many of the characters of the mineral vary with the amount of iron present (Fe_2O_3, 5–17%), for instance, the colour, the optical constants, and the specific gravity (3·3–3·5). The hardness is 6½. The colour is green, grey, brown or nearly black, but usually yellowish- or pistachio-green.

Epidote is an abundant rock-forming mineral, but one of secondary origin. It occurs in crystalline limestones and schistose rocks of metamorphic origin, and is also a product of weathering of various minerals composing igneous rocks; combined with quartz it is known as epidosite (*q.v.*). Well-developed crystals are found at many localities, the best being from Knappenwand, in the Untersulzbachthal in Salzburg, and Prince of Wales island, Alaska. The perfectly transparent, dark-green crystals from the Knappenwand and Brazil have occasionally been cut as gem-stones.

Belonging to the same isomorphous group with epidote are the species piedmontite and allanite, which may be described as manganese and cerium epidotes respectively. *Piedmontite* occurs as small, reddish-black, monoclinic crystals in the manganese mines at San Marcel, Piedmont, and in crystalline schists at several places in Japan. The purple colour of the Egyptian *porfido rosso antico* is due to the presence of this mineral. *Allanite* contains ferric iron and metals of the cerium group; externally it differs widely from epidote, being black or dark brown in colour, pitchy in lustre, and opaque in the mass. Although not a common mineral it is of fairly wide distribution as a primary accessory constituent of many crystalline rocks. Orthite, from ὀρθός, "straight," is a hydrated form found as slender prismatic crystals, sometimes 1ft. in length, at Finbo, Sweden. (L. J. S.)

EPIGONI: *see* OEDIPUS.

EPIGONION, an ancient stringed instrument mentioned in Athenaeus. The epigonion was invented, or at least introduced into Greece, by Epigonus, a Greek musician of Ambracia, in Epirus, who was admitted to citizenship at Sicyon as a recognition of his great musical ability, and of his having been the first to pluck the strings with his fingers, instead of using the plectrum. The instrument, which Epigonus named after himself, had 40 strings and was a kind of harp. When Epigonus lived is unknown.

EPIGRAM, which originally meant "an inscription," has in the course of time come to mean any pithy (and usually pungent) saying in prose or verse. We find that the name has been given—first, in strict accordance with its Greek etymology, to any actual inscription on monument, statue or building; secondly, to verses never intended for such a purpose, but assuming for artistic reasons the epigraphical form; thirdly, to verses expressing with something of the terseness of an inscription a striking or beautiful thought; and fourthly, by unwarrantable restriction, to a little poem ending in a "point," especially of the satirical kind. The last has obtained popularity from the well-known:—

> "The qualities rare in a bee that we meet
> In an epigram never should fail;
> The body should always be little and sweet,
> And a sting should be left in its tail"—

which represent the older Latin of some unknown writer:—

> "Omne epigramma sit instar apis: sit aculeus illi;
> Sint sua mella; sit et corporis exigui."

Scaliger, in the third book of his *Poetics,* gives a fivefold division of epigrams which displays a certain ingenuity in the nomenclature but is very superficial: the first class takes its name from *mel,* or honey, and consists of adulatory specimens; the second from *fel,* or gall; the third from *acetum,* or vinegar; and the fourth from *sal,* or salt; while the fifth is styled the condensed, or multiplex. This classification is adopted by Nicolaus Mercerius in his *De conscribendo epigrammate* (Paris, 1653); but he supplemented it by another of much more scientific value, based on the figures of the ancient rhetoricians. Lessing, in the preface to his own epigrams, gives an interesting treatment of the theory, his principal doctrine being that there ought to be two parts more or less clearly distinguished—the first awakening the reader's attention in the same way as an actual monument might do, and the other satisfying his curiosity in some unexpected manner.

The verse epigram is one of the most catholic of literary forms, and lends itself to the expression of almost any feeling or thought. It may be an elegy, satire, or love-poem, an embodiment of the wisdom of the ages, or a bon-mot set off with rhymes.

From its very brevity there is no small danger of the epigram passing into childish triviality. For proof of this there is unfortunately no need to look far; but perhaps the reader could not find a better collection ready to his hand than the second 25 of the *Epigrammatum centuriae* of Samuel Erichius; by the time he reaches No. 11 of the 47th century, he will be quite ready to grant the appropriateness of the identity maintained between the German *Seele,* or soul, and the German *Esel,* or ass.

Of the epigram as cultivated by the Greeks an account is given in the article ANTHOLOGY. As regards Latin literature, the epigrammatists whose work has been preserved are comparatively few, and though several of them, as Catullus and Martial, are men of high literary genius, too much of what they have left behind is vitiated by brutality and obscenity. On the subsequent history of the epigram, indeed, Martial has exercised an influence as baneful as it is extensive. Nearly all the learned Latinists of the 16th and 17th centuries may claim admittance into the list of epigrammatists. Melanchthon, who succeeded in combining so much of Pagan culture with his Reformation Christianity, has left us some graceful specimens, but his editor, Joannes Major Joachimus, has so little idea of what an epigram is, that he includes in his collection some translations from the Psalms. The Latin epigrams of Étienne Pasquier were among the most admirable which the Renaissance produced in France. John Owen, a Cambro-Briton, attained unusual celebrity in this department, and is regularly distinguished as Owen the Epigrammatist. The tradition of the Latin epigram has been kept alive in England by such men as Porson, Vincent Bourne and Walter Savage Landor.

In English literature proper there is no writer like Martial in Latin or Logau in German, whose fame is entirely due to his epigrams. Epigram, however, is used by earlier English writers with laxity, and given or withheld without apparent reason. Weever's collection (1599) is of interest mainly because of its allusion to Shakespeare. Ben Jonson furnishes several noble examples in his *Underwoods;* and one or two of Spenser's little poems and a great many of Herrick's are properly classed as epigrams. Cowley, Waller, Dryden, Prior, Parnell, Swift, Addison, Johnson, Goldsmith, Young, Burns, Blake, Shelley and Landor have all been at times successful in their epigrammatical attempts; but perhaps none of them has proved himself so much "to the manner born" as Pope, whose name indeed is almost identified with the epigrammatical spirit in English literature. Among contemporary poets, Sir William Watson, W. B. Yeats, Hilaire Belloc and J. C. Squire have all written brilliant epigrams.

The French are undoubtedly the most successful cultivators of the "salt" and the "vinegar" epigram; and from the 16th century downwards many of their principal authors have earned celebrity in this department. The epigram was introduced into French literature by Mellin de St. Gelais and Clément Marot. It is enough to mention the names of Boileau, J. B. Rousseau, Lebrun, Voltaire, Marmontel, Piron, Rulhière, and M. J. Chénier. In spite of Rapin's dictum that a man ought to be content if he succeeded in writing one really good epigram, those of Lebrun alone number upwards of 600, and a very fair proportion of them would doubtless pass muster even with Rapin himself.

While any fair collection of German epigrams will furnish examples that for keenness of wit would be quite in place in a French anthology, the Teutonic tendency to the moral and didactic has given rise to a class but sparingly represented in French. The very name of *Sinngedichte* bears witness to this peculiarity, which is exemplified equally by the rude *priameln* or *proeameln,* of the 13th and 14th centuries, and the polished lines of Goethe and Schiller. Logau published his *Deutsche Sinngedichte Drey Tausend* in 1654, and Wernicke no fewer than six volumes of *Ueberschriften oder Epigrammata* in 1697; Kästner's *Sinngedichte* appeared in 1782, and Haug and Weissen's *Epigrammatische Anthologie* in 1804. Kleist, Opitz, Gleim, Hagedorn, Klopstock

and A. W. Schlegel all possess some reputation as epigrammatists; Lessing is *facile princeps* in the satirical style; and Herder has enriched his language from Oriental and classical sources.

The two collections of epigrams most accessible to the English reader are Booth's *Epigrams, Ancient and Modern* (1863) and Dodd's *The Epigrammatists* (1870). In the appendix to the latter is a pretty full bibliography.

EPIGRAPHY, a term used to denote (1) the study of inscriptions collectively; (2) the science connected with the classification and explanation of inscriptions; and (3) in a more contracted sense, the palaeography in inscriptions. Coins come under the heading NUMISMATICS.

See INSCRIPTIONS; PALAEOGRAPHY.

EPILEPSY, a disorder the essential symptom of which is a recurring, abrupt loss or alteration of consciousness, includes many types of seizures, *e.g.*, convulsions, emotional explosions, irritable periods, vertigoes, and psychic clouding. There are normal gradations of consciousness, as sleep, degrees of attentiveness or mental concentration, etc. Convulsions, because of their alarming appearance, early impressed mankind. This continued, preventing recognition of mental traits and important minor phenomena of the epilepsies. Symptomatic convulsions occur in other disorders, *e.g.*, uraemia, diabetes, eclampsia, psychosis, and in infancy and childhood, especially at the onset of acute infections.

Facts pertaining to heredity are not established sufficiently to formulate laws regarding transmission of epilepsies. Direct similar heredity in epilepsy is uncommon. Infections and malnutrition during foetal life, infancy, and childhood may damage vital systems and produce subsequent epilepsy. The majority of epilepsies seem due to multiple factors. Injurious influences affecting the brain during early life may permit later of otherwise harmless influences exciting seizures. Without such predisposition, normal functioning of essential organs would withstand the influence which produces epilepsy. Paralytics surviving from birth injury usually become epileptic. Finer changes in the nervous system from birth injury often cause subsequent mental defect, epilepsy, or both. In many epileptics the heart and large blood-vessels are abnormally small. There may be other organ inferiorities. Seemingly inhibition, not stimulation of the cerebral cortex, resulting in loss of control over lower brain centres (decerebration) produces impairment or loss of consciousness with convulsive manifestations. Regressive changes may result in lack of inhibitory control of the brain.

The gravity of a skull injury bears no relationship to development of traumatic epilepsy, which sometimes follows comparatively slight head injuries. Only a small proportion of head injuries in children or adults result in epilepsy. In epileptics having frequent seizures, the brain at autopsy may appear quite normal, finer changes being found upon microscopic examination. In cases with marked abnormalities there may have been few seizures. Such brain changes are considered in some to have been predisposing, in others resultant or merely concomitant.

The immediate cause of epileptic phenomena is cerebral vascular disturbance with resulting nutritive upset and transitory oedema of parts of the brain. Such vasomotor disturbance in the brain cannot ordinarily be demonstrated in life nor found *post mortem*. It may be caused by insufficient or excessive activity of endocrines, protein sensitization, passage from the intestines into the circulation of toxins which eventually reach the brain, toxic substances produced locally in the brain as a result of vascular disturbance in encephalitis, brain tumour, arteriosclerosis, brain scars with adhesions, etc. Faulty metabolism of foods may result in substances toxic to brain cells and cause seizures, although simple retention of ordinary waste products may not so act. Some investigators claim an acidosis, others an alkalosis, precipitates seizures. Attacks may be induced by excess or undue diminution of blood sugar, sudden lowering or increase of blood pressure, great loss of blood, increased intracranial pressure, etc. Some maintain a severe convulsion automatically adjusts faulty metabolism resulting in an interval of relatively normal health. Habit may act in causing recurrence of seizures. The importance of eyestrain, teething, worms, scars on extremities, abnormalities of sex organs, etc., as reflex causes, has been exaggerated. Apparently menstruation, pregnancy, and menopause provoke some seizures. Up to 20 years of age the two sexes are equally affected, subsequently males exceed because of habits, occupation, etc.

Some describe the epileptic as one with inherited defect which causes various types of stress, ultimately psychic in character, producing reactions of unconsciousness, recurring periodically, which permits riddance of a particular, adaptive demand through regression to the unconscious, a state of peace and harmony, comparable to existence before reality had become part of the mental demand. Mentality of epileptics may range from normal to marked defectiveness. Deprivation, retardation, and deterioration are factors acting in many. A number are highly intelligent, the majority living normally in their community never reaching institutions. In some, outstanding symptoms are ego-centricity, supersensitiveness, emotional poverty, self-satisfaction, superficial religious manifestations, and abnormal fluctuation of attention.

Attacks may be classified as follows: motor seizures, with or without apparent loss of consciousness; sensory seizures; psychic disturbances, acute or chronic. All symptoms considered part of the disorder are modifications of one or all of these reactions. Automatism, a part of certain seizures, is frequently unrecognized, the individual unconsciously committing certain acts. Medicolegally such periods as well as psychic phenomena of epilepsy are of importance. Many present "epileptic optimism," *i.e.*, failure to appreciate the necessity for avoiding dangerous situations or assuming undue responsibilities. An epileptic may appreciate the onset of a seizure, but not recall it by lack of memory fixation. Numerous factors seemingly favour occurrence of seizure, *e.g.*, circulatory changes accompanying onset and cessation of sleep, puberty, dietary indiscretions, emotional reactions, atmospheric humidity, etc.

Minor attacks are often overlooked, as the person may not fall; simply pauses for an instant, looks strange, then resumes conscious life. He may fall and immediately arise, such seizure being mistaken for syncope, but distinguished by suddenness of onset and recovery. Ramsay Hunt suggests attacks are due to sudden momentary loss of postural muscular control, associated with transient unconsciousness. Recurring mild attacks in children may be a forerunner of epilepsy or cease without impairment.

Cerebral apoplexy seldom occurs in severe convulsions, although minute haemorrhages without doubt do, causing recurrence of symptoms. Study of the seizure itself does not with certainty differentiate those due to organic disease from those due to psychic cause. Research has thus far failed to prove perversions of function or organs peculiar to the epilepsies. No drug is specific because essential epilepsy is not a disease, but a symptom complex resulting from unknown underlying conditions. The basis of treatment is to find and remove, at least minimize, factors that adversely influence the central nervous system.

The epileptic should be placed under proper guidance early, not necessarily public surveillance, but a physician or person competent to advise. In effecting readjustment of life, it is necessary carefully to analyze symptoms and individualize treatment possible to carry out. The mode of living cannot be entirely changed, let alone environment; nevertheless, many circumstances or habits which act injuriously may be diminished. The patient must be considered as a whole and not solely as presenting types of seizures. Reasonable restriction of diet, allowing for maintenance of normal nutrition, with exclusion of articles difficult to digest will accomplish as much as extreme methods of prolonged starvation. Some are benefited with increase of fats, some by other food groups, depending on chemical examinations of blood, urine, etc. Due care must be given to the elimination of waste products. Surgery is indicated only in certain symptomatic epilepsies, *e.g.*, brain tumour and to relieve conditions lowering general health.

The longer the freedom from seizures, and the better the adjustment to ordinary environments, the better the prognosis. Carelessness in mode of life may result in recurrence of seizures. Remissions over more or less prolonged periods, irrespective of

treatment, are not uncommon. Spontaneous arrest seemingly occurs in some. Expectation of life in epileptics is some 20 years less than in others. To effect material improvement there must be only disturbed function, not destruction, of portions of the central nervous system and related organs. Psychic-maladjustments, lack of adaptation of organs and the individual as a whole, *i.e.*, constitutional instability, the environment created by neurotic relations or associates, or the ordinary environment to the stresses of which the abnormal person cannot react properly are factors influencing epilepsy. An epileptic ordinarily presents the reactions common to mankind, a fact to be remembered in prescribing for him. Salts of bromine have been used with more or less success for 70 years. Sodium or strontium salts produce least irritation in the gastro-intestinal tract. If bromides are used particular care must be given to elimination and avoidance of deleterious influence on the mentality. Favourable results have followed the use of luminal (phenyl-barbital) in diminishing frequency of seizures, especially of the severer type, or holding them completely in abeyance. Alleged "cure-alls" often do much harm. Marriage of epileptics should be discouraged because of possibility of transmission of the condition to offspring, incompatibility of temperament, and difficulty of assuming responsibility. Educational work among younger epileptics is beneficial, *e.g.*, discipline should be inculcated, interests aroused and self-control developed. Responsibility begets confidence. The epileptic should be allowed to participate in activities of his circle, permitting energy outlets. The feeling that he is a person set apart from relations and associates has a bad influence on mental functioning and metabolism. Occupation inducing normal healthy fatigue is most beneficial.

(*See* Epileptic Fit.) (W. T. S.)

EPILEPTIC FIT. Three well-marked varieties of the epileptic seizure are known, *le grand mal, le petit mal* and *Jacksonian epilepsy*. Any may exist alone, but the two former may occur together. The first is generally known as an *epileptic fit*.

Although in most instances an attack comes on suddenly, it is in many cases preceded by certain indications or warnings. These are very varied and may be in the form of some temporary change in the disposition, such as unusual depression or elevation of spirits, or of some alteration in the look. Besides these general symptoms, peculiar sensations often immediately precede the onset of the fit (*aura epileptica*). The aura may be mental *e.g.*, an agonizing feeling of momentary duration; sensorial *e.g.*, pain in a limb or in some internal organ, or may concern the special senses; or, motorial *e.g.*, contractions or trembling in some of the muscles. When such sensations affect a limb, the employment of firm compression by the hand or by a ligature occasionally succeeds in warding off an attack. The aura may be so distinct and of such duration as to enable the patient to lie down, or seek a place of safety before the fit comes on.

The seizure is usually preceded by a loud scream or cry, not due to terror or pain, but to the convulsive action of the muscles of the larynx, and expulsion of a column of air through the narrowed glottis. If the patient is standing he immediately falls, and often sustains serious injury. Unconsciousness is complete, and the muscles generally are in a state of stiffness or tonic contraction, mainly affecting one side of the body. The head is jerked towards one or other shoulder, the breathing is for the moment arrested, the countenance first pale then livid, the pupils dilated and the pulse rapid. This, the first stage of the fit, generally lasts for about half a minute, and is followed by the state of clonic (*i.e.*, tumultuous) spasm of the muscles, in which the whole body is thrown into violent agitation, occasionally so great that bones are fractured or dislocated. The eyes roll wildly, the teeth are gnashed together, and the tongue and cheeks are often severely bitten. The breathing is noisy and laborious, and foam (often tinged with blood) issues from the mouth, while the contents of the bowels and bladder are ejected. This stage lasts from a few seconds to several minutes, when the convulsive movements gradually subside, and relaxation of the muscles takes place, together with partial return of consciousness, the patient looking confusedly about him and attempting to speak. This, however, is soon followed by drowsiness and stupor, which may continue for several hours, when he awakes either apparently quite recovered or fatigued and depressed, and occasionally in a state of excitement which sometimes assumes the form of mania.

Epileptic fits of this sort succeed each other with varying degrees of frequency, and occasionally, though not frequently, with regular periodicity. In some persons they only occur once in a lifetime, or once in the course of many years, while in others they return every week or two, or even are of daily occurrence, and occasionally there are numerous attacks each day. When the fit returns it is not uncommon for one seizure to be followed by another within a few hours or days. Occasionally there occurs a constant succession of attacks extending over many hours, and with such rapidity that the patient appears as if he had never come out of the one fit. The term *status epilepticus* is applied to this condition, which is sometimes fatal. In many epileptics the fits occur by night as well as by day, but in some instances they are entirely nocturnal, and then the disease may long remain unrecognized.

The second manifestation of epilepsy (*le petit mal*), differs from that above described in the absence of the convulsive spasms. It consists essentially in a sudden, short arrest of volition and consciousness, and may be accompanied with staggering or some alteration in position or motion, or simply exhibit itself in a look of absence or confusion, and should the patient happen to be engaged in conversation, by an abrupt termination of the act. In general it lasts but a few seconds, and the individual resumes his occupation without perhaps being aware of anything having been the matter. In some instances there is a degree of spasmodic action in certain muscles which may cause the patient to make some unexpected movement, such as turning half round, or walking abruptly aside, or may show itself by some unusual expression of countenance, such as squinting or grinning. There may be some aura preceding such attacks, and also faintness following them.

The third manifestation—*Jacksonian epilepsy* or *partial epilepsy*—is distinguished by the fact that consciousness is retained or lost late. The patient is conscious throughout, and is able to watch the march of the spasm. The attacks are usually the result of lesions in the motor area of the brain *e.g.*, cerebral tumour or depressed fracture of skull.

Epilepsy appears to exert no necessarily injurious effect upon the general health, and is quite consistent with great bodily vigour. It is very different, however, with regard to its influence upon the mind. Allusion has already been made to the occasional occurrence of maniacal excitement as one of the results of the epileptic seizure. Such attacks (epileptic insanity) are generally accompanied by dangerous and violent acts and appear to be more frequently associated with the milder form of epilepsy where they either replace or immediately follow the short period of unconsciousness. The subject is one of the greatest medico-legal interest and importance in regard to criminal responsibility.

EPILOBIUM, a genus of plants of the family Onagraceae, popularly called willow-herbs (*q.v.*). There are about 160 species, all confined to temperate and Arctic regions; 9 are found in the British Isles and about 40 occur in North America. They are mostly tall herbs with pink, purple or whitish flowers.

EPILOGUE. The appendix or supplement to a literary work, and in particular to a drama in verse, is called an *epilogue*, from ἐπίλογος the name given by the Greeks to the peroration of a speech. As we read in Shakespeare's *Midsummer Night's Dream,* the epilogue was generally treated as the apology for a play; it was a final appeal made to encourage the good-nature of the audiences, and to deprecate attack. Ben Jonson made it a feature of his drama, and may almost be said to have invented the tradition of its regular use. He employed the epilogue for two purposes, either to assert the merit of the play or to deprecate censure of its defects. Beaumont and Fletcher used the epilogue sparingly, but after their day it came more and more into vogue, and the form was almost invariably that which Ben Jonson had brought into fashion, namely, the short complete piece in heroic couplets. The hey-day of the epilogue, however, was the Restoration, and from 1660 to the decline of the drama in the reign of

Queen Anne scarcely a play, serious or comic, was produced on the London stage without a prologue and an epilogue. It became the custom for playwrights to ask their friends to write these poems for them, and the publishers would even come to a prominent poet and ask him to supply one for a fee. It gives us an idea of the seriousness with which the epilogue was treated that Dryden originally published his valuable "Defence of the Epilogue; or An Essay on the Dramatic Poetry of the Last Age" (1672) as a defence of the epilogue which he had written for *The Conquest of Granada*.

EPIMENIDES, a semi-historical poet and prophet of Cnossos, in Crete, who lived in the 6th century B.C. He is said to have fallen into a deep sleep in the Dictaean cave, from which he did not awake for 57 years (Diogenes Laërtius i. 109–115). When the Athenians were visited by a pestilence, in consequence of the murder of Cylon, he was invited by Solon (596) to purify the city. He died in Crete at an advanced age; according to his countrymen, who afterwards honoured him as a god, he lived nearly 300 years. According to another story, he was taken prisoner in a war between the Spartans and Cnossians and put to death by his captors because he refused to prophesy favourably for them. A collection of oracles, a theogony, an epic poem on the Argonautic expedition, prose works on purifications and sacrifices, and a cosmogony were attributed to him. He is supposed to be the Cretan prophet alluded to in the epistle to Titus (i. 12).

See H. Demoulin, *Épimenide de Crète* (1901); H. Diels, *Die Fragmente der Vorsokratiker* (1903); O. Kern in Pauly-Wissowa's *Realencyklopädie*.

ÉPINAL, a town on the north-eastern frontier of France, capital of the department of Vosges, 46 m. S.S.E. of Nancy on the Eastern railway between that town and Belfort. Pop. (1926) 21,959. Épinal grew round a 10th century monastery, founded by Theodoric (Dietrich) I., bishop of Metz, whose successors ruled the town till 1444, when its inhabitants placed themselves under King Charles VII. In 1466 it was transferred to the duchy of Lorraine, and in 1766 it was, along with that duchy, incorporated with France. It was occupied by the Germans in the Franco-Prussian War. The town proper—the Grande Ville—stands on the right bank of the Moselle, which here divides into two arms forming an island whereon another quarter—the Petite Ville—is built. The lesser of these two arms, which is canalized, separates the island from the suburb of Hospice on its left bank. On the right bank of the Moselle a park surrounds the ruins of an old stronghold which dominated the Grande Ville from a height on the east. The church of St. Goëry (or St. Maurice) preserves a tower of the 12th century. The old hospital on the island-quarter contains a museum with paintings, Gallo-Roman antiquities, sculpture, etc. Close by stands the library, which possesses many valuable mss.

The fortifications of Épinal are connected southward with Belfort, Dijon and Besançon, by the fortified line of the Moselle, and north of it lies the unfortified zone called the *Trouée d'Épinal*, a gap between Épinal and Toul, another great fortress. The circle of forts, with a perimeter of nearly 30 m., was in 1895 reinforced by the construction of sixteen new works.

Épinal is the seat of a prefect and of a court of assizes and has tribunals of first instance and of commerce, a board of trade-arbitrators, a chamber of commerce and an industrial and commercial school. The town, which is important as the centre of a cotton-spinning region, carries on the spinning, weaving and printing of cotton and the manufacture of glucose, embroidery and hats. An industry peculiar to Épinal is the production of cheap images, lithographs and engravings. There is also trade in wine, grain, live-stock and starch products made in the vicinity. Épinal is an important junction on the Eastern railway.

EPINAOS, in architecture, the open vestibule behind the enclosed portion, or cella, of a temple; the rear porch. When enclosed, it is known as an *opisthodomos*.

EPINAY, LOUISE FLORENCE PETRONILLE TARDIEU D'ESCLAVELLES D' (1726–1783), French writer, was born at Valenciennes on March 11, 1726. She is well known on account of her *liaisons* with Rousseau and Baron von Grimm, and her acquaintance with Diderot, D'Alembert, D'Holbach and other French men of letters. Her marriage with her cousin Denis Joseph de La Live d'Epinay, a collector-general of taxes was an unhappy one; and Louise d'Epinay obtained a formal separation in 1749. She settled in the château of La Chevrette in the valley of Montmorency, and there received a number of distinguished visitors. Conceiving a strong attachment for J. J. Rousseau, she furnished for him in 1756 in the valley of Montmorency a cottage which she named the "Hermitage," and in this retreat he found for a time the quiet rural pleasures he praised so highly. Rousseau, in his *Confessions*, affirmed that the inclination was all on her side; but as, after her visit to Geneva, Rousseau became her bitter enemy, little weight can be given to his statements. Her intimacy with Grimm, which began in 1755, marks a turning-point in her life, for under his influence she escaped from the somewhat compromising conditions of her life at La Chevrette. In 1757–59 she paid a long visit to Geneva, where she was a constant guest of Voltaire. In Grimm's absence from France (1775–76), Madame d'Epinay continued, under the superintendence of Diderot, the correspondence he had begun with various European sovereigns. She spent most of her later life at La Briche, a small house near La Chevrette, in the society of Grimm and of a small circle of men of letters. She died on April 17, 1783. Her *Conversations d'Emilie* (1774), composed for the education of her grand-daughter, Emilie de Belsunce, was crowned by the French Academy in 1783. The *Mémoires et Correspondance de Mme. d'Epinay, renfermant un grand nombre de lettres inédites de Grimm, de Diderot, et de J.-J. Rousseau, ainsi que des détails,* etc., was published at Paris (1818) from a ms. which she had bequeathed to Grimm. The *Mémoires* are written in the form of an autobiographic romance, in which Madame d'Epinay figures as Madame de Montbrillant, René is generally recognized as Rousseau, Volx as Grimm, Garnier as Diderot. All the letters and documents published along with the *Mémoires* are genuine. Many of Madame d'Epinay's letters are contained in the *Correspondance de l'abbé Galiani* (1818). Two anonymous works, *Lettres à mon fils* (Geneva, 1752) and *Mes moments heureux* (Geneva, 1759), are also by Madame d'Epinay.

See Rousseau's *Confessions;* Lucien Perey [Mlle. Herpin] and Gaston Maugras, *La Jeunesse de Mme. d'Épinay, les dernières années de Mme. d'Épinay* (1882–83); Sainte-Beuve, *Causeries du lundi*, vol. ii.; Edmond Scherer, *Études sur la littérature contemporaine*, vols. iii. and vii. There are editions of the *Mémoires* by L. Enault (1855) and by P. Boiteau (1865); and an English translation, with introduction and notes (1897), by J. H. Freese.

EPINEPHRINE: *see* ADRENALIN; SUPRARENAL EXTRACT.

EPIPHANIUS, SAINT (*c.* 315–402), Bishop of Constantia or Salamis, a celebrated Church Father, born at Bezanduca, a village of Palestine, and probably of Jewish extraction. In his youth he resided in Egypt, where he freed himself from Gnostic influences. Returning to Palestine he was ordained presbyter and became the president of a monastery which he founded near his native place. In 367 he was nominated bishop of Constantia, previously known as Salamis, the metropolis of Cyprus—an office which he held till his death. Epiphanius devoted himself to the spread of monasticism, and the confutation of heresy, of which he regarded Origen and his followers as the chief representatives. He denounced John, bishop of Jerusalem from his own pulpit at Jerusalem so violently that the bishop sent his archdeacon to request him to desist. Instigated by Theophilus, bishop of Alexandria, he summoned a council of Cyprian bishops to condemn the errors of Origen. Later he came into conflict with Chrysostom, the patriarch of Constantinople, who had given temporary shelter to four Nitrian monks whom Theophilus had expelled on the charge of Origenism. The monks gained the support of the empress Eudoxia, and when she summoned Theophilus to Constantinople the aged Epiphanius went with him, but died on his way home. The principal work of Epiphanius is the *Panarion,* or treatise on heresies, the accounts of the earlier errors (where he has preserved large excerpts from the original Greek of Irenaeus) being the more reliable. He also wrote the *Ancoratus,* or discourse on the true faith, a treatise on Jewish weights and measures, another (incomplete) on ancient gems, and two epistles to

John of Jerusalem and Jerome. His other works are lost. In allusion to his knowledge of Hebrew, Syriac, Egyptian, Greek and Latin, Jerome styles Epiphanius Πεντάγλωσσος (Five-tongued). His erudition is outweighed by his borrowing, his prejudice, and his credulity.

See the church histories of Socrates and Sozomen, Palladius' *De vita Chrysostomi* and Jerome's *De vir. illust.* 114. His works were published by Petau (Petavius) 2 vols. (Paris, 1622) and by Migne, *Patr. Graec.* 41–43. The last edition of the *Ancoratus* and *Panarion* is by K. Holl, 2 vols. (Leipzig, 1915). His *Discourses on the Holy Virgin* was edited with an Eng. trans. by Wallis Budge in *Misc. Coptic Texts* (1915).

Other theologians of the same name were: (1) Epiphanius Scholasticus, friend of Cassiodorus; (2) Epiphanius, bishop of Ticinum (Pavia), *c.* 438–496; (3) Epiphanius, bishop of Constantia and Metropolitan of Cyprus (the Younger), *c.* A.D. 680, to whom some critics have ascribed certain works supposedly by the greater Epiphanius; (4) Epiphanius, bishop of Constantia in the 9th century, to whom a similar attribution has been made.

EPIPHANY, FEAST OF, the commemoration of the Baptism, also called by the Greek fathers of the 14th century the Theophany or Theophanies, and the Day of Lights, *i.e.*, of the Illumination of Jesus or of the Light which shone in the Jordan. In the Teutonic west it has become the Festival of the three kings (*i.e.*, the Magi), or simply Twelfth day. Leo the Great called it the Feast of the *Declaration;* Fulgentius, of the *Manifestation;* others, of the *Apparition* of Christ.

Clement of Alexandria first mentions it. Writing *c.* 194 he states that the Basilidians feasted the day of the Baptism, devoting the whole night which preceded it to lections of the scriptures. They fixed it in the 15th year of Tiberius, on the 15th or 11th of the month Tobi, dates of the Egyptian fixed calendar equivalent to January 10th and 6th. When Clement wrote the great church had not adopted it, but toward A.D. 300 it was widely in vogue.

In the age of the Nicene Council, A.D. 325, the primate of Alexandria was charged at every Epiphany Feast to announce to the churches in a "Festal Letter" the date of the forthcoming Easter. In Jerusalem, according to the epistle of Macarius to the Armenians, *c.* 330, the feast was kept with zeal and splendour, and was with Easter and Pentecost a favourite season for Baptism. We have evidence of the 4th century from Spain that a long fast marked the season of Advent, and prepared for the feast of Epiphany on the 6th of January. The council of Saragossa *c.* 380 enacted that for 21 days, from the 17th of December to the 6th of January, the Epiphany, the faithful should not dance or make merry. Our earliest Spanish lectionary, the *Liber comicus* of Toledo, edited by Don Morin (*Anecd. Maredsol.* vol. i.), provides lections for five Sundays in Advent, and the gospel lections chosen regard the Baptism of Christ, not His Birth, of which the feast, like that of the Annunciation, is mentioned, but not yet dated, December 25 being assigned to St. Stephen. In Armenia as early as 450 a month of fasting prepared for the Advent of the Lord at Epiphany, and the fast was interpreted as a reiteration of John the Baptist's season of Repentance.

In Antioch as late as about 386 Epiphany and Easter were the two great feasts, and the physical Birth of Christ was not yet feasted. On the eve of Epiphany after nightfall the springs and rivers were blessed, and water was drawn from them and stored for the whole year to be used in lustrations and baptisms. Epiphanius boldly removed the date of the Baptism to the 8th of November. "January 6" (=Tobi 11), he writes, "is the day of Christ's Birth, that is, of the Epiphanies." He uses the plural, because he adds on January 6 the commemoration of the water miracle of Cana. Although in 375 he thus protested that January 6 was the day "of the Birth after the Flesh," he became before the end of the century a convert, according to John of Nice, to the new opinion that December 25 was the real day of this Birth. That as early as about 385, January 6 was kept as the physical birthday in Jerusalem, or rather in Bethlehem, we know from a contemporary witness of it, the lady pilgrim of Gaul (Egeria Silvia), whose *peregrinatio,* recently discovered by Gamurrini, is confirmed by the old Jerusalem Lectionary preserved in Armenian (translated in *Rituale Armenorum* [1905]).

In 385 Pope Siricius calls January 6 *Natalicia,* "the Birthday of Christ or of Apparition," and protests against the Spanish custom (at Tarragona) of baptizing on that day—another proof that in Spain in the 4th century it commemorated the Baptism. In Gaul at Vienna in 360 Julian the Apostate, out of deference to Christian feeling, went to church "on the festival which they keep in January and call Epiphania."

Why the feast of the Baptism was called the feast or day of the Saviour's Birth, and why fathers of that age when they call Christmas the birthday constantly qualify and add the words "in the flesh," we are able to divine from Pope Leo's (*c.* 447) 18th Epistle to the bishops of Sicily. For here we learn that in Sicily they held that in His Baptism the Saviour was reborn through the Holy Spirit.

OTHER MANUSCRIPTS

Fortune has preserved to us among the *Spuria* of several Latin fathers, Ambrose, Augustine, Jerome and Maximus of Turin, various homilies for Sundays of the Advent fast and for Epiphany. The Advent lections of these homilists were much the same as those of the Spanish *Liber comicus;* and they insist on Advent being kept as a strict fast, without marriage celebrations. Their Epiphany lection is, however, Matt. iii. 1–17, which must therefore have once on a time been assigned in the *Liber comicus* also in harmony with its general scheme. The baptism is declared by these homilists to have been "the consecration of Christ," and "regeneration of Christ and a strengthening of our faith," to have been "Christ's second nativity." "This *second birth* hath more renown than his first . . . for now the God of majesty is inscribed (as his father), but then (at his first birth) Joseph the Carpenter was assumed to be his father . . . he hath more honour who cries aloud from Heaven (*viz.*, God the Father), than he who labours upon earth" (*viz.*, Joseph).

Another homily preserved in a ms. of the 7th or 8th century and assigned to Maximus of Turin declares that the Epiphany was known as the Birthday of Jesus, either because He was then born of the Virgin or *reborn in baptism.* As late as the 9th century the Armenians had at least three discrepant dates for the Annunciation—January 5, January 9, April 6; and of these January 5 and 9 were older than April 6, which they perhaps borrowed from Epiphanius's commentary on the Gospels. The Epiphany feast had therefore in its own right acquired the name of *natalis dies* or birthday, as commemorating the spiritual rebirth of Jesus in Jordan, before the *natalis in carne,* the Birthday *in the flesh,* as Jerome and others call it, was associated with it. This idea was condemned as Ebionite in the 3rd century, yet it influences Christian writers long before and long afterwards.

A letter is preserved by John of Nice of a bishop of Jerusalem to the bishop of Rome which attests a temporary union of both feasts on January 6 in the holy places. The faithful, it says, met before dawn at Bethlehem to celebrate the Birth from the Virgin in the cave; but before their hymns and lections were finished they had to hurry off to Jordan, 13 m. the other side of Jerusalem, to celebrate the Baptism, and by consequence neither commemoration could be kept fully and reverently. The writer therefore begs the pope to look in the archives of the Jews brought to Rome after the destruction of Jerusalem, and to ascertain from them the real date of Christ's birth. The pope looked in the works of Josephus and found it to be December 25. The letter's genuineness has been called in question; but from internal evidence it appears that it could not have been invented. Now we know what sort of considerations influenced this sect in fixing other feasts, so we have a clue. They fixed the Birth of Jesus on Pachon 25 (=May 20), the day of the Niloa, or feast of the descent of the Nile from heaven. We should thus expect January 6 to be equally a Nile festival, as it actually was. On Tobi 11, says Epiphanius (*c.* 370), every one draws up water from the river and stores it up, not only in Egypt itself, but in many other countries. In many places, he adds, springs and rivers turn into wine on this day, *e.g.*, at Cibyra in Caria and Gerasa in Arabia. Aristides Rhetor (*c.* 160) also relates how in the winter, which began with Tobi, the Nile water was at its purest.

Two centuries later Chrysostom, as we have seen, commends

in identical terms the water blessed and drawn from the rivers at the Baptismal feast. It is therefore probable that the Basilidian feast was a Christianized form of the blessing of the Nile, called by Chabas in his Coptic calendar *Hydreusis*. Mas'ūdī the Arab historian of the 10th century, in his *Prairies d'or* (French trans. Paris, 1863, ii., 364), enlarges on the splendours of this feast as he saw it still celebrated in Egypt.

Epiphanius also (*Haer.* 51) relates a curious celebration held at Alexandria of the Birth of the Aeon. On January 5 or 6 the votaries met in the holy compound or Temple of the Maiden (Korē), and sang hymns to the music of the flute till dawn, when they went down with torches into a shrine under ground, and fetched up a wooden idol on a bier representing Korē, seated and naked, with crosses marked on her brow, her hands and her knees. Then with flute-playing, hymns and dances they carried the image seven times round the central shrine, before restoring it again to its dwelling-place below. He adds: "And the votaries say that to-day at this hour *Korē*, that is, the Virgin, gave birth to the Aeon."

The earliest extant Greek text of the Epiphany rite is in a Euchologion of about the year 795, now in the Vatican. The prayers recite that at His baptism Christ hallowed the waters by His presence in Jordan, and ask that they may now be blessed by the Holy Spirit visiting them, by its power and inworking, as the streams of Jordan were blessed.

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EPIPHENOMENON means a secondary appearance or by-product. The term is used to express a certain view of the relation of mind to body, or consciousness to matter. According to Huxley, Hodgson and Maudsley consciousness is just something incidental to the organism in which it occurs, and has no influence upon it—"a mere foam, aura, or melody arising from the brain, but without reaction upon it" (S. H. Hodgson, *Time and Space*). See *Body and Soul;* H. Maudsley, *Physiology and Pathology of Mind* (1867); S. H. Hodgson, *Time and Space* (1865), *The Theory of Practice* (1870).

EPIPHYTE, the term used in botany to denote those plants which grow perched upon others. Epiphytes are a characteristic feature of tropical forests. Plants of many families have become adapted to this mode of life, notably orchids (*q.v.*) A feature of epiphytes is the development of aerial roots. (*See* Root.)

EPIRUS or **EPEIRUS,** an ancient district of northern Greece extending along the Ionian Sea from the Acroceraunian promontory on the north to the Ambracian gulf on the south, and conterminous on the landward side with Illyria, Macedonia and Thessaly. It thus corresponds to the southern portion of Albania (*q.v.*). The name Epirus (Ἤπειρος) signified "mainland," and was originally applied to the whole west coast north of the Corinthian gulf, in contradistinction to the neighbouring islands. The country is mountainous, especially where the rivers Achelous, Arachthus and Aous rise in Mt. Lacmon, the backbone of Pindus. In ancient times Epirus did not produce corn sufficient for its inhabitants; but it has always been celebrated for its cattle and horses. According to Theopompus (4th cent. B.C.), the Epirots were divided into fourteen independent tribes, of which the principal were the Chaones (perhaps akin to the Chones in the heel of Italy) along the Acroceraunian shore, the Molossians inland round Lake Pambotis (mod. Jannina), and the Thesprotians north of the Ambracian gulf. In spite of distance and barbarian repute, Epirus exerted early no small influence on Greece, through the oracle of Dodona (*q.v.*). Aristotle even placed here the original home of the Hellenes. But in historic times its part is passive. Numerous Greek colonies on its coast formed stepping-stones towards the Adriatic and the West. One of the earliest and most flourishing was the Corinthian colony of Ambracia, which gives its name to the gulf. Elatria, Bucheta and Pandosia, in Thesprotia, originated from Elis. Other towns of some importance were *In Chaonia:* Palaeste and Chimaera, fortified posts to which country folk could retire in war; Onchesmus or Anchiasmus, opposite Corcyra; Phoenice, wealthiest of all, and after the fall of the Molossian kingdom the centre of an Epirote League; Buthrotum, Phanote, important in the Roman campaigns in Epirus; and Adrianopolis, named from its founder. *In Thesprotia:* Cassope, chief town of the most powerful Thesprotian clan; and Ephyra, afterwards Cichyrus. *In Molossia:* Passaron, where the kings were wont to receive their people's allegiance; and Tecmon, Phylace and Horreum. The Byzantine town of Rogus is probably the modern Luro, the Greek Oropus.

History.—The chieftains of the Molossians, who ultimately dominated all Epirus, claimed to be descended from Pyrrhus, son of Achilles, who settled here after the sack of Troy, and transmitted his kingdom to Molossus, his son by Andromache. The early history of the dynasty is obscure; but Admetus, in the 5th century B.C., is remembered for his hospitable reception of the banished Themistocles, though he had persuaded his countrymen to refuse the Molossian alliance offered when victory against the Persians was already secured. Admetus was succeeded, about 429 B.C., by his son or grandson, Tharymbas or Arymbas I., who was educated at Athens, and introduced higher civilization. A later king, Alcetas, was restored by Dionysius of Syracuse about 385 B.C. His son Arymbas II. ruled with prudence and equity, and gave encouragement to literature and the arts. To him Xenocrates of Chalcedon dedicated his four books on the art of governing; and it is specially mentioned that he bestowed great care on the education of the children of his deceased brother Neoptolemus. One of them, Troas, he married; Olympias, the other, was married to Philip II. of Macedon and became the mother of Alexander the Great. On the death of Arymbas, Alexander the brother of Olympias, was enthroned by Philip, married his daughter Cleopatra, and assumed the title of king. Asked by Tarentum for aid against the Samnites and Lucanians, he landed at Paestum in 332 B.C., and reduced several Lucanian cities, but was defeated and slain near Pandosia in Bruttium.

Aeacides, the son of Arymbas II., succeeded Alexander. He supported Olympias against Cassander, but was dethroned by his own soldiers, and fell in battle (313 B.C.) against Philip, brother of Cassander. He had, by his wife Phthia, a son, the celebrated Pyrrhus, and two daughters, Deidamia and Troas; the former married Demetrius Poliorcetes. His brother and successor, Alcetas, fought against Cassander; was put to death by his own subjects in 295 B.C., and was succeeded by Pyrrhus (*q.v.*), who for six years fought against the Romans in south Italy and Sicily, and gave to Epirus its sole moment of importance.

Alexander, his son, who succeeded in 272 B.C., defeated Antigonus Gonatas of Macedon but was himself driven from his kingdom by Demetrius. He recovered it, however, and spent the rest of his days in peace. Two other insignificant reigns brought the family of Pyrrhus to its close, and Epirus was thenceforward governed by a magistrate, elected annually in a general assembly at Passaron. Having imprudently supported Perseus (*q.v.*) in 168 B.C., it was devastated by the Romans, and never recovered. At the dissolution of the Achaean League (*q.v.*), 146 B.C., it became part of the Roman province of Macedonia, receiving the name Epirus Vetus, to distinguish it from Epirus Nova.

On the division of the empire it fell to the East, and so remained until the taking of Constantinople by the Latins in 1204, when Michel Angelus Comnenus seized Aetolia and Epirus. On the death of Michel in 1216, these countries fell into the hands of his brother Theodore. Thomas, the last of the direct line, was murdered in 1318 by his nephew Thomas, lord of Zante and Cephalonia, and his dominions were dismembered. Not long after, Epirus was overrun by Serbs and Albanians. Charles II. Tocco, lord of Cephalonia and Zante, was recognized as Despot of Epirus by the emperor Manuel Comnenus in the beginning of the 15th century; but his family was deprived in 1431 by Murad (Amurath) II. In 1443, Scanderbeg, king of Albania,

made himself master of a considerable part of Epirus; but on his death it fell to the Venetians, and from these passed to the Turks. For modern history see ALBANIA.

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EPISCOPACY, the general term technically applied to that system of church organization in which the chief ecclesiastical authority within a defined district, or diocese, is vested in a bishop (from Late Lat. *episcopatus*, the office of a bishop, *episcopus*). As such it is distinguished on the one hand from Presbyterianism, government by elders, and Congregationalism, in which the individual church or community of worshippers is autonomous, and on the other from Papalism. The origin and development of episcopacy in the Christian Church, and the functions and attributes of bishops in the various churches, are dealt with elsewhere (*see* CHURCH HISTORY and BISHOP). Under the present heading it is proposed only to discuss briefly the various types of episcopacy actually existing, and the different principles that they represent.

The deepest line of cleavage is naturally between the view that episcopacy is a divinely ordained institution essential to the effective existence of a church as a channel of grace, and the view that it is merely a convenient form of church order, evolved as the result of a variety of historical causes, and not necessary to the proper constitution of a church. The first of these views is closely connected with the doctrine of the Apostolical Succession. According to this, Christ committed to his apostles certain powers of order and jurisdiction in the Church, including that of transmitting these powers to others through "the laying on of hands"; and this power, whatever obscurity may surround the practice of the primitive Church, was very early confined to the order of bishops, who by virtue of a special consecration became the successors of the apostles in the function of handing on the powers and graces of the ministry. A valid episcopate, then, is one derived in an unbroken series of "layings on of hands" by bishops from the time of the apostles (*see* ORDER, HOLY). This is the Catholic view, common to all the ancient Churches whether of the West or East, and it is one that necessarily excludes from the union of Christendom all those Christian communities which possess no such apostolically derived ministry. This high theory of episcopacy which, if certain of the Ignatian letters be genuine, has a very early origin, has, of course, fallen upon evil days. The power of the collective episcopate to maintain Catholic unity was disproved long before it was overshadowed by the centralized authority of Rome; before the Reformation, its last efforts to assert its supremacy in the Western Church, at the councils of Basel and Constance, had broken down; and the religious revolution of the 16th century left it largely discredited and exposed to a double attack, by the papal monarchy on the one hand and the democratic Presbyterian model on the other. Within the Roman Catholic Church the high doctrine of episcopacy continued to be maintained by the Gallicans and Febronians (*see* GALLICANISM and FEBRONIANISM) as against the claims of the Papacy, and for a while with success; but a system which had failed to preserve the unity of the Church even when the world was united under the Roman empire could not be expected to do so in a world split up into a series of rival states, of which many had already reorganized their churches on a national basis. "Febronius," indeed, was in favour of a frank recognition of this national basis of ecclesiastical organization, and saw in Episcopacy the best means of reuniting the dissidents to the Catholic Church, which was to consist, as it were, of a free federation of episcopal churches under the presidency of the bishop of Rome. The idea had considerable success; for it happened to march with the views of the secular princes. But the Revolution intervened; and when, during the religious reaction that followed, men sought for an ultimate authority, they found it in the papal monarch, exalted now by ultramontane zeal into the sole depositary of the apostolical tradition (*see* ULTRAMONTANISM). At the Vatican Council of 1870 episcopacy made its last stand against papalism, and was vanquished (*see* VATICAN COUNCIL). The pope still addresses his fellow-bishops as "venerable brothers"; but from the Roman Catholic Church the fraternal union of coequal authorities, which is of the essence of episcopacy, has vanished; and in its place is set the autocracy of one. The modern Roman Catholic Church is episcopal, for it preserves the bishops, whose *potestas ordinis* not even the pope can exercise until he has been duly consecrated; but the bishops as such are now but subordinate elements in a system for which "Episcopacy" is certainly no longer an appropriate term.

The word Episcopacy has, in fact, since the Reformation, been more especially associated with those churches which, while ceasing to be in communion with Rome, have preserved the episcopal model. Of these by far the most important is the Church of England, which has preserved its ecclesiastical organization essentially unchanged since its foundation by St. Augustine, and its daughter churches (*see* ENGLAND, CHURCH OF). The Church of England since the Reformation has been the chief champion of the principle of Episcopacy against the papal pretensions on the one hand and Presbyterianism and Congregationalism on the other. As to the divine origin of Episcopacy and, consequently, of its universal obligation in the Christian Church, Anglican opinion has been, and still is, considerably divided. The "High Church" view, is practically identical with that of the Gallicans and Febronians, and is based on Catholic practice anterior to the division of East and West, especially as expounded and defended by Cyprian (*q.v.*). So far as this view, however, is the outcome of the general Catholic movement of the 19th century, it can hardly be taken as typical of Anglican tradition in this matter. The whole issue has, in fact, become confused with the confusion of functions of the Church and State. According to the historic tradition of the Church of England, the ultimate governance of the Christian community, in things spiritual and temporal, was vested not in the clergy but in the "Christian prince." It was the transference to the territorial sovereigns of modern Europe of the theocratic character of the Christian heads of the Roman world-empire; with the result that for the reformed Churches the unit of church organization was no longer the diocese, or the group of dioceses, but the Christian state which could dictate its subjects' faith (*see* ENGLAND, CHURCH OF). With the constitutional changes of the 18th and 19th centuries, however, a corresponding modification took place in the character of the English episcopate; and a still further change resulted from the multiplication of colonial and missionary sees having no connection with the state. The consciousness of being in the line of apostolic succession helped the English clergy to revert to the principle *Ecclesia est in episcopo*, and the great periodical conferences of Anglican bishops from all parts of the world resemble, though they do not claim the oecumenical authority, the general councils of the early Church (*see* LAMBETH CONFERENCES).

On the survivals of Episcopacy in the Lutheran communion, *see* LUTHERAN CHURCH (especially in Scandinavia); in the Methodist Episcopal Church of America, *see* METHODISM; also articles MORAVIAN CHURCH, OLD CATHOLICS and ORTHODOX EASTERN CHURCH. On the position of Episcopacy in the Anglican and Roman communions *see* ENGLAND, CHURCH OF, and ROMAN CATHOLIC CHURCH.

EPISCOPIUS, SIMON (Simon Bischop) (1583–1643), Dutch theologian, was born at Amsterdam on Jan. 1, 1583. In 1600 he entered the university of Leiden, where he studied theology under Jacobus Arminius. In 1610, the year in which the Arminians presented the famous Remonstrance to the states of Holland, he became pastor at Bleyswick, near Rotterdam; in the following year he supported the Remonstrants (*q.v.*) at the Hague conference. In 1612 he was made professor of theology at Leiden. Episcopius was spokesman of the thirteen representatives of the Remonstrants before the synod of Dort in 1618; but he was refused a hearing, the Remonstrant doctrines condemned and he and the other Arminian representatives banished (*see* DORT, SYNOD OF). After the death (1625) of Prince Maurice, the Arminian controversy abated and Episcopius was permitted in 1626 to return to his own country. He was appointed preacher at the Remonstrant college in Amsterdam. Episcopius may be regarded as the

systematizer of Arminianism. He protested against the tendency of Calvinists to stress abstract dogma, and argued that Christianity was practical rather than theoretical.

His principal works are *Confessio s. declaratio sententiae pastorum qui in foederato Belgio Remonstrantes vocantur* (1621), *Apologia pro confessione* (1629), *Verus theologus remonstrans*, and his incomplete *Institutiones theologicae* (1650). His life was written by P. Limborch, and one was also prefixed by his successor, Curcellaeus, to an edition of his collected works in 2 vols. (1650–65). *See* Herzog-Hauck, *Realencyklopädie.*

EPISODE, an incident occurring in the history of a nation, an institution or an individual, especially with the significance of being an interruption of an ordered course of events. The word is derived from a word (ἐπείσοδος) with a technical meaning in ancient Greek tragedy. It is defined by Aristotle (*Poetics*, 12) as μέρος ὅλον τραγῳδίας τὸ μεταξὺ ὅλων χορικῶν μελῶν, all the scenes; that is, which fall between the choric songs. (εἴσοδος), or entrance, is generally applied to the entrance of the chorus, but the reference may be to that of the actors at the close of the choric songs. In early Greek tragedy the parts spoken by the actors were considered of subsidiary importance to those sung by the chorus, and it is from this aspect that the meaning of the word, as something which breaks off the course of events, is derived.

See A. E. Haigh, *The Tragic Drama of the Greeks*, p. 353 (1896).

In music, episode is a more or less distinctive but subordinate section of an instrumental work serving to impart variety and interest to the general design. Beethoven raised the episode to its highest point as an element of sonata form, though in the case of fugues the value of such accessory sections had been recognized long previously.

EPISTAXIS, the medical term for bleeding from the nose. It is common and usually of little importance in childhood. But it may be symptomatic of haemophilia (bleeders) when probably it will be necessary to apply styptics or plug the nostrils. In middle age it may indicate arterio-sclerosis and high arterial tension and then the bleeding is salutary. Epistaxis also occurs in fracture of the base of the skull.

EPISTEMOLOGY, in philosophy, a term applied, probably first by J. F. Ferrier, to that department of thought whose subject matter is the nature and validity of knowledge (Gr. ἐπιστήμη, knowledge, and λόγος, theory, account; Ger. *Erkenntnistheorie*). It is thus contrasted with metaphysics, which considers the nature of reality, and with psychology, which deals with the objective part of cognition, and, as Prof. James Ward said, "is essentially genetic in its method." Epistemology is concerned rather with the possibility of knowledge in the abstract. In the evolution of thought epistemological inquiry succeeded the speculations of the early thinkers, who concerned themselves primarily with attempts to explain existence. The differences of opinion which arose on this problem naturally led to the inquiry as to whether any universally valid statement was possible. The Sophists and the Sceptics, Plato and Aristotle, the Stoics and the Epicureans took up the question, and from the time of Locke and Kant it has been prominent in modern philosophy. It is extremely difficult, if not impossible, to draw a hard and fast line between epistemology and other branches of philosophy. If, for example, philosophy is divided into the theory of knowing and the theory of being, it is impossible entirely to separate the latter (Ontology) from the analysis of knowledge (Epistemology), so close is the connection between the two. Again, the relation between logic in its widest sense and the theory of knowledge is extremely close. Some thinkers have identified the two, while others regard Epistemology as a subdivision of logic; others demarcate their relative spheres by confining logic to the science of the laws of thought, *i.e.*, to formal logic. An attempt has been made by some philosophers to substitute "Gnosiology" (Gr. γνῶσις) for "Epistemology" as a special term for that part of Epistemology which is confined to "systematic analysis of the conceptions employed by ordinary and scientific thought in interpreting the world, and including an investigation of the art of knowledge, or the nature of knowledge as such." "Epistemology" would thus be reserved for the broad questions of "the origin, nature and limits of knowledge" (Baldwin's *Dict. of Philos.* i. pp. 333 and 414). The term Gnosiology has not, however, come into general use. (*See* PHILOSOPHY; KNOWLEDGE, THEORY OF.)

EPISTLE, in its primary sense any letter addressed to an absent person. At the present day the term is used only for letters of an ancient time, or for elaborate literary productions which are, or affect to be, written to a person at a distance.

Epistles and Letters.—A broad distinction exists between the letter and the epistle. The letter is essentially a spontaneous, non-literary production, personal and private, a substitute for a spoken conversation. The epistle, on the other hand, rather takes the place of a public speech, it is written with an audience in view, it is a literary form, a distinctly artistic effort aiming at permanence.

Both letters and epistles have come down to us in considerable variety and extent from the ancient world. Babylonia and Assyria, Egypt, Greece and Rome alike contribute to our inheritance of letters. Those of Aristotle are of questionable genuineness, but we can rely, at any rate in part, on those of Isocrates and Epicurus. Some of the letters of Cicero are rather epistles, since they were meant ultimately for the general eye. The epistles of Dionysius of Halicarnassus, Plutarch, Seneca and the younger Pliny claim mention at this point. In the later Roman period and into the middle ages, formal epistles were almost a distinct branch of literature. The 10 books of Symmachus's *Epistolae*, so highly esteemed in the cultured circles of the 4th century, may be contrasted with the less elegant but more forceful epistles of Jerome.

The distinction between letters and epistles has particular interest for the student of early Christian literature. G. A. Deissmann (*Bible Studies*) assigns to the category of letters all the Pauline writings as well as 2 and 3 John. The books bearing the names of James, Peter, and Jude, together with the Pastorals and the Apocalypse, he regards as epistles. The first epistle of John he calls less a letter or an epistle than a religious tract. It is doubtful, however, whether we can thus reduce all the letters of the New Testament to one or other of these categories. We have a particularly interesting form of epistle in the communications between churches (as distinct from individuals) known as the *First Epistle of Clement* (Rome to Corinth), the *Martyrdom of Polycarp* (Smyrna to Philomelium), and the *Letters of the Churches of Vienne and Lyons* (to the congregations of Asia Minor and Phrygia) describing the Gallican martyrdoms of A.D. 177. In the following centuries we have the valuable epistles of Cyprian, of Gregory Nazianzen (to Cledonius on the Apollinarian controversy), of Basil, Ambrose, Chrysostom, Augustine and Jerome.

In the Renaissance one of the most common forms of literary production was that modelled upon Cicero's letters. From Petrarch to the *Epistolae obscurorum virorum* there is a whole epistolary literature. The *Epistolae obscurorum virorum* have to some extent a counterpart in the Epistles of Martin Marprelate. Later satires in an epistolary form are Pascal's *Provincial Letters*, Swift's *Drapier Letters*, and the *Letters of Junius*. The "open letter" of modern journalism is really an epistle.

Epistles in Poetry.—A branch of poetry bears the name of the Epistle, and is modelled on those pieces of Horace which are almost essays on moral or philosophical subjects, and are chiefly distinguished from other poems by being addressed to particular patrons or friends. Examples of the work in this direction of Ovid, Claudian, Ausonius and other late Latin poets have been preserved, but it is particularly those of Horace which have given this character to the epistles in verse which form so very characteristic a section of French poetry. Clément Marot, in the 16th century, first made the epistle popular in France. Boileau's epistles, 12 in number, are the classic examples of this form of verse in French literature; they were composed at different dates between 1668 and 1695. In the 18th century Voltaire enjoyed a supremacy in this graceful and sparkling species of writing; the *Epître à Uranie* is perhaps the most famous of his verse-letters.

In England the verse-epistle was first prominently employed by Samuel Daniel in his "Letter from Octavia to Marcus Antonius" (1599), and later on, more legitimately, in his "Certain Epistles" (1601–03). His letter, in *terza rima*, to Lucy, Countess of Bristol, is one of the finest examples of this form in English literature. It was Daniel's deliberate intention to introduce the Epistle into

English poetry, "after the manner of Horace." He was supported by Ben Jonson, who has some fine Horatian epistles in his *Forests* (1616) and his *Underwoods*. *Letters to Several Persons of Honour* form an important section in the poetry of John Donne. At the close of the 17th century Dryden greatly excelled in this class of poetry, and his epistles to Congreve (1694) and to the duchess of Ormond (1700) are among the most graceful and eloquent that we possess. During the age of Anne various Augustan poets essayed the epistle with more or less success, and it was employed by Gay for several exercises in his elegant persiflage. But the great writer of epistles in English is Pope. The "Epistle to Dr. Arbuthnot" has not been surpassed, if equalled, in Latin or French poetry of the same class. After the day of Pope the epistle again fell into desuetude, or occasional use, in England. It revived in the charming naïveté of Cowper's lyrical letters in octosyllabics to his friends, such as William Bull and Lady Austin (1782). At the close of the century Samuel Rogers endeavoured to resuscitate the neglected form in his "Epistle to a Friend" (1798). Shelley's "Letter to Maria Gisborne" (1820), Keats's "Epistle to Charles Clarke" (1816), and Landor's "To Julius Hare" (1836), in spite of their romantic colouring, are genuine Horatian epistles and of the pure Augustan type. This type, in English literature, is commonly, though not at all universally, cast in heroic verse. But Daniel employs *rime royale* and *terza rima*, while some modern epistles have been in iambic rhymed measures or in blank verse.

For St. Paul's Epistles *see* PAUL, for St. Peter's *see* PETER, for Apocryphal Epistles *see* APOCRYPHAL LITERATURE, for Plato's *see* PLATO, etc.

EPISTYLE, the Greek term for architrave, the lower member of the entablature of the classic orders (*q.v.*).

EPITAPH, strictly an inscription upon a tomb, though by a natural extension of usage, the name is applied to anything written ostensibly for that purpose, whether actually on a tomb or not.

Probably the earliest epitaphial inscriptions that have come down to us are those of the ancient Egyptians, written, as their mode of sepulture necessitated, upon the sarcophagi and coffins. Those that have been deciphered are all very much in the same form, commencing with a prayer to a deity, generally Osiris or Anubis, on behalf of the deceased, whose name, descent and office are usually specified. Ancient Greek epitaphs, unlike the Egyptian, are of great literary interest, deep and often tender in feeling, rich and varied in expression, and generally epigrammatic in form. They are written usually in elegiac verse, though many of the later epitaphs are in prose. Among the gems of the Greek anthology familiar to English readers through translations are the epitaphs upon those who had fallen in battle. There are several ascribed to Simonides on the heroes of Thermopylae, of which the most celebrated is the epigram:

> Go tell the Spartans, thou that passest by,
> That here, obedient to their laws, we lie.

In Sparta epitaphs were inscribed only upon the graves of those who had been especially distinguished in war; in Athens they were applied more indiscriminately.

Roman epitaphs, in contrast to those of the Greeks, contained as a rule, nothing beyond a record of facts. The inscriptions on the urns, of which numerous specimens are to be found in the British Museum, present but little variation. The letters D.M. or D.M.S (Diis Manibus or Diis Manibus Sacrum) are followed by the name of the person whose ashes are enclosed, his age at death, and sometimes one or two other particulars. It is a curious illustration of the survival of traces of an old faith after it has been formally discarded to find that the letters D.M. are not uncommon on the Christian inscriptions in the catacombs.

Inscriptions usually began with the appropriate words *Siste Viator* or *Aspice Viator*, the origin doubtless of the "Stop Passenger" which still meets the eye in many parish churchyards of Britain. Another phrase of very common occurrence on Ancient Roman tombstones, *Sit tibi terra levis* ("Light lie the earth upon thee"), has continued in frequent use down to modern times. A remarkable feature of many of the Roman epitaphs was the denunciation they often pronounced upon those who violated the sepulchre. Such denunciations were not uncommon in later times. A well-known instance is the lines on Shakespeare's tomb at Stratford-on-Avon, said to have been written by the poet himself:

> Good frend, for Jesus' sake forbeare
> To digg the dust enclosed heare;
> Blest be y^e^ man y^t^ spares thes stones,
> And curst be he y^t^ moves my bones.

The earliest existing British epitaphs belonged to the Roman period, and are written in Latin after the Roman form. Specimens are to be seen in various museums throughout the country; some of the inscriptions are given in Bruce's *Roman Wall*, and the seventh volume of the *Corpus Inscriptionum Latinarum* edited by Hubner, containing the British inscriptions, is a valuable repertory for the earlier Roman epitaphs in Britain. The earliest, of course, are commemorative of soldiers belonging to the legions of occupation, but the Roman form was afterwards adopted for native Britons. It is only in fact within recent years that Latin has become unusual and the more natural practice has been adopted of writing the epitaphs of distinguished men in the language of the country in which they lived. The comparatively few English epitaphs that remain of the 11th and 12th centuries are all in Latin. In the 13th century French began to be used in writing epitaphs and most of the inscriptions to celebrated historical personages between 1200 and 1400 are in that language. Mention may be made of those to Robert the 3rd earl of Oxford (d. 1221) as given in Weever, to Henry III. (d. 1272) at Westminster Abbey, and to Edward the Black Prince (d. 1376) at Canterbury.

The epitaph almost invariably closes with a request, sometimes very urgently worded, for the prayers of the reader that the soul of the deceased may pass to glory, and an invocation of blessing, general or specific, upon all who comply. Epitaphs preserved much of the same character after English began to used towards the close of the 14th century. The following, to a member of the Savile family at Thornhill, is probably even earlier:

> Bonys emongg stonys lys ful
> steyl gwylste the sawle wan-
> deris were that God wylethe

that is, Bones among stones lie full still, whilst the soul wanders whither God willeth. It may be noted that most inscriptions, Latin and English, from 1300 to the Reformation, that have been preserved, are upon brasses (*see* BRONZE).

It was in the reign of Elizabeth that epitaphs in English began to assume a distinct literary character and value, entitling them to rank with those that had hitherto been composed in Latin. We learn from Nash that at the close of the 16th century it had become a trade to supply epitaphs in English verse. One of the finest epitaphs in English is that by Milton upon Shakespeare.

The epitaphs of Pope are still considered to possess very great literary merit, though they were rated higher by Johnson and critics of his period than they are now.

Dr. Johnson, who thought so highly of Pope's epitaphs, was himself a great authority on both the theory and practice of this species of composition. His essay on epitaphs is one of the few existing monographs on the subject, and his opinion as to the use of Latin had great influence. The manner in which he met the delicately insinuated request of a number of eminent men that English should be employed in the case of Oliver Goldsmith was characteristic and showed the strength of his conviction.

In classifying epitaphs various principles of division may be adopted. Arranged according to nationality they indicate distinctions of race less clearly perhaps than any other form of literature does. At the same time the influence of nationality may to some extent be traced in epitaphs. The characteristics of the French style, its grace, clearness, wit and epigrammatic point, are all recognizable in French epitaphs. In the 16th century those of Étienne Pasquier were universally admired. Instances such as Piron's epitaph written for himself after his rejection by the French Academy:

> Ci-gît Piron, qui ne fut rien,
> Pas même académicien

and one by a relieved husband, to be seen at Père Lachaise—

> Ci-gît ma femme, Ah! qu'elle est bien
> Pour son repos et pour le mien

might be multiplied indefinitely. One can hardly look through a collection of English epitaphs without being struck with the fact that these represent a greater variety of intellectual and emotional states than those of any other nation.

Epitaphs are sometimes classified according to their authorship and sometimes according to their subject, but neither division is so interesting as that which arranges them according to their characteristic features. What has just been said of English epitaphs is, of course, more true of epitaphs generally. They exemplify every variety of sentiment and taste, from lofty pathos and dignified eulogy to coarse buffoonery and the vilest scurrility.

See Weever, ***Ancient Funerall Monuments*** (1631, 1661, Tooke's ed., 1767); Philippe Labbe, ***Thesaurus epitaphiorum*** (1666); ***Theatrum funebre extructum a Dodone Richea seu Ottone Aicher*** (1675); Hackett, ***Select and Remarkable Epitaphs*** (1757); de Laplace, ***Epitaphes sérieuses, badines, satiriques et burlesques*** (1782); Pulleyn, ***Churchyard Gleanings*** (*c.* 1830); L. Lewysohn, ***Sechzig Epitaphien von Grabsteinen d. israelit. Friedhofes zu Worms*** (1855); Pettigrew, ***Chronicles of the Tombs*** (1857); S. Tissington, ***Epitaphs*** (1857); Robinson, ***Epitaphs from Cemeteries in London, Edinburgh, &c.***, (1859); le Blant, ***Inscriptions chrétiennes de la Gaule antérieures au VIII***e ***siècle*** (*1856, 1865*); H. J. Loaring, ***Quaint, Curious, and Elegant Epitaphs*** (1872); J. R. Kippax, ***Churchyard Literature, a Choice Collection of American Epitaphs*** (Chicago, 1876); also William Wordsworth's *Essay on Epitaphs;* W. H. Beable, ***Epitaphs; Graveyard Humor and Eulogy*** (1925).

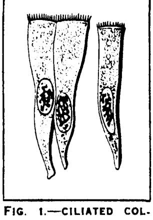

FIG. 1.—CILIATED COLUMNAR EPITHELIAL CELLS, HIGHLY MAGNIFIED, FROM THE INTESTINE OF A FROG

EPITHALAMIUM, originally among the Greeks a song in praise of bride and bridegroom, which was sung by a number of boys and girls at the door of the nuptial chamber. According to the scholiast on Theocritus, one form, the *κατακοιμητικόν*, was employed at night, and another, the *διεγερτικόν*, to arouse the bride and bridegroom on the following morning. Among the Romans a similar custom was in vogue, but the song was sung by girls only. In the hands of the poets the epithalamium was developed into a special literary form and received considerable cultivation. Sappho, Anacreon, Stesichorus and Pindar are all regarded as masters of the species, but the finest example preserved in Greek literature is the 18th Idyll of Theocritus, which celebrates the marriage of Menelaus and Helen. In Latin, the epithalamium, imitated from Fescennine Greek models, was a base form of literature, when Catullus redeemed it and gave it dignity by modelling his *Marriage of Thetis and Peleus* on a lost ode of Sappho. The names of Ronsard, Malherbe and Scarron are especially associated with the species in French literature, and Marini and Metastasio in Italian. Perhaps no poem of this class has been more universally admired than the *Epithalamium* of Spenser (1595), though he has found not unworthy rivals in Ben Jonson, Donne and Quarles.

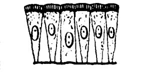

FIG. 2.—COLUMNAR EPITHELIAL CELLS, CILIATED, RESTING ON A BASEMENT MEMBRANE. HIGHLY MAGNIFIED

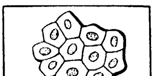

FIG. 3.—MOSAIC APPEARANCE OF COLUMNAR EPITHELIUM AS SEEN FROM ABOVE. MAGNIFIED

EPITHELIUM, in anatomy. Every surface of the body which may come into contact with foreign substances is covered with a protecting layer of cells closely bound to one another to form continuous sheets. By the formation of outgrowths or ingrowths from these surfaces, structures, consisting largely or entirely of cells directly derived from the surface epithelium, may be formed. In this way originate the central nervous system, the sensitive surfaces of the special sense organs, the glands, and the hairs, nails, etc. The epithelial cells possess typical microscopical characters which enable them to be readily distinguished from all others. Thus the cell outline is clearly marked, the nucleus large and spherical or ellipsoidal. The protoplasm of the cell is usually large in amount and often contains large numbers of granules.

Varieties.—The cells forming an epithelial membrane may be *flattened,* or *squamous, cubical, columnar, irregular, ciliated* or *flagellated.* The membranes formed by these cells may be only one cell thick, as in the major part of the alimentary canal, or consist of several layers of cells, as in the epidermis of the skin.

1. *Columnar Epithelium* (figs. 1 and 2).—This variety covers the intestinal tract from the end of the oesophagus to the commencement of the rectum. It also lines the ducts of many glands. In a highly typical form it covers the villi of the small intestine (fig. 1). The close apposition of these cells to form a closed membrane is well seen when a surface covered by them is examined from above (fig. 3).

2. *Cubical Epithelium.*—This differs from the former in that the cells are less in height. It is found in many glands and ducts (*e.g.* the kidney), in the middle ear, choroid plexuses of the brain, etc.

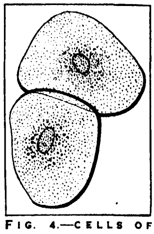

FIG. 4.—CELLS OF SQUAMOUS EPITHELIUM FROM THE MOUTH. HIGHLY MAGNIFIED

3. *Squamous or Flattened Epithelium* (fig. 4).—In this variety the cell is flattened, very thin and irregular in outline. It occurs as the covering epithelium of the alveoli of the lung, of the kidney glomerules and capsule, etc. The surface epithelial cells of a stratified epithelium are also of this type.

4. *Ciliated Epithelium* (fig. 5).—The surface cells of many epithelial membranes carry fine protoplasmic processes or *cilia.* Most commonly the cells are columnar, but other shapes are also found. During life the cilia are always in movement, and set up a current tending to drive fluid or other material on the surface in one direction along the membrane or tube lined by such epithelium. Ciliated epithelium lines the trachea, bronchi, parts of the nasal cavities and the uterus, oviduct, vas deferens, epididymis, etc. If there be but a single process from the exposed surface of the cell it is usually large and long, and is known as a *flagellum.* Such cells are common on the surface of many simple animal organisms.

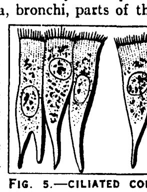

FIG. 5.—CILIATED COLUMNAR EPITHELIUM CELLS FROM TRACHEA. HIGHLY MAGNIFIED

When the cells of an epithelial surface are arranged several layers deep, we can again distinguish various types:

5. *Stratified Epithelium* (figs. 6 and 7).—This is found in the epithelium of the skin and of many mucous membranes (mouth, oesophagus, rectum, conjunctiva, vagina, etc.). Here the surface cells are very much flattened, those of the middle layer are polyhedral and those of the lowest layer are cubical or columnar. This type of epithelium covers surfaces exposed to friction. The surface may be dry, *e.g.*, skin, or moist, *e.g.*, mouth. The surface cells are constantly being rubbed off, and are replaced by new cells growing up from below. Hence the deepest layer is formative and in successive stages from this we can trace the gradual transformation of these protoplasmic cells into scaly cells, which no longer show any sign of being alive. In the moist mucous surfaces the number of cells forming the epithelial layer is usually much smaller than in a dry stratified epithelium.

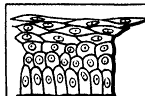

FIG. 6.—STRATIFIED EPITHELIUM FROM A MUCOUS MEMBRANE. HIGHLY MAGNIFIED

6. *Stratified Ciliated Epithelium.*—In this variety the superficial cells are ciliated and columnar; between the bases of these are found fusiform cells and the lowest cells are cubical or pyramidal. This epithelium lines parts of the respiratory passages, the vas deferens and the epididymis.

7. *Transitional Epithelium* (fig. 8).—This variety of epithelium lines the urinary bladder, and its appearance depends upon the contracted or distended state of the bladder from which the preparation was made. If the bladder was contracted the form seen in fig. 8 is obtained. The epithelium is in three or more layers, the superficial one being very characteristic. The cells are cubical

and fit over the rounded ends of the cells of the next layer. These are pear-shaped, the points of the pear resting on the basement membrane. Between the bases of these cells lie those of the lowermost layer. These are irregularly columnar. If the bladder is distended before the preparation is made, the cells are stretched transversely. The surface cells then become very flattened.

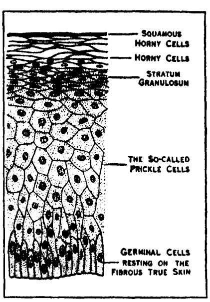

FIG. 7.—STRATIFIED SQUAMOUS EPITHELIUM OF SKIN, HIGHLY MAGNIFIED, SHOWING KINDS OF CELLS

Considering epithelium from the point of view of function, it may be protective, absorptive or secretory. It may produce special outgrowths (hairs, nails, horns, etc.), and for such purposes it may manufacture within itself chemical material best suited for that purpose, *e.g.* keratin; here the whole cell becomes modified. In other instances it contains fat droplets, granules of various kinds, protein, mucin, watery granules or glycogen, etc. In a typical absorbing cell granules of material being absorbed may be seen. A secreting cell of normal type forming specific substances stores these in its interior until wanted, *e.g.*, fat as in sebaceous and mammary glands, ferment precursors (salivary, gastric glands, etc.), and various excretory substances, as in the renal epithelium (*see* GLAND).

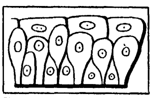

FIG. 8.—TRANSITIONAL EPITHELIUM FROM THE URINARY BLADDER. HIGHLY MAGNIFIED

EPITOME, an abridgment, abstract or summary giving the salient points of a book, law case, etc., a short and concise account of any particular subject or event. By transference *epitome* is also used to express the representation of a larger thing, concrete or abstract, reproduced in miniature. Thus St. Mark's was called by Ruskin the "Epitome of Venice," as it embraces examples of architecture from the 10th to the 19th centuries.

EPITROCHOID: *see* CURVES, SPECIAL.

EPOCH, a term for a stated period of time, and so used of a date accepted as the starting-point of an era or of a new period in chronology, such as the birth of Christ (Gr. ἐποχή, holding in suspense, a pause, from ἐπέχειν, to hold up, to stop). It is hence transferred to a period which marks a great change, whether in the history of a country or a science, such as a great discovery or invention. Thus an event may be spoken of as "epoch-making." The word is also used, synonymously with "period," for any space of time marked by a distinctive condition or series of events.

In astronomy the word is used for a moment from which time is measured, or at which a definite position of a body or a definite relation of two bodies occurs. For example, the position of a body moving in an orbit cannot be determined unless its position at some given time is known. The given time is then the epoch; but the term is often loosely used for "mean longitude at the epoch."

EPODE, a Greek ode, and (according to some authorities) elaborated by Stesichorus, and as exhibited, *e.g.*, in the plays and in Pindar, was based on a system of strophe, antistrophe (these exactly corresponding) and a concluding epode (ἐπῳδὸς περίοδος); a system which the reader may see quite fairly represented in Gray's *Bard* and *Progress of Poesy.* At the conclusion of the antistrophe the two halves of the chorus are said to have combined and sung the epode together (or, in certain cases, to have left it to the *coryphaeus* or leader). Though the Latins found Pindar impossible of imitation, certain poems of Catullus and Horace bear a rough resemblance to this form. It must be distinguished from the epode of Archilochus, in which (as a rule) the iambic was used as a vehicle of satire. This class is best known from Horace's *Epodon Liber,* written in confessed dependence on Archilochus, and, like its model, sarcastic and often coarse. It is this class, so different from the genuine epode of Sophocles and Pindar, that has almost appropriated the name.

EPONA. As her name implies (*epo-*, Gallic equivalent of Latin *equo-*), this goddess was patroness of horses, but also of asses and mules. The majority of inscriptions and images bearing her name have been found in Gaul, Germany and the Danube countries; of the few that occur in Rome most were exhumed on the site of the barracks of the *equites singulares,* a foreign imperial bodyguard recruited mainly from the Batavians. Her cult does not appear to have been introduced into Rome before imperial times, when she is often called Augusta and invoked on behalf of the emperor and the imperial house. The Romans used to place the image of the goddess, crowned with flowers on festive occasions, in a sort of shrine in the centre of the architrave of the stable. In art she is generally represented seated, with her hand on the head of the accompanying horse or ass.

See articles in Daremberg and Saglio's *Dict. des antiquités* and Pauly-Wissowa's *Realencyklopädie.*

EPONYMOUS (Gr. ἐπώνυμος [ὄνομα, a name]), a word originally meaning "given as a name" or "named after" a person or thing, and coming in time to mean "that which gives a name" to a person or thing, a term especially applied to the mythical or semi-mythical personages, heroes, deities, etc., from whom a country or city took its name. Thus Pelops is the giver of the name to the Peloponnese. At Athens the chief archon (*q.v.*) of the year was known as the ἄρχων ἐπώνυμος, as the year was known by his name.

EPPING, a market town in the Epping parliamentary division of Essex, England, 17m. N.N.E. from London on the Chipping Ongar branch of the L.N.E. railway. Pop. of urban district (1921), 4,196. The town lies high and picturesquely situated at the northern outskirts of Epping forest. In 1889 the modern church of St. John the Baptist took the place as parish church of the old parish church of All Saints, Epping Upland, 2m. N.W.

Epping forest forms part of the ancient Waltham forest or great forest of Essex (*q.v.*), which once covered the greater part of the county. Disafforestation had already begun at an early date, and in the 17th century a royal commission estimated the area at 60,000 acres. The forest became one of the commonable lands of royal chases or hunting-grounds. But the various encroachments and enclosures, especially from the end of the 18th century (*see* COMMONS), having threatened total obliteration, at the instance of the corporation of the City of London, a board of commissioners was appointed (under the Epping Forest Act of 1871), and eventually the corporation purchased the freehold interest of waste land, and secured some 5,600 ac., magnificently timbered, to the use of the public for ever. The tract was declared open in 1882. The ancient Court of Verderers was also revived, and the guardianship of the forest entrusted to a chief ranger, verderers, keepers, and the parish reeves representing the parishes on its outskirts. The present forest lies between the valleys of the Roding and the Lea, and extends southward from Epping for about 7 miles. It is readily traversed from the villages on its outskirts, such as Woodford, Chingford and Loughton, which are served by railway, and is a favourite resort of Londoners in the summer.

EPPS, the name of an English family, well known in commerce and medicine. In the second half of the 18th century they had been settled near Ashford, Kent, for some generations, claiming descent from an equerry of Charles II., but were reduced in circumstances, when JOHN EPPS rose to prosperity as a provision merchant in London, and restored the family fortunes. He had four sons, of whom JOHN EPPS (1805–1869), GEORGE NAPOLEON EPPS (1815–1874) and JAMES EPPS (1821–1907) were notable men of their day, the two former as prominent doctors who were ardent converts to homoeopathy, and James as a homoeopathic chemist and the founder of the great cocoa business associated with his name. Among Dr. G. N. Epps's children were Dr. Washington Epps, a well known homoeopathist, Lady Alma-Tadema and Lady Gosse.

ÉPRÉMESNIL (ESPRÉMESNIL or ÉPRÉMÉNIL), **JEAN JACQUES DUVAL D'** (1745–1794), French magistrate and

politician, was born in India on Dec. 5, 1745 at Pondicherry, his father being a colleague of Dupleix. He studied law in Paris, and became in 1775 *conseiller* in the parlement of Paris, where he defended the rights of the parlement against the royal prerogative. On Nov. 19, 1787 he was the spokesman of the parlement in demanding the convocation of the states-general. A royal officer was sent to the palais de justice to arrest Éprémesnil and his chief supporter Goislard de Montsabert, but the parlement (May 5, 1788) declared that they were all Éprémesnils, and the arrest was only effected on the next day on the voluntary surrender of the two members. After four months' imprisonment on the island of Ste. Marguerite, Éprémesnil was returned to the states-general as deputy of the nobility of the outlying districts of Paris. But with the rapid advance towards revolution his views changed; in his *Réflexions impartiales* . . . (Jan. 1789) he defended the monarchy, and he led the party among the nobility that refused to meet with the third estate until summoned to do so by royal command. He was imprisoned for a short time in 1792. In Sept. 1793 he was arrested at Le Havre and denounced to the Convention as an agent of Pitt. He was brought to trial before the revolutionary tribunal in Paris on April 21, 1794, and was guillotined the next day.

D'Éprémesnil's speeches were collected in a small volume in 1823. *See* also H. Carré, *Un Précurseur inconscient de la Révolution* (1897).

EPSOM, a town of Surrey, England, on the edge of Banstead Downs, 15 m. S.W. by S. of London, on the main road to Dorking, with stations (including Epsom Downs and Tattenham Corner, on the racecourse) on the S.R. Pop. of urban district (1921) 18,804. The parish church of St. Martin is a modern Gothic restoration. Epsom (a contraction of Ebbisham, the name of the old manor) first came into notice when mineral springs were discovered there about 1618 and as a spa reached its zenith a century later. Horse races appear to have been established here as early as James I.'s residence at Nonsuch, but they did not assume a permanent character until 1730. The principal races—the Derby and the Oaks, named after the twelfth earl of Derby and his seat, the Oaks, in the neighbourhood—were established in 1780 and 1779 respectively. The spring races (which include the Metropolitan and the City and Suburban) are held towards the close of April; while the great Epsom meeting takes place on the Tuesday and three following days immediately before Whitsuntide,—the Derby on the Wednesday, and the Oaks on the Friday (*see* HORSE-RACING). The grandstand was first erected in 1829, and subsequently enlarged; there are numerous training stables and several well known residences in the vicinity. Close to the town are the extensive buildings of Epsom college, founded in 1855, which by the terms of the foundation grants scholarships to the sons of medical men. Epsom Downs (387·5 ac.) and Epsom Common (435·5 ac.) have been common land from time immemorial. The council also maintains recreation grounds, and owns the water and electricity supplies and certain of the stables. The urban district and certain parishes in the rural district fall within the metropolitan police district of Greater London.

EPSOM SALTS, familiar as small, colourless, needle-shaped crystals which appear white if powdered, heptahydrated magnesium sulphate, $MgSO_4 \cdot 7H_2O$, the *magnesii sulphas* of pharmacy (Ger. *Bittersalz*). It occurs dissolved in sea water and in most mineral waters, especially in those at Epsom (from which place it takes its name), Seidlitz, Saidschutz and Pullna. It also occurs in nature in fibrous excrescences, constituting the mineral epsomite or hairsalt; and as compact masses (reichardite), as in the Stassfurt mines. It is also found associated with limestone, as in the Mammoth Cave, Kentucky, or with gypsum, as at Montmartre. Epsom salts form orthorhombic crystals, being isomorphous with the corresponding zinc and nickel sulphates, and also with magnesium chromate. It is used in the arts for weighting cotton fabrics, as a top dressing for clover hay in agriculture, and in dyeing. In medicine it is frequently employed as a hydragogue purgative, specially valuable in febrile diseases, in congestion of the portal system, and in the obstinate constipation of painters' colic. In the last case it is combined with potassium iodide, the two salts being exceedingly effective in causing the elimination of lead from the system. It is also very useful as a supplement to mercury, which needs a saline aperient to complete its action. It possesses the advantage of exercising but little irritant effect upon the bowels. Its nauseous bitter taste may to some extent be concealed by acidifying the solution with dilute sulphuric acid, and in some cases where full doses have failed the repeated administration of small ones has proved effectual. (*See* MAGNESIUM.)

EPSTEIN, JACOB (1880–), sculptor, was born in New York, on Nov. 10, 1880, the son of Russian-Polish parents. He received his early training at the School of the Art Students league of New York, and in 1902 he worked for a time at the École des Beaux-Arts in Paris. He went to London in 1905, and three years later obtained the commission to decorate the front of the British Medical Association building in the Strand, for which he made 18 large figures. In 1909 he carved the large sphinx for the Oscar Wilde memorial, placed in the Père Lachaise cemetery in Paris in 1912. His next works—the marble group "Two Doves" (1913), the marble Venus (1914) and his interesting carvings in flenite—belong to his period of experiment in "abstract" sculpture. The life-sized bronze figure of Christ roused the storm of opposition which has signalized the appearance of each of the sculptor's most important works.

His series of bronze portraits, in which he may be said to have obtained his greatest success, began in 1907 with the portrait of Mrs. McEvoy. This was followed by the portrait of Lord Fisher in the Imperial War museum (1915), a mask of Mrs. Jacob Epstein (1916), the half-length "Meum with a Fan" and the "Duchess of Marlborough" (1917), a bust of Mrs. Jacob Epstein (1918), Hélène (1919), the "Girl from Senegal," "Kathleen" and "Jacob Kramer" in the National Gallery of British art (1921), the "Weeping Woman" and "Dolores" (1922), Ferosa Rastourmji, R. B. Cunninghame Graham and "Old Pinager" (1923), Joseph Conrad (1924), "Sunita" and Sybil Thorndike (1925). His Hudson memorial in Hyde park—a panel carved with a figure of Rima—was unveiled in 1925. Exhibitions of the sculptor's works were held at the Leicester galleries, London, in 1917, 1920 and 1924. In the fall of 1927 Epstein came to America for work in New York and in other cities of the United States. The Ferargil galleries in New York held an exhibit of his work at that time, and another was held early in 1928 at the Art Students league. *The Nation* (New York) included his name in its honour roll for 1927 "for the strange beauty of his creations." (*See* SCULPTURE.)

See Bernard van Dieren, *Epstein* (1920); also the volume devoted to the sculptor in the "Contemporary British Artists" series (1925).

EQUATION OF THE CENTRE, in astronomy, the angular distance, measured around the centre of motion, by which a planet moving in an ellipse deviates from the mean position which it would occupy if it moved uniformly. Its amount is the correction which must be applied positively or negatively to the mean anomaly in order to obtain the true anomaly. It arises from the ellipticity of the orbit, is zero at pericentre and apocentre, and reaches a maximum nearly midway between these. (*See* ORBIT.)

EQUATION OF TIME, the difference between apparent time (*e.g.*, by a sun-dial) and mean time (by a standard clock). The earth rotates on its axis in 23h. 56m.; the interval from noon to noon is 24h. om. the extra 4m. being occupied in "catching up" the sun, which has moved on in the sky since it must make a complete circuit in a year. This 4m. (strictly 3m. 55·91s) is an average allowance; the sun moves sometimes faster, sometimes slower, reflecting the varying motion of the earth in its elliptic orbit. The motion is fastest at time of perihelion (Jan. 3); accordingly at that time of the year the clock allowance is insufficient, and apparent noon by the actual sun becomes later and later according to the uniform clock. It is for this reason that after the shortest day the afternoons lengthen faster than the mornings. Another cause of difference between the sun and the clock is the inclination of the ecliptic (the sun's track in the sky) to the equator. The two causes combined give the following average values for different dates. The + sign means that the sun passes the meridian *after* mean noon; the − sign *before* mean noon.

Table of the Equation of Time.

		m.	s.			m.	s.			m.	s.
Jan.	1	+ 3	26	May	1	− 2	55	Sept.	1	+ 0	9
	6	5	45		6	− 3	27		6	− 1	28
	11	7	51		11	− 3	46		11	− 3	10
	16	9	43		16	− 3	51		16	− 4	55
	21	11	19		21	− 3	40		21	− 6	41
	26	12	36		26	− 3	16		26	− 8	25
Feb.	1	+13	42	June	1	− 2	32	Oct.	1	−10	5
	6	14	14		6	− 1	44		6	−11	38
	11	14	25		11	− 0	48		11	−13	2
	16	14	17		16	+ 0	14		16	−14	14
	21	13	52		21	1	19		21	−15	11
	26	13	11		26	2	24		26	−15	52
March	1	+12	39	July	1	+ 3	26	Nov.	1	−16	18
	6	11	35		6	4	21		6	−16	19
	11	10	20		11	5	8		11	−15	58
	16	8	58		16	5	44		16	−15	15
	21	7	30		21	6	8		21	−14	12
	26	5	59		26	6	18		26	−12	49
April	1	+ 4	9	Aug.	1	+ 6	10	Dec.	1	−11	7
	6	2	40		6	5	47		6	− 9	9
	11	+ 1	15		11	5	9		11	− 6	57
	16	− 0	3		16	4	17		16	− 4	35
	21	− 1	12		21	3	12		21	− 2	7
	26	− 2	10		26	1	55		26	+ 0	23

EQUATIONS, THEORY OF. An equation is the statement of an equality between one or more unknown numbers and known, or given, numbers, which is true, not for all values of the unknowns, but only for certain of them (Lat. *aequatio*, an equalizing). An equality which holds for all values of the unknowns is an identity. Thus $3x+2=5$, true only for $x=1$, is an equation; $x^2-y^2=(x+y)(x-y)$, holding for all values of x, y, is an identity. To distinguish identities from equations the symbol $\equiv$ is used, as in $x^2-y^2\equiv(x+y)(x-y)$. This symbol will also be used, where no confusion can arise, to signify a definition; thus $x\equiv a$ means x is a.

The earliest known equivalents of algebraic equations occur in the Rhind papyrus, evidently compiled from earlier works, by the Egyptian Ahmes, about 1650 or 1700 B.C. For example, he proposes this problem:—"A quantity and its seventh added together become 19. What is the quantity?" His word for the unknown is *'aha'* or *'ḥ'*, formerly written *hau* and translated "heap" or "mass." The problem, therefore, is to solve the equation $x+\frac{1}{7}x=19$, as we would now express it. Lacking a convenient algebraic notation, he proceeded by a cumbersome method later known as that of "false position." Indeed, neither the Egyptians nor their Greek successors made any progress that is significant from a modern point of view, and neither people rose to the abstract conception of a theory of equations as a fruitful field of mathematical science. The Indians, with their peculiar addiction to arithmetic, achieved more.

The theory of equations is concerned chiefly with the properties of a single algebraic equation of the type

$$c_0x^n+c_1x^{n-1}+\cdots+c_n=0,$$

in which n is a positive whole number, the coefficients $c_0, c_1, \cdots, c_{n-1}$ are any given numbers, or numbers that are not specified but are assumed known, and $c_0\neq 0$. The nature of the coefficients will be made more precise later, as on them the whole theory depends. The degree of this equation is n. Roughly speaking, the theory of equations discusses this problem:—The coefficients being specified, find all values of x which make the equation true. This again will be amplified and made more definite as we proceed. The finding of x is called *solving the equation*.

The Greeks are sometimes credited with solving equations of the second degree. Thus Euclid's *Elements*, ii. 11, is equivalent to solving $x^2+ax=a^2$. There are two values of x; Euclid was content with one. In the 9th century A.D. the Arab, Mohammed ibn Mûsâ al-Khowârizmî (whose name is variously transliterated) gave both values 3, 7 of x in $x^2+21=10x$; he also discussed many more equations of the second degree. Like other Arabic writers, he used the equivalent of the term "root" for a value of the unknown. Great advances were made in the 15th and 16th centuries by the Italian mathematicians, who solved the general equations of the third and fourth degrees. These will be considered later. In spite of its brilliance, their work had but little direct influence on the evolution of a *theory* of algebraic equations. Curiosity as to the underlying reason for success or failure seems not to have perturbed the practical mind of the 16th-century algebraist. That rare type of speculation was reserved for the golden age of the late 18th and early 19th centuries; and although significant progress was made in the 18th century, notably by Joseph Louis Lagrange in a classic memoir of 1770–71, it was only with the researches of Évariste Galois (1811–1832) that the theory, at one stride, reached its maturity. Galois was killed in a duel at the age of 21.

Formerly the theory included much that is now relegated to other departments of algebra, *e.g.*, the solution of simultaneous equations of the first degree in several unknowns, which is now an application of determinants (*q.v.*) and matrices. As commonly understood to-day, the theory of algebraic equations is concerned chiefly with two problems and their numerous ramifications, all of which sprang directly from the necessity for solving the equations presented by problems in pure and applied science. To describe these, a few definitions must first be recalled. For an understanding of certain parts of the sequel an elementary acquaintance with the plotting of simple curves is presupposed; for others, a knowledge of derivatives, and Taylor's theorem (*q.v.*), and finally, for the modern theory, the reader is assumed to have read parts of the article GROUPS.

A number $a+bi$, in which a, b are real numbers and $i\equiv\sqrt{-1}$, is called complex (*see* COMPLEX NUMBER); if $b=0$, the number is real, otherwise it is imaginary. Let n be a positive integer other than zero, and let $c_0, c_1, \cdots, c_n$ be complex numbers not involving x. If c_0 is not zero, the polynomial

$$f(x)\equiv c_0x^n+c_1x^{n-1}+\cdots+c_n$$

is of degree n. A complex number k, which is such that $f(k)=0$, is called a root of the algebraic equation $f(x)=0$ of degree n, and the value k of n is said to satisfy the equation; $f(x)$ is also said to vanish when $x=k$. According as none, or some, of the coefficients $c_0, c_1, \cdots, c_n$ are imaginary, the equation $f(x)=0$ is called real or imaginary. It is necessary to consider both real and imaginary equations. If $f(x)=0$ is imaginary, its solution is reduced to that of real equations thus:—Write $f(x)$ in the form $g(x)+ih(x)$, where the coefficients of $g(x)$, $h(x)$ are all real. Then $g(x)+ih(x)=0$. Multiply the last throughout by the conjugate imaginary $g(x)-ih(x)$. The result is a real equation, among whose roots occur all those of $f(x)=0$. Real equations are thus the fundamental ones, but we shall not assume $f(x)=0$ to be real unless so stated.

The central problems of the theory are these: (a) To find a root of $f(x)=0$, *i.e.*, to solve the equation, when the degree n and the coefficients $c_0, c_1, \cdots, c_n$ are given. (b) To determine the precise conditions under which the roots of $f(x)=0$ can be expressed in terms of the coefficients by means of a finite number of algebraic operations (additions, multiplications, subtractions, divisions, extractions of roots). This is called the algebraic solution, or the solution by radicals, of $f(x)=0$. The exact sense in which the coefficients are "given" in this problem is the crux of the modern theory; for the present it suffices to state that they may be considered as independent variables. If in (a), when the coefficients have given numerical values, a root cannot be found exactly, a practicable process must be devised whereby a root may be exhibited to any prescribed degree of approximation. If in (b) the roots are not expressible in the form demanded, it is required to construct the simplest functions of the coefficients that do satisfy the equation. For example, it was almost proved in 1824 by Niels Heinrick Abel, then only 22 years of age, that the solution by radicals of the general equation of degree >4 is impossible. His attempt contains two oversights, now easily rectified by the Galois theory. The current assertion that Abel proved the general equation of degree >4 solvable by radicals

impossible, is definitely incorrect. The objections by William Rowan Hamilton in 1839 to Abel's alleged proof alone are valid.

In 1858 Charles Hermite first solved the general equation of degree 5 by means of elliptic functions (*q.v.*). Modern work in this direction, originating with Henri Poincaré about 1880, solves the general equation of degree n in terms of Fuchsian functions. Current developments of (b) are inextricably interwoven with the theories of substitution groups, algebraic numbers (modern higher arithmetic) and special functions of a complex variable; (a) is practically exhausted.

The Fundamental Theorem.—A basic result for both (a) and (b) is the so-called fundamental theorem of algebra, which states that every algebraic equation has a root. More fully, it is proved either from this, or almost in one step from an application of an integral formula of Augustin Louis Cauchy in the theory of functions of a complex variable, that an equation of degree n has precisely n roots. The remarkable feature of this theorem is that, in order to solve completely any algebraic equation, it is unnecessary to go beyond the domain of complex numbers. It is by no means obvious that this should be so. The novice in algebra regards the theorem as a truism; the seasoned mathematician sees in it a species of fortunate miracle, while the sophisticated critic views it with suspicion. The first alleged satisfactory proof was given in 1799 by Karl Friedrich Gauss, who subsequently added three more.

Actually the theorem is not in the purview of algebra, as all proofs, depending ultimately upon continuity, are analytic and belong to the calculus. A proof adequate to the demands of modern rigour would implicitly traverse the entire theory of the continuum. Certain ultra-rigorists of the school founded by Leopold Kronecker, and invigorated to-day by L. E. J. Brouwer and Hermann Weyl, might even assert that, not only has the fundamental theorem not yet been proved, but also that it is without meaning. From the standpoint of modern mathematical foundations a fatal epistemological imperfection of the classical proofs is their failure to exhibit a process for constructing, in a well-defined number of well-defined operations, the roots whose existence the purported proofs undertake to establish. The difficulty here, of course, is irrelevant for the pragmatic problem of solving a numerical equation to a prescribed degree of accuracy. However disturbing such scepticism may be to the 20th-century critical logician, it need not deter the engineer who is capable of plotting a graph sufficiently accurate for most practical purposes. It is interesting, however, on account of its indication that mathematical reasoning may be as fallible as any other; and it should not be forgotten by the professional mathematician that to-day's heterodoxy is to-morrow's rigorous orthodoxy.

Symmetric Functions.—Before developing the elementary consequences of the fundamental theorem (provided it be proved, or accepted as a hypothesis), it is necessary to define symmetric functions and to state a few of their properties. Let $x_1, x_2, \cdots, x_n$ be independent variables. A rational function of $x_1, x_2, \cdots, x_n$ (obtained from these by a finite number of additions, multiplications, subtractions, divisions, no divisor being zero), is said to be symmetric in $x_1, x_2, \cdots, x_n$ if it is unchanged when any two of $x_1, x_2, \cdots, x_n$ are interchanged. Thus $x_1x_2+x_2x_3+x_3x_1$ is symmetric in x_1, x_2, x_3, since it is unchanged when x_1 and x_2, or x_2 and x_3, or x_3 and x_1 are interchanged. Let $(x_a x_b x_c \cdots x_q x_p)$ denote a substitution which replaces x_a by x_b, x_b by $x_c, \cdots, x_q$ by x_p, x_p by x_a, and let 1 indicate the substitution ("the identity") which leaves every letter unchanged. The set of all substitutions on $x_1, x_2, \cdots, x_n$ is a group, called the symmetric group on these letters; any symmetric function of the n letters is said to belong to this group, since it is unchanged under all substitutions of the group. Thus $x_1x_2+x_2x_3+x_3x_1$ belongs to 1, (x_1x_2), (x_2x_3), (x_3x_1), $(x_1x_2x_3)$, $(x_1x_3x_2)$. These ideas and their generalization to groups other than the symmetric will be of use later.

The jth elementary symmetric function of $x_1, x_2, \cdots, x_n$, for $j=1, 2, \cdots, n$, is, by definition, the sum of all possible products of precisely j different variables chosen from the set $x_1, x_2, \cdots, x_n$. Thus, for $n=3$, the 1st, 2nd, 3rd elementary symmetric functions are $x_1+x_2+x_3$, $x_1x_2+x_2x_3+x_3x_1$, $x_1x_2x_3$, and these are all the elementary symmetric functions of x_1, x_2, x_3. There are obviously an unlimited number of symmetric functions other than the elementary; it suffices to apply to any rational function of $x_1, x_2, \cdots, x_n$ the $n!$ substitutions of the symmetric group on these letters and add the results; any numerical factor common to all the terms may be suppressed. For example, when $n=3$, $x_1^2+x_2^2+x_3^2$ is symmetric in x_1, x_2, x_3, and is equal to

$$(x_1+x_2+x_3)^2-2(x_1x_2+x_2x_3+x_3x_1).$$

The last illustrates the important theorem that any polynomial P which is symmetric in $x_1, x_2, \cdots, x_n$, is equal to a polynomial Q in the elementary symmetric functions and the coefficients of P; the coefficients of Q are whole numbers. If all the coefficients of P are also whole numbers, Q is a polynomial in the elementary symmetric functions alone with whole number coefficients. These properties constitute the fundamental theorem of symmetric functions. The reduction to elementary symmetric functions is unique.

Relations Between Roots and Coefficients.—The first useful consequence of the fundamental theorem of algebra is this:— If $x_1, x_2, \cdots, x_n$ are the n roots of $f(x)=0$, where

$$f(x)\equiv c_0x^n+c_1x^{n-1}+\cdots+c_n,$$

then

$$f(x)=c_0(x-x_1)(x-x_2)\cdots(x-x_n).$$

Conversely, if $f(k)=0$, then $x-k$ is a factor of $f(x)$. More generally, if t is any complex number, $f(t)$ is equal to the remainder obtained on dividing $f(x)$ by $x-t$, and hence $f(t)$ can be calculated by division, a result of importance in the numerical solution of equations. This is called the *remainder theorem*.

Since $c_0, c_1, \cdots, c_n$ are any complex numbers independent of x, and $c_0\neq 0$, the equation $f(x)=0$ may be divided throughout by c_0. It then becomes $x^n+a_1x^{n-1}+\cdots+a_n=0$, where $a_1, \cdots, a_n$ are complex numbers, and this form is precisely as general as the original. When convenient we shall use it. If the roots are $\alpha_1, \alpha_2, \cdots, \alpha_n$, the linear ($\equiv$first degree in x), factors of

$$x^n+a_1x^{n-1}+\cdots+a_n$$

are

$$(x-\alpha_1)\ (x-\alpha_2)\cdots(x-\alpha_n),$$

and hence, on comparing coefficients of like powers of x, we see that $a_j=(-1)^j$ times the jth elementary symmetric function of the roots, for $j=1, 2, \cdots, n$. In particular, $a_n=(-1)^n$ times the product of all the roots. This frequently is useful in testing for rational roots of an equation whose coefficients are rational numbers; by this means all the rational roots may be found. By the fundamental theorem on symmetric functions it follows that any symmetric polynomial P in the roots $\alpha_1, \alpha_2, \cdots, \alpha_n$ is equal to a polynomial Q in the coefficients $a_1, a_2, \cdots, a_n$ and the coefficients of P; the coefficients of Q are whole numbers. If both the coefficients of the equation and those of P are rational numbers, then Q is a rational number.

Simple Properties of Real Equations.—Among the more useful elementary properties of real equations are the following: Imaginary roots, if any, occur in conjugate pairs, $a+bi$, $a-bi$ (a, b are real numbers and $i\equiv\sqrt{-1}$). Hence, if the degree n is odd, the equation has at least one real root. Again, $f(x)$ being a real, continuous function of x (*see* FUNCTION), it follows that if $f(r)$, $f(s)$ have opposite signs, where r, s are real numbers, the curve whose equation is $y=f(x)$ cuts the axis of x an odd number of times between r and s. If among the n roots of $f(x)=0$ there are precisely h each equal to α, and $h>1$, the root α is said to be of multiplicity h. Let $f'(x)$ be the first derivative of $f(x)$. Then the *theorem of Michel Rolle* states that between two consecutive real roots of $f(x)=0$ there is an odd number of real roots of $f'(x)=0$, provided a root of multiplicity h be counted as h roots.

As several subsequent theorems are considerably simpler for equations having no multiple roots, it is important to refer all cases back to this, as follows: If the highest common factor of $f(x)$ and $f'(x)$ involves x, let it be $g(x)$. Then a root of $g(x)=0$, of multiplicity m, is a root of $f(x)=0$, of multiplicity $m+1$; conversely, any root of $f(x)=0$, of multiplicity $m+1$, is a root

of $g(x)=0$, of multiplicity m. By successive applications of the process for finding the highest common factor, any multiple roots that may be present can be found. If the root α is of multiplicity h, $(x-\alpha)^h$ is a factor of $f(x)$, and similarly for all multiple roots. Dividing $f(x)$ by the product of all such $(x-\alpha)^h, \cdots$, we obtain a polynomial which vanishes only for the simple roots of $f(x)=0$. This argument for multiple roots is perfectly general and is not restricted to real equations.

When $f(x)=0$ is *real*, it is possible, by measuring where the graph of $y=f(x)$ crosses the x-axis, to ascertain how many real roots lie within given limits; by sufficiently enlarging the scale a particular real root may be located with any desired degree of accuracy. The graphical method is a valuable adjunct to the arithmetical processes, as in all numerical solutions the initial difficulty is in approximately locating the root to be calculated. If the real equation $f(x)=0$ has *imaginary roots* $u+iv$, $v\neq 0$, the values of u, v are found by solving the simultaneous equations

$$f(u)-f^{(2)}(u)v^2/2!+f^{(4)}(u)v^4/4!-\cdots=0,$$
$$f^{(1)}(u)-f^{(3)}(u)v^3/3!+f^{(5)}(u)v^5/5!-\cdots=0,$$

where $f^{(j)}(u)$ denotes the jth derivative of $f(u)$. These are obtained by equating to zero the real and imaginary parts of the Taylor expansion (*see* TAYLOR'S THEOREM) of $f(u+iv)$. Their solution is reduced to that of an equation in u or v alone by elimination. The determination of the roots, real and imaginary, of real equations is thus thrown back to the problem of finding the real roots of real equations and, as we have seen, the solution of an imaginary equation is reducible to the same. A further reduction, which in the case of equations with numerical coefficients is of great utility, is possible. The negative real roots of the real equation $f(x)=0$ are evidently the positive real roots of $f(-x)=0$. To find the negative real roots of $f(x)=0$, it suffices therefore to find the positive real roots of the equation obtained from $f(x)=0$ by changing the signs of all the terms of odd degree in $f(x)=0$. Thus problem (a) may be limited to the discovery of the positive real roots of real equations.

Elimination.—This process being of frequent occurrence in the theory and its applications, we shall describe the so-called dialytic method, invented by James Joseph Sylvester, for performing it. Usually this is as simple as any other, and often is simpler. Let $f(x)$, $g(x)$ be polynomials in x of degrees m, n respectively. We seek first a necessary and sufficient condition that $f(x)=0$ and $g(x)=0$ shall have a root in common. Let $x_1, x_2, \cdots, x_n$ be the roots of $f(x)=0$. Then $f(x)=0$ and $g(x)=0$ will have a common root when and only when $g(x_1)\,g(x_2)\cdots g(x_n)=0$, since $g(x)$ vanishes only when x is a root of $g(x)=0$. To avoid fractions in the final expression, multiply by c_0^n ($c_0\equiv$ the coefficient of x^n in $f(x)=0$), and obtain $c_0^n g(x_1)g(x_2)\cdots g(x_n)$, whose vanishing expresses the required condition. This function of $x_1, x_2, \cdots, x_n$ is called the resultant of the two equations. The vanishing of their resultant is therefore a necessary and sufficient condition that two equations shall have at least one root in common. Since the resultant as written is a symmetric function of the roots $x_1, \cdots, x_n$, it is a rational (also integral, by the factor c_0^n) function of the coefficients of both equations. Denote this function by $[f, g]$. Then $[f, g]=0$ is called the result of eliminating x from the two equations.

The actual elimination is easily performed by Sylvester's method. First, it is shown in the theory of determinants, that a necessary and sufficient condition that n linear and homogeneous equations in n unknown shall have a common set of solutions, other than the trivial one in which each unknown is zero, is that the determinant of the coefficients vanish. Apply this to $f(x)=0$, of degree m, and $g(x)=0$, of degree n, as follows:— Multiply the first equation throughout by $1, x, x^2, \cdots, x^{m-1}$ in turn, and the second by $1, x, x^2, \cdots, x^{n-1}$. This gives $n+m$ equations linear and homogeneous in $1, x, x^2, \cdots, x^{m+n-1}$. The determinant of this set equated to zero is the required elimination.

Discriminants.—Occasionally in physical problems it is sufficient to know whether a given equation has real roots, and, if so, how many. A graph will usually give the desired information most readily. Algebraically, the question is answered for degrees 2, 3, 4 by examining the simplest rational integral function of the coefficients whose vanishing is the condition that the given equation shall have a pair of equal roots. This function is called the discriminant of the given equation. From the foregoing statements concerning multiple roots and resultants, a sufficient condition that $f(x)=0$ shall have a pair of equal roots is that the resultant of $f(x)=0$ and $f'(x)=0$ vanish. Thus, for

$$ax^3+bx^2+cx+d=0,$$

the general equation of the third degree,

$$f'(x)=3ax^2+2bx+c,$$

and elimination gives

$$18abcd-4b^3d-4c^3a+b^2c^2-27a^2d^2=0,$$

the left of which is the discriminant of the given equation.

An alternative definition is the following. Let $x_1, x_2, \cdots, x_n$ be the n roots of $f(x)=0$, and write $\delta_{ab}\equiv x_a-x_b$ for $b>a$. There are thus precisely $(n-1)+(n-2)+\cdots+1$ differences δ_{ab}, as a runs through $1, 2, \cdots, n-1$. The product of the squares of these $n(n-1)/2$ differences, multiplied by c_0^{2n-2} (where c_0 is the coefficient of x^n in the stated equation), is a rational integral function of the coefficients of $f(x)=0$, since it is symmetric in the roots and the factor c_0^{2n-2} cancels all denominators. This function is taken as the discriminant of $f(x)=0$, as it obviously satisfies all the requirements of the definition. It is easily proved that the two methods of finding the discriminant lead to the same result.

As specimens of the information furnished by discriminants, examples for real equations of the second and third degrees will suffice. The discriminant of $ax^2+bx+c=0$ is b^2-4ac. If this equation is real, its roots are real and distinct, real and equal, imaginary and distinct, according as the discriminant is greater than, equal to, or less than zero. Likewise, a real equation of the third degree has three distinct real roots, or one real root and two conjugate imaginary roots, or at least two equal roots, according as the discriminant of the equation is greater than, less than, or equal to zero. Discriminants are of capital importance in solutions by radicals.

Location of Roots.—We have seen that the problem of solving an equation with given numerical coefficients is reducible to that of finding the positive real roots of real equations. Accordingly, it is assumed in the following discussion that $f(x)=0$ is a real equation. The first step in finding the real roots, positive, zero, or negative, is to isolate them. A real root r of $f(x)=0$ is said to be isolated when two real numbers, a, b, between which r lies, and between which lies no other root of $f(x)=0$, are known. The graphical method, as already indicated, is useful here as a reconnaissance, but usually more powerful weapons must be applied. One is René Descartes' *rule of signs* which gives, in most cases, some information regarding the total number of real roots. Let $f(x)$ be $c_0x^n+c_1x^{n-1}+\cdots+c_n$, the coefficients being real numbers, positive, zero or negative, $c_0\neq 0$. If $c_0<0$, change the signs throughout $f(x)=0$. Thus, without loss of generality, we assume $c_0>0$. Write down now all the signs of the non-zero coefficients in the order in which they occur in $f(x)$. A change from $+$ to $-$, or from $-$ to $+$, is called a variation. Count the variations. Thus, in $++---+-$ there are three. Descartes' rule states that $f(x)=0$ has as many positive real roots, or fewer by an even number, as there are variations. The roots of $f(-x)=0$ being the negatives of those of $f(x)=0$, the rule, applied to $f(-x)=0$, gives similar information regarding the number of negative real roots. This rule, however, may fail to tell us anything of value. Its proof is quite simple.

A conclusive method for isolating the roots was discovered in 1829 by J. C. F. Sturm. Let $f'(x)$ be the first derivative of $f(x)$. Write $f(x)\equiv f$, $f'(x)\equiv f'$, and similarly, in what follows, for all polynomials in x. Proceed as in finding the highest common factor of f, f'. Let q_1 be the quotient and r_1 the remainder at the first step. Then $f=q_1f'+r_1$. Before using r_1 as the next divisor, change its sign, and write $-r_1\equiv f_2$, so that $f=q_1f'-f_2$. Divide f' by f_2; denote the remainder, with its sign changed, by f_3. Continue thus with all remainders. For simplicity suppose first that

$f(x)=0$ has no pair of equal roots. The last changed remainder, f_n, will then be a constant $\neq 0$. The sequence of changed remainders, with f, f' prefixed, viz.,

$$f(x),\ f'(x),\ f_2(x),\ \cdots,\ f_{n-1}(x),\ f_n,$$

is called the set of *Sturm functions* for $f(x)$.

Now let a, b be real numbers, neither a root of $f(x)=0$, and let $a<b$. To find the number of real roots of $f(x)=0$ lying between a and b, put $x=a$ in the Sturm functions, and delete any terms that then vanish. Count the variations of sign (as in Descartes' rule) in the resulting sequence of real numbers. Let there be V_a variations. Proceed similarly with b, and obtain V_b. Then the number of real roots between a and b is V_a-V_b. In particular, if $a=-\infty$, $b=+\infty$. Sturm's theorem thus gives the total number of real roots when we attend only to the signs attached to the highest powers of x in his functions. (The computations are usually laborious, but awkward fractions can be avoided by multiplying each dividend by a properly chosen positive constant before dividing). Next, if $f(x)=0$ has multiple roots, V_a-V_b is still the number of real roots between a and b, provided each multiple root be counted once only. In practice, however, it is simplest to get rid of the multiple roots first, by the method already indicated.

A less powerful theorem by the French physician F. D. Budan (1807), proved by J. B. J. Fourier about 1829, involves less computation than Sturm's, and is often usable. Let $f^{(j)}(x)$be the jth derivative of $f(x)$; replace Sturm's sequence by

$$f(x),\ f^{(1)}(x),\ f^{(2)}(x),\ \cdots,\ f^{(n)}(x),$$

and proceed in this sequence with the same a, b as before, precisely as in calculating V_a, V_b for Sturm's. Then, if a root of multiplicity m be now counted as m roots, V_a-V_b for this sequence is either the number of real roots of $f(x)=0$ between a and b, or exceeds it by a positive whole number.

It is sometimes convenient to know an upper limit L to the value of the real roots of $f(x)=0$. Let G be the greatest of the numerical values of the coefficients $c_0, c_1, \cdots, c_n$. If the first negative coefficient is preceded by precisely s coefficients that are greater than, or equal to, zero, then $L=1+\sqrt[s]{(G/c_0)}$. Another upper limit is as follows: If c_0 is negative, change all signs in $f(x)=0$. Divide then the numerical value of each negative coefficient by the sum of all those positive coefficients that precede it. Let Q be the greatest of these quotients. Then $1+Q$ is the upper limit in question.

Computation of Roots.—When a real root of a real equation $f(x)=0$ has been isolated by any of the methods suggested, it may be calculated, digit by digit, by any one of several arithmetical processes, the commonest of which is that, named after W. G. Horner (1819), which was known to the Chinese mathematicians of the 13th century, and Isaac Newton's of about 1675. Newton's method has the great advantage of being applicable to equations other than algebraic. It can be explained by his own example, $x^3-2x-5=0$. This has only one root between 2 and 3. To find this root, replace x by $2+h$, where h is necessarily between 0 and 1. The terms in h^2 and h^3 being neglected, in comparison with h, in the new equation

$$h^3+6h^2+10h-1=0$$

we get $h=0{\cdot}1$ as a first approximation to h, and hence the root is roughly $2{\cdot}1$. For the next approximation, replace h by $0{\cdot}1+k$ in the h-equation, and obtain

$$k^3+6{\cdot}3k^2+11{\cdot}23k+0{\cdot}061=0.$$

Omit the k^3, k^2 terms, which will be small in comparison with k; then k is approximately $-0{\cdot}0054$. From $h=0{\cdot}1+k$ we get $h=0{\cdot}0946$, giving $2{\cdot}0946$ as an approximate value of the required root. By repeating the process a sufficient number of times any desired degree of accuracy is attainable. The method amounts to retaining only the first two terms in the Taylor series (*see* TAYLOR'S THEOREM) for $f(r+h)$, on the supposition that h is small in comparison with the approximate value r of a real root of $f(x)=0$; so that $0=f(r+h)=f(r)+hf'(r)$ approximately, and $h=-f(r)/f'(r)$; whence $r_1=r+h$ is the first approximation. The process is repeated with $h_1=-f(r_1)/f'(r_1)$; and $r_2=r+h+h_1$ is the second approximation. In Newton's example,

$$f(x)=x^3-2x-5,\ f'(x)=3x^2-2,\ r=2,\ h=0{\cdot}1,\ h_1=-0{\cdot}0054.$$

In Horner's method (the one usually given in elementary texts on algebra, except those most popular on the continent of Europe) a set of equations, one for each digit of the required root, is obtained successively from the given equation. The process is an arithmetical restatement and refinement of the crude graphical method, and amounts to successive shifts of the origin and magnifications of the scale. As already pointed out, it is sufficient to discuss the method for positive real roots only. The essence of the method is the successive diminution of the roots of the given equation by the smaller member in successive pairs of positive real numbers; *i.e.*, we gradually creep up on the root from behind. Suppose, for example, that a real root of $f(x)=0$ has been isolated between 200 and 300. If we can construct an equation $f_1(x)=0$, whose roots are those of $f(x)=0$ each diminished by 200, then $f_1(x)=0$ will have one and only one root between 0 and 100. By any of the proposed methods locate this root; say it is between 60 and 70. Then $f(x)=0$ has a root between 260 and 270. Construct $f_2(x)=0$, whose roots are those of $f_1(x)=0$ diminished by 60, and repeat the argument. Then $f_2(x)=0$ has a root between 0 and 10, which may be located as before; *e.g.*, between 5 and 6. Then 5 is the third digit of the required root of $f(x)=0$, and we next form $f_3(x)=0$, whose roots are those of $f_2(x)=0$ diminished by 5, and $f_3(x)=0$ has a root between 0 and 1, say $0{\cdot}2$. The required root so far is $265{\cdot}2$, and the process can be continued to any prescribed number of digits. It will automatically terminate, or yield a repeating decimal, if the root is a rational number. The rational roots, if any, are however best obtained first by trial by examining the constant term of $f(x)$ as already indicated.

The essential detail of constructing the equation $f_1(x)=0$ whose roots are those of $f(x)=0$ each diminished by the positive number h, is performed by synthetic division according to the following theorem, which is an immediate consequence of the expansion of $f(x+h)$ by Taylor's theorem. If

$$f(x)\equiv c_0x^n+c_1x^{n-1}+\cdots+c_n$$

be divided by $x-h$, let the quotient be q_n and the remainder r_n. Divide q_n by $x-h$; let the quotient be q_{n-1} and the remainder r_{n-1}. Continue thus to n divisions. The last quotient is c_0; say the last remainder is r_1. Then

$$f_1(x)\equiv c_0x^n+r_1x^{n-1}+r_2x^{n-2}+\cdots+r_{n-1}x+r_n.$$

Many devices for shortening the labour of Horner's method are explained in treatises on equations; in particular the last digit (at least) that is required can, in general, be obtained by simple division. Horner's method is, beyond any question, the most practical yet devised for the numerical solution of equations with numerical coefficients. Other methods of solving numerical equations are an impracticable one by continued fractions, due to Lagrange, and others by expansions in infinite series. The latter has recently been reconsidered by E. T. Whittaker, who expresses the coefficients in the series for a root in terms of determinants that can be easily computed.

Algebraic Solutions of Equations of the Second, Third and Fourth Degrees.—These equations are called respectively the *quadratic*, the *cubic*, and the *biquadratic*. The initial step in seeking a solution by radicals is usually the reduction of the given equation to another containing fewer powers of the unknown. In particular, the second highest power of the unknown, if present, may be removed as follows: In $c_0x^n+c_1x^{n-1}+\cdots+c_n=0$ put $x=y+k$. The coefficient of y^{n-1} is then nkc_0+c_1. Hence by choosing $k=-c_1/nc_0$, we obtain an equation in y lacking the second term. If the y-equation can be solved, the roots of the x-equation are obtained from $x=y-c_1/nc_0$.

Thus, for the general quadratic, $c_0x^2+c_1x+c_2=0$, we have

$$k=-c_1/2c_0;$$

the y-equation is $y^2=K$, where

$$K=(c_0k^2+c_1k+c_2)/c_0, \ =(c_1^2-4c_0c_2)/4c_0^2,$$

and hence, from $y=\pm\sqrt{K}$, $x=y+k$, we have the roots

$$[-c_1\pm\sqrt{(c_1^2-4c_0c_2)}]/2c_0$$

of the x-equation in the usual form. For the general cubic

$$c_0x^3+c_1x^2+c_2x+c_3=0,$$

the value of k is $-a_1/3a_0$; the substitution $x=y-a_1/3a_0$ gives $y^3+py+q=0$, where

$$p\equiv(3a_0a_2-a_1^2)/3a_0^2, \quad q\equiv(2a_1^3-9a_0a_1a_2+27a_0^2a_3)/27a_0^3.$$

If y_1, y_2, y_3 are the roots of the y-equation, and x_1, x_2, x_3 those of the x-equation,

$$x_j=y_j-a_1/3a_0, \quad (j=1, 2, 3).$$

Before Lagrange the solution of $y^3+py+q=0$ was achieved by ingenious substitutions based on nothing, apparently, but skill in guessing. Thus, by choosing $y\equiv z-p/3z$, François Viète (Vieta) in 1591 obtained $z^6+qz^3-p^3/27=0$, a quadratic in z^3 whence he obtained three permissible values of y, and thence x_1, x_2, x_3. The final formulae, reproduced in texts on algebra, were first published in the *Ars Magna* (1545) by Hieronimo Cardano, who had obtained them from Tartaglia ("the stutterer," true name Nicolo Fontana) by questionable means. In numerical work, Horner's method is greatly preferable to direct substitution into Tartaglia's formulae. When all three roots are real, the so-called irreducible case, the formulae involve cube roots of imaginaries and are then necessarily worthless. In this case a usable trigonometric solution is found by putting $y=tz$ in $y^3+py+q=0$, and identifying the resulting equation with

$$\cos 3\theta\equiv 4\cos^3\theta-3\cos\theta,$$

by means of

$$z\equiv\cos\theta, \quad t\equiv\sqrt{(-4p/3)}, \quad \cos 3\theta\equiv -q/2\sqrt{(-p^3/27)}.$$

The last gives the 3 values of z, namely $\cos\theta$, $\cos(\theta+120^0)$, $\cos(\theta+240^0)$, whose numerical values can be obtained from trigonometric tables. Finally the values of y are found by multiplying those of z by t. The irreducible case has a plethoric literature of its own.

The general biquadratic may be taken in the form

$$x^4+a_1x^3+a_2x^2+a_3x+a_4=0.$$

Its solution, due to Ludovici Ferrari, but first published in the *Ars Magna*, was found by adding $(mx+b)^2$ to both sides and imposing the condition that the new left-hand member be identically the square of $x^2+a_1x/2+k$, where h is to be found. By comparison of coefficients in the assumed identity, and subsequent elimination of m, a cubic for h is obtained. This cubic is called the resolvent, or reducing, cubic; its 3 roots enable us to find m and b. The solution of the biquadratic is thus finally reduced to that of two quadratics,

$$x^2+a_1/2+k\pm(mx+b)=0,$$

whose 4 roots are those required. The ultimate formulae, with the value of h inserted, are too complicated to be usable. Solutions by means of elliptic functions are known, but they also are mere algebraic curiosities.

There is a vast literature on cubic and biquadratic equations. Little of it is to-day of any vital mathematical consequence, and the most of it is of no practical value. Nevertheless, the incessant activity of nearly three centuries reflected in this accumulation of algebraic lore was not wholly futile, for without at least some of it, the sure clue to the maze could probably not have been discovered. To appreciate the true magnitude of this early work, the modern algebraist should attempt to restore it for himself, with but such tools and notations as its creators had. He will rise from his efforts with a new respect for his forbears.

A new era began with Lagrange in 1770. In an illuminating critique of his predecessors' solutions of the general cubic and biquadratic, he observed that the solution by radicals of any algebraic equation can be made to depend upon that of another, now called the resolvent, which may or may not be easier to solve. Thus, for equations of degree 5, the resolvent is of degree 6. The roots of a resolvent equation are rational functions of those of the original. By such considerations, and others arising naturally from them, Lagrange transposed the problem of solution by radicals to a profound study of rational functions of the roots of equations, and in particular to an investigation of the number of distinct values, which such functions of the roots, considered as independent variables, assume under permutations of the roots. This work contains a germ of the modern theory founded by Galois, in which the theory of substitution groups plays a central part.

An idea of Lagrange's attack can be gained from a brief reconsideration of $x^3+px+q=0$, which will also prepare the way for the Galois theory. Let the roots be x_1, x_2, x_3. The discriminant of this equation is the square of

$$D\equiv(x_1-x_2)\ (x_1-x_3)\ (x_2-x_3).$$

Let ω be an imaginary root of $x^3-1=0$, and write

$$F\equiv(x_1+\omega x_2+\omega^2x_3), \quad G\equiv(x_1+\omega^2x_2+\omega x_3).$$

The three functions F^3, G^3, D have the significant property that any substitution on x_1, x_2, x_3 which leaves one of these functions unchanged, leaves also the other two unchanged; for example, $(x_1x_2x_3)$. The totality of substitutions on n independent variables which leave a given function of those variables unchanged, form a group; the function is said to belong to the group. Lagrange proved that, if several functions belong to the same group, any one of them is a rational function of each of the others. Hence each of F^3, G^3 is a rational function of D, and therefore each is rational in the square root of a polynomial in p, q, since D^2, being the discriminant, is rational and integral in the coefficients of the equation. The coefficient of x^2 being zero in $x^3+px+q=0$, we have $x_1+x_2+x_3=0$, which, with the values of F, G just indicated, gives three equations of degree 1 to solve for x_1, x_2, x_3 in terms of algebraic functions of p, q. Since the determinant of the set does not vanish, a solution exists, and it is thus known *à priori* that the general cubic is solvable by radicals. When elaborated, this method yields the roots explicitly. The biquadratic is treated in a similar manner; the general equation of degree 5 cannot be so solved, for a reason that will appear in the concluding sections.

As Lagrange's great work was but a preliminary to that of the modern school, further discussion of it may be omitted. Contemporaneously with Lagrange, an Italian physician, Paolo Ruffini, began issuing in 1799 a series of memoirs containing incidentally theorems which would now be restated in terms of substitution groups on five letters, in an attempt to prove the general equation of the fourth degree algebraically unsolvable. He almost succeeded, but his projected proof, like Abel's, is incomplete, and the whole matter is to-day surveyed from the higher point of view of Galois. Before passing to this we examine a general process of which several applications have occurred in what preceded.

Transformations.—The importance of transforming a given equation into another, whose roots are particular functions of those of the original, was seen in the preceding sketches of the solutions, numerical or algebraic, of equations. Thus, an important detail of Horner's method was equivalent to the linear transformation $x=y+k$; the roots of the y-equation were those of the x-equation each diminished by k. This is one of the simplest examples of a more general transformation introduced in 1683 by Ehrenfried Walther Tschirnhausen (or Tschirnhaus), who attempted to solve all equations by reducing them to the form $y^n=A$ — an impossible project. Let $x_1, x_2, \cdots, x_n$ be the roots of $f(x)=0$. On dividing any polynomial P in a given root, say x_1, by $f(x_1)$, the polynomial is reduced to another of degree $n-1$, at most, in x_1. Tschirnhaus transformations are of the type $y=P(x)/Q(x)$, where P, Q are polynomials of degree $<n$, and $Q(x)$ vanishes for no root of $f(x)=0$; $Q(x)$ may reduce to a numerical constant, in particular to 1. This transforms $f(x)=0$ into an equation in y whose roots are $P(x_j)/Q(x_j)$, $(j=1, 2, \cdots, n)$. The y-equation can be obtained by elimination; the details usually

are tedious.

The use of such transformations is evident from the following specimens. By a transformation $y=p+qx+x^2$, where p, q do not involve x, the general cubic is reducible to $y^3=A$, where A depends only on p, q and the coefficients of the cubic. More generally, by a linear transformation, or by a Tschirnhaus transformation $y=a+bx+cx^2$, whose coefficients involve only 1 square root, the general equation of degree n can be reduced to an equation of degree n in y lacking the terms in y^{n-1}, y^{n-2}. Or again, by a Tschirnhaus transformation whose coefficients involve only 1 cube root and 3 square roots, the general equation of degree n is reducible to an equation in y of degree n lacking the terms in y^{n-1}, y^{n-2}, y^{n-3}. The last is of capital importance, for the general equation of degree 5, which is thus reducible to $y^5+ry+s=0$, a result obtained by E. S. Bring about 1786, and independently by G. B. Jerrard in 1827. This is one point of departure for the solution in terms of elliptic functions, as a similar equation appears naturally in the construction of elliptic functions whose periods are fifths of those of given functions.

Fields and Reducibility.—These concepts are fundamental in the modern theory. A field is a set of elements closed under addition, subtraction, multiplication, division, no divisor being the zero of the set. The elements may be numerical, or mere marks, or they may be partly one and partly the other. Marks can be considered as independent complex variables. Elements of a given field are said to be "rationally known." In the general equation $x^n+c_1x^{n-1}+\cdots+c_n=0$ of degree n, the coefficients are independent complex variables. Rational functions of the roots $x_1, x_2, \cdots, x_n$ are equal only when they are equal for all sets of values of the roots; *i.e.*, the roots are considered as indeterminates. If, however, the coefficients of an equation are given numerical constants, equality of rational functions of the roots means equality of numerical values of the functions. It must be noticed that, although a substitution on the roots may change the form of a rational function, the numerical value of the function may remain unchanged. The substitutions leaving unchanged a rational function of the roots, considered as marks, form a group; in general the like is false for roots of numerical equations. If the coefficients of a rational function are rationally known, it is called rational, and similarly for rational relations between the roots. Functions not equal as just defined are called distinct; two functions are said to be unchanged by a substitution on the roots if the new function is equal, as defined, to the original. If all the coefficients of a polynomial P are in a given field F, P is said to be in F. If P is neither the product of two polynomials in F, nor a constant, P is called irreducible (in F).

Group of an Equation.—Let the roots $x_1, \cdots, x_n$ of $f(x)=0$ be distinct. For a proper choice of $m_1, \cdots, m_n$, the function $V_1\equiv m_1x_1+\cdots+m_nx_n$ takes $n!$ distinct values under the symmetric group on the roots. It can be shown that any rational function $r(x_1, \cdots, x_n)$ of the roots is a rational function of V_1, say $R(V_1)$; and, with a certain restriction which we may ignore here, if $S_1\equiv 1, S_2, \cdots, S_h$ is any substitution group on the roots, and if $r_j(x_1, \cdots, x_n)$ is the result of applying S_j to $r(x_1, \cdots, x_n)$, then $r_j(x_1, \cdots, x_n)=R(V_j)$, where V_j comes from applying S_j to V_1. In particular then, each of $x_1, \cdots, x_n$ is a rational function of V_1. Write

$$F(V)\equiv(V-V_1)\ (V-V_2)\cdots(V-V_{n!}),$$

and, whether $F(V)$ is or is not reducible, let $F_1(V)=0$ be the irreducible factor of $F(V)$ such that $F_1(V)=0$ has V_1 as a root; $F_1(V)=0$ is called a Galois resolvent of $f(x)=0$. Each of its roots is a rational function of one of them. To solve $f(x)=0$ is equivalent then to finding one root, say V_1, of its Galois resolvent.

The degree g of $F_1(V)=0$ does not exceed $n!$; its g roots can be derived from V_1 by the substitutions of a group G, the so-called group of $f(x)=0$ for the field of its coefficients. Every rational function of the roots which is unchanged by all the substitutions of G is rationally known; every rationally known rational function of the roots of $f(x)=0$ is unchanged by all the substitutions of G; moreover, G is the smallest group having the first property, and the largest having the second. The group of the general equation of degree n is the symmetric group on the roots. If to the field of the coefficients of $f(x)=0$ there be adjoined a rational function of the roots, giving an enlarged field which contains the original, and if this function belongs to a subgroup of G, the group of the equation is reduced to the subgroup.

Solvability by Radicals.—A group is simple only if its invariant subgroups are itself and the identity; non-simple groups are called composite. A subgroup of G other than G is called proper; an invariant proper subgroup not a subgroup of a larger invariant proper subgroup is called maximal. Let H be a maximal invariant proper subgroup of any group G; let K be a maximal invariant proper subgroup of H, and so on, till the identity group 1. Then $G, H, K, \cdots, L$, 1 is called a series of composition of G. Let the respective orders of these groups be $g, h, k, \cdots, l$, 1. Then g/h, $h/k, \cdots, l$ are integers. They are the same, except for order, for all series of composition for G, and are called the factors of composition of G, which is called solvable if and only if its factors of composition are all primes.

The crown of Galois's theory is the beautiful theorem that an algebraic equation is solvable by radicals if and only if its group for the field of its coefficients is solvable. By the known properties of the symmetric groups on n letters, it follows at once that when $n>4$, the general equation of degree n is not solvable by radicals.

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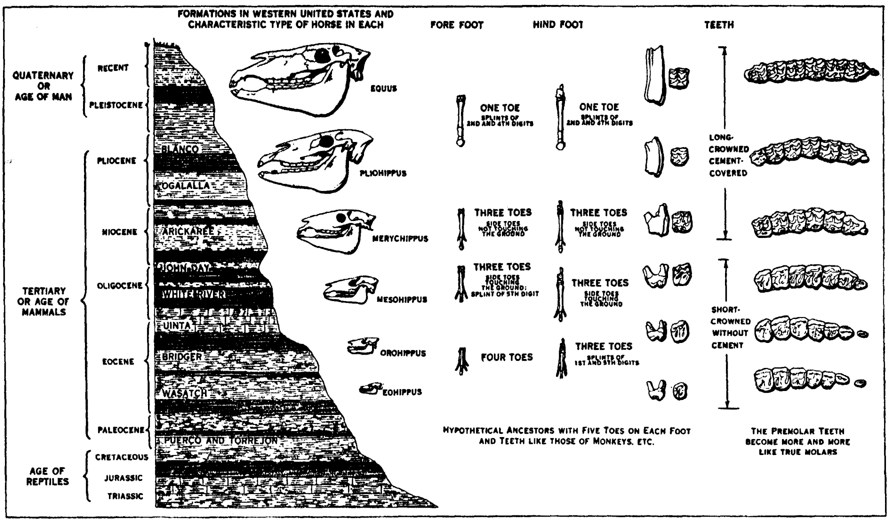
EQUATOR, in geography, that great circle of the earth, equidistant from the two poles, which divides the northern from the southern hemisphere and lies in a plane perpendicular to the axis of the earth; this is termed the "geographical" or "terrestrial equator." In astronomy, the "celestial equator" is the name given to the great circle in which the plane of the terrestrial equator intersects the celestial sphere; it is consequently equidistant from the celestial poles. The "magnetic equator" is an imaginary line encircling the earth, along which the vertical component of the earth's magnetic force is zero; it nearly coincides with the terrestrial equator.

EQUERRY, a contracted form of "gentleman of the equerry," an officer in charge of the stables of a royal household. At the British court, equerries are officers attached to the department of the master of the horse, the first of whom is called chief equerry (*see* Household, Royal).

EQUIDAE, the horse family, a family of hoofed mammals, of the order Perissodactyla, of which the modern genus *Equus* is the type. It is customary to include in this family the entire series of Tertiary ancestors of the horse, the three principal progressive stages being distinguished as sub-families—Hyracotheriinae, Anchitheriinae and Equinae. The Equidae, with the nearly related family of Palaeotheriidae, are included in the Hippoidea, one of the four primary groups into which the Perissodactyla subdivided early in the Eocene, the others being the Tapiroidea, Rhinocerotoidea and Chalicotheroidea. The fundamental distinction lies in the composition of the molars. The primitive pattern of the upper molars in the Perissodactyla consists of six rounded cusps partially united into an outer and two obliquely transverse crests. In the Hippoidea this pattern is converted into two outer crescents and two incomplete oblique transverse crests. This primitive pattern is perfected in the Anchitheriinae and is further modified in the Equinae in connection with the progressive conversion of the transverse crests into a pair of inner crescents and one or two more or less isolated inner pillars. The molars are thus finally converted into tall square prisms with a surface pattern of four crescents and an inner pillar, which grow up from the jaw as they are worn off at the top. They do not, however, attain the final stage of hypsodonty and become rootless ever-growing teeth



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EVOLUTION OF THE HORSE FROM THE AGE OF REPTILES TO THE PRESENT

as do the molars of edentates, some rodents, etc., but close up the roots at about the sixth year (in the modern horse). As in all Perissodactyls the premolars except $p\frac{1}{1}$ become progressively molariform. The front teeth in primitive Perissodactyla consist of a convex row of small spatulate incisors flanked by larger and more pointed canines, and separated by a considerable gap or diastema from the cheek teeth (premolars and molars). In the Hippoidea the incisors are progressively developed as a row of cropping teeth, the canines tend to be reduced or incisoform, the lower cheek teeth conform to the changes in the upper series, developing in the anchitheriine stage two obliquely set unsymmetric crescents, the posterior wing strong and subtransverse, the anterior wing weak, while in the Equinae the pattern is changed into a pair of symmetrical inward-facing outer crescents flanked by four supporting pillars on the inner side.

The feet in the Hippoidea undergo a marked reduction and specialization of the digits, commencing with the primitive hyracotheriines with four well-developed toes in the fore and three in the hind foot, followed by the anchitheriines with three toes on each foot but the lateral digits much reduced, then by the Equinae with the lateral digits further reduced, and finally becoming vestigial splints, the phalanges wholly lost, and the foot monodactyl. As the lateral digits are reduced the central (third) digit is enlarged, the metapodials elongated into cylindrical tubular cannon-bones, the central wrist and ankle bones enlarged and the lateral bones tend to acquire a footing on the median digit, or else disappear. The ulna and fibula are reduced and consolidated with the radius and tibia, these bones are elongated, while the humerus and femur tend to assume a more horizontal position and to be caught up into the shoulder and flank of the body. The neck vertebrae and the facial part of the skull are very considerably increased in length, the orbits become enclosed by a bridge of bone separating them from the temporal fossa, the angular region of the lower jaw and the ridge above the cheek teeth are much developed, in order to provide adequate attachments for powerful masseter muscles used in grinding the food; but the coronoid process and the median sagittal crest over the brain-case are relatively reduced, as the temporal jaw muscles are less used. The brain likewise increases in size and number of convolutions.

All these changes are features of adaptation of the equine phylum to swift-running for long distances in open and more or less level country, and to feeding chiefly upon the dry, hard grasses of the plains. They are paralleled in the evolution of various other races of similar habits and environment. In one family of the extinct Litopterna (*q.v.*) of South America a completely monodactyl running foot was developed, from the third digit as in the horses, but in the teeth these animals were less progressive than the horses, reaching only to a stage comparable with *Mesohippus*. In the ruminants a similar running foot is developed by consolidation of third and fourth digits; and in many of them, especially the cattle, there is also a close parallelism in teeth to the modern horse, the upper molar having two outer and two inner crescents and a separate inner pillar; but this is evolved out of different primary cusp elements than in the horses, and the premolars do not become molariform in any ruminant. The kangaroo has likewise developed a nearly monodactyl foot, but for leaping instead of running.

The evolution of the Equidae has been traced through a closely connected series of intermediate stages back to *Hyracotherium* or *Eohippus* of the Lower Eocene, about the size of a fox, with four complete toes on the fore foot and three on the hind foot and with short-crowned semi-bunodont molars, premolars smaller and of simple pattern. In the Middle and Upper Eocene stages (*Orohippus, Epihippus*) the premolars except $p\frac{1}{1}$ become progressively molariform and the molar crowns somewhat higher with more clearly defined crescents and cross-crests; the lateral digits are slightly reduced but the outer fifth digit of the fore foot is still functional. In the Oligocene *Mesohippus* and *Miohippus* the premolars except $p\frac{1}{1}$ are fully molariform and the feet much more progressive, three toes on fore and hind, the lateral digits reduced and median digit enlarged, the fifth digit of the fore foot reduced to a small short splint. *Parahippus* of the Lower Miocene and *Merychippus* of the Middle and Upper Miocene show a progressive increase in the height of the cheek teeth, with corresponding development of cement on the crown and change of pattern toward that of the later horses. The feet also progress, becoming fully unguligrade, the side toes further reduced and no longer resting on the ground, while the central metapodial becomes longer

and more tubular.

Pliohippus of the Lower and *Plesippus* of the Upper Pliocene have the teeth further elongated and the pattern progressively nearer to that of *Equus*, the lateral digits reduced to splints, very long in the former, shortened up in the latter genus.

Equus proper appears at the base of the Pleistocene in America and was widely distributed during that period (*see* HORSE, *fossil*) surviving to-day in Asia and Africa.

Side branches of this phylum are *Anchitherium* and *Hypohippus* of the Miocene and Pliocene, retaining the short-crowned teeth and other characters of *Miohippus* but increasing progressively to the size of a small horse (*Hypohippus matthewi*, Pliocene); and *Hipparion* of the Pliocene retaining the three-toed feet of *Merychippus* but with progressive teeth of a pattern somewhat diverse from the *Equus* line. Both these side branches originated in America but found their way to the Old World, *Anchitherium* in the Miocene, *Hipparion* in the Pliocene, as did *Equus* itself in the Pleistocene. The region of evolution and dispersal of the family appears on present evidence to have been North America. A third side branch, *Hippidium, Onohippidium,* is found in South America. It is of the size of *Equus* but has shorter legs and a peculiarly modified nasal opening in the skull; the cheek teeth are very like those of *Pliohippus*.

Many of the later Tertiary Equidae have a deep pit or fossa on the skull in front of the orbit, which has been variously explained as indicating a proboscis (like tapirs) or a scent gland (like deer), but is now believed to have lodged an air-sac communicating with the front end of the nasal passages, remnants of which are found in modern horses.

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(W. D. M.)

EQUILIBRIUM, ANIMAL. If we had to construct a machine to imitate a man one of our many difficulties would be to arrange it so as to walk and run, or even to stand upright, without falling over. We should have to contrive so that every movement of the limbs would call into play some compensating device which would redress the balance and keep it within the narrow limits imposed by the small base of support. The problem would be easier if our machine were to imitate a four-footed animal, but it would still be difficult enough. One of the most interesting topics of present-day physiology is that concerned with the equilibrium of the body at rest and in motion, and considerable advances have been made in the past few years.

To maintain the normal posture of the body constant muscular activity is necessary; this must be controlled by the central nervous system, and the central nervous system must be directed by the messages received from the various sense organs which indicate what kind of adjustment is necessary and how well it is succeeding. An analysis of the mechanism of equilibrium must therefore begin with the sense organs which guide it. These are the labyrinth organs in the internal ear, the sense organs in the muscles, tendons, joints and skin, and, in many animals, the eyes.

In man it is obvious that the eyes play an important part in balancing the body. We can see the relation of our body to the ground and if we shut our eyes it is much more difficult to stand upright with the feet close together. Anyone who experiences a steeply banked turn in an aeroplane for the first time will realize that the eyes are not the only sense organ concerned in giving us a frame of reference in space. The horizon seems to tilt and the aeroplane to remain level owing to the effect of centrifugal force on the labyrinth organs which make us feel that "up" and "down" are still where they were before in relation to our seat in the aeroplane. In man, therefore, the eyes can be overruled by the labyrinths; but it is a remarkable fact that in many animals the eyes seem to give no information at all as to the position of the animal in space. Magnus and his co-workers at Utrecht have shown that an animal suspended in any position above the ground has a tendency to turn the head into the normal position, *i.e.*, the position it would take up if the animal were standing on the level. In monkeys, cats and dogs, as in man, the "righting" of the head in space is dependent on messages received from the eyes as well as from the labyrinth organs. The righting will still take place after the destruction of the labyrinths, provided that the animal can see, but if it is blindfolded the head hangs limply and no attempt is made to raise it. But in rabbits and guinea pigs, the destruction of the labyrinths stops the righting reaction completely and the eyes play no part in it. In fact the optical righting reactions are only present when the eyes and their nervous connections in the brain are highly developed.

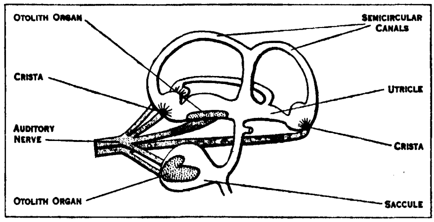

FIG. 1.—THE MEMBRANOUS LABYRINTH AND ITS NERVOUS CONNECTIONS IN THE INTERNAL EAR; ENTIRELY RELATED TO POSTURE AND EQUILIBRIUM, THOUGH CLOSELY CONNECTED WITH THE HEARING APPARATUS

The reactions due to the labyrinth organs are found in all the vertebrates, and the labyrinth is the one sense organ entirely concerned with posture and equilibrium. It consists of a series of membranous chambers and tubes immersed in fluid and contained in the bony cavity of the inner ear. In mammals the labyrinth is closely joined to the cochlea, the sense organ responsive to sound, but the two are supplied by separate branches of the viii. cranial nerve and the branches have separate connections in the brain stem. The membranous part of the labyrinth is composed of two small bags, the saccule and the utricle, and three semicircular canals which open into it and lie in three planes at right angles to one another (*see* fig. 1). The nerve fibres which supply the labyrinth (the vestibular division of the viii. nerve) end in close connection with a number of cells furnished with hair-like projections and grouped together to form the two otolith organs in the saccule and utricle and the three cristae of the semicircular canals. In the otolith organs the hairs are embedded in a gelatinous substance containing small masses of calcium carbonate called otoliths. The hairs of the cristae are much longer and the gelatinous substance round them has no otoliths.

The action of the different parts of the labyrinth is still far from clear, though there is no doubt about the action of the organ as a whole. When the animal is at rest the labyrinth signals the direction of the earth's gravitational attraction; when the animal is in motion it signals any change in acceleration due either to rotation or to movement in a straight line. If the labyrinths are destroyed on both sides, an animal without optical righting reflexes hangs limply when held in the air instead of struggling to right itself. Other sense organs can come into play when the body is in contact with the ground and the animal can then move from an abnormal into the normal posture because the abnormal distribution of pressure on the body surface gives the necessary information to the nervous system. In man equilibrium can be maintained without the labyrinth organs by the aid of the eyes and the sense organs of the muscles and body surface, and it is so maintained in congenital deaf mutes whose inner ear is imperfectly developed. But a man with defective labyrinths if blindfolded and placed in water so as to equalize the pressure on the body, becomes completely helpless and has no longer any notion of the position of his body in space.

The ceaseless activity of the labyrinth and its overwhelming influence on the posture of the body is shown most clearly from the effects of destruction of one labyrinth leaving the other intact. Bilateral destruction will not produce a serious disturbance of equilibrium unless the other sense organs (eyes, body wall,

muscles, etc.) are out of action as well, but unilateral destruction allows the nervous system to be subjected to the labyrinthine stimuli from one side only and the result is a gross distortion of posture often combined with violent rolling movements of the body about its long axis. The sudden convulsive attacks of Menière's disease are due to the same lack of balance between the two labyrinths in patients with disease of the inner ear.

It is generally supposed that the labyrinth acts by signalling (a) the pull of gravity on the otoliths of the saccule and utricle and (b) the movement of fluid past the cristae of the semi-circular canals caused by angular or linear acceleration of the head, the otolith organs being responsible for the steady posture of the animal at rest and the semi-circular canals for the balancing of the body in movement. This view was based on the earlier work of Breuer and Mach, and until recently it seemed to be confirmed, for mammals at least, by the experiments of Magnus and de Kleijn in which the otolith organs were destroyed without injury to the semi-circular canals. But the latest results tend to show that it is not possible to draw a clear distinction between the static and dynamic apparatus of the labyrinth, for there is evidence of preservation of the static reactions in mammals after the otolith organs have been destroyed. This agrees with the observations of Maxwell in fish, where either otoliths or semi-circular canals can be put out of action without producing any marked disturbance of equilibrium either at rest or in motion. For the present, therefore, we must be content to take the labyrinth as a whole without attempting to draw a sharp distinction between the functions of the otoliths and the canals.

Apart from the eyes and the labyrinths, the nervous system is continually receiving messages from the sense organs in the muscles, tendons and joints and from those responsive to pressure and touch. The former group signal the position of the head and limbs in relation to the body and the amount of tension each muscle is exerting. The latter show where the weight is resting.

The nervous mechanism for co-ordinating these sensory messages is centered in the brain stem just below the cerebral hemispheres. Both the cerebrum and the cerebellum may be removed without interfering with the balancing power of an animal as high in the scale as a cat or dog, but no trace of any posture, normal or abnormal, remains if the brain stem is destroyed down to the level of the medulla (*see* fig. 2). If only the upper part of the brain stem is destroyed, the nervous mechanism is seriously damaged, but it is still able to produce something like a co-ordinated posture. The limbs are rigidly extended and the trunk arched backwards so that the animal would be in something like its normal standing position if it were placed on its feet. This condition is known as "decerebrate rigidity" and Sherrington's investigation of it and appreciation of its meaning has been the starting point of the whole analysis of the postural mechanism carried out recently by Magnus.

In decerebrate rigidity the only postural reactions which remain are of no use to the animal. The extended position of the limbs is retained for hours, but the animal cannot stand by itself and makes no attempt to change its position if placed on its back or side. Yet there is no doubt that the posture of decerebrate rigidity is brought about by the same nervous mechanism (or what remains of it) as that normally responsible for the act of standing. The same muscles are brought into play and the force of contraction in the different muscles depends in the same way on sensory messages from the labyrinths and from the muscles themselves. Thus a change in the position of the head relative to the ground alters the distribution of the rigidity owing to the stimulation of the labyrinths, and the amount of contraction in each muscle is governed by the sensory impulses arising from it, so that the pull is just adequate to the load.

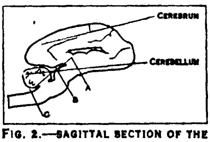

FIG. 2.—SAGITTAL SECTION OF THE BRAIN OF A CAT

Section at A leaves postural reactions intact; section at B gives decerebrate rigidity, and at C abolishes all reactions except those from neck muscles

There is one group of sensory impulses from muscles which has a special influence on the distribution of the rigidity and plays an important part in the normal posture. These are the impulses arising from sense organs in the muscles of the neck. If the head is bent out of its normal position relative to the trunk one or other set of neck muscles will be stretched, the sense organs in the muscle will be stimulated and so any deviation from the normal relation of head and body will be signalled at once to the brain. The effect of these impulses can be seen most clearly after the destruction of the labyrinths, since these also will be stimulated by head movements. When the labyrinths are destroyed it is found that bending the head into any position will modify the posture of the body and limbs, usually in such a way as to bring the trunk into line with the head. For instance, if the head is bent upwards the rigidity increases in the fore limbs and diminishes in the hind limbs, so that the animal squats on its haunches with the body inclined upwards in line with the head; if the head is rotated, the extension of the limbs increases on the side towards which the jaw is turned, so that the body tends to rotate on its long axis in the same direction as the head.

The discovery of these reactions arising from the neck muscles in decerebrate rigidity provided the clue to the analysis of the postural reactions in animals with the brain stem intact. We have seen that an animal suspended in mid air brings its head into the normal position owing to impulses from the labyrinths reinforced in some cases by the eyes. This initial righting of the head will bend the neck and start a fresh set of sensory impulses from the neck muscles, and these will produce the movements needed to bring the body into line with the head. Thus the position of the head in relation to the earth is determined by the labyrinths and the position of the body is determined by that of the head.

In an animal with the brain stem intact, these two sets of reflexes enable the animal to regain its normal posture; they do not merely indicate how it might be regained, as they do in decerebrate rigidity. A third set of reflexes also appears when the brain stem is intact, reflexes arising from unequal stimulation of the body wall and enabling the animal to bring its body into the normal position even though the head is prevented from righting itself. These are not equally developed in all animals; it is well known, for instance, that the best way to keep a horse lying on its side is to sit on its head. Here the body is not righted independently, though righting movements follow once the head is released.

By the co-operation of these reflexes an animal with intact brain stem can bring its body into the normal standing posture. To maintain its equilibrium during movement a further series of reflexes comes into play depending partly on impulses from the eyes and labyrinths and partly on impulses from the muscles. Many of these have been worked out in detail and, as before, the nervous control is carried out by the brain stem.

There is, however, a vast difference between the behaviour of an intact animal and one deprived of its cerebrum. The latter can stand, walk and run and it may even show some spontaneous activity, but it has none of the variety of movement of a normal animal. When the cerebrum is absent, the maintenance of equilibrium is the dominating activity; when it is intact an animal like a dog or a cat can lie on its side and turn its head in all directions without turning its body. The postural reactions are no longer dominant though the animal is still dependent on them for its normal equilibrium. The greater the development of the cerebral hemispheres the less easy does it become to trace the sequence of reactions involved in balancing the body, and in man, though it is possible to detect the postural reflexes from the labyrinths, eyes and neck muscles, there is none of the mechanical obedience to them which we find in a guinea pig or a rabbit. For the adjustments necessary when movement is so largely controlled by the cerebrum, the brain stem mechanism is probably reinforced by the cerebellum which is closely linked with it and with the cerebrum.

The exact function of the cerebellum is still to some extent a puzzle, for its removal in a normal animal causes gross incoordination and no other symptoms, yet in an animal with the cerebrum destroyed the presence or absence of the cerebellum

makes no difference. The explanation appears to be that in the higher mammals the cerebellum has become a subordinate part of the cerebral apparatus and so has little function when the cerebral control is removed. Until we know more of the cerebellar mechanism, the finer details of muscular adjustment will remain uncertain, and this applies particularly to the balancing reactions which are acquired after infancy; *e.g.*, those involved in riding a bicycle. But the basic reactions of equilibrium are those of the brain stem and their analysis has already shown what may be achieved by the co-operation of a few fairly simple reflexes.

For equilibrium of forces, etc., *see* MECHANICS; for chemical equilibrium *see* CHEMICAL ACTION; for other forms of physical equilibria *see* RADIATION, THEORY OF; THERMODYNAMICS; RADIOACTIVITY. (E. D. A.)

EQUINOX, a term used to express either the moment at which, or the point at which, the sun apparently crosses the celestial equator. (From the Lat. *aequus*, equal, and *nox*, night.) Since the sun moves in the ecliptic, it is in the last-named sense the point of intersection of the ecliptic and the celestial equator. This is the usual meaning of the term in astronomy. There are two such points, opposite each other, at one of which the sun crosses the equator toward the north and at the other toward the south. They are called vernal and autumnal respectively, from the relation of the corresponding times to the seasons of the northern hemisphere. The line of the equinoxes is the diameter of the celestial sphere which joins them. The vernal equinox, alternatively called the First Point of Aries, is the initial point from which the right ascensions and the longitudes of the heavenly bodies are measured (*see* ASTRONOMY; *Spherical;* also PRECESSION OF THE EQUINOXES).

Equinoctial Gales.—At the time of the equinox it is commonly believed that strong gales may be expected. This popular idea has no foundation in fact, for continued observations have failed to show any unusual prevalence of gales at this season. In one case observations taken for 50 years show that during the five days from March 21 to 25, and from September 21 to 25, there were fewer gales and storms than during the preceding and succeeding five days.

EQUITABLE DEFENCE, in English law, the defence made in a court of equity, differing from the defence made in a court of law, in that it requires equitable jurisdiction, as in cases of fraud (*see* EQUITY).

EQUITABLE TRUST COMPANY OF NEW YORK, THE, founded on April 19, 1871, as the Traders Deposit Company, began business with an authorized capital of $50,000. In 1902 the name was changed to The Equitable Trust Company of New York and its activities extended to include every banking and trust function. On April 2, 1902, the paid-in capital stock was increased to $1,000,000 and in 1903 to $3,000,000. Subsequent growth in capitalization has been as follows: (1917) $6,000,000; (1919) $12,000,000; (1922) $20,000,000; (1923) $23,000,000; (1926) $30,000,000. The Equitable Trust Company has developed into a bank of world-wide connections with capital, surplus and undivided profits of over $50,000,000 and total resources of over $500,000,000. It recently erected a 42 storey bank and office building at 11 Broad street, New York. The bank's activities include every form of domestic and foreign banking service, personal and corporate fiduciary service and bond investment service. Subsidiary companies are the Equitable Eastern Banking Corporation, handling the company's Far East business; The Equitable Securities Co. Inc. and The Equitable Safe Deposit Company of New York. (A. W. L.)

EQUITES (Lat. *eques*, a horseman), originally a division of the Roman army, but subsequently a political order. Romulus is said to have instituted a patrician cavalry corps, consisting of three *centuriae* ("hundreds"), called after the three tribes from which they were taken (Ramnes, Tities, Luceres). Servius Tullius found six centuries in existence, to which he added 12, including plebeians, making 18 in all, a number which remained unchanged throughout the republican period. In the early constitution the *equites* had the privilege of leading the voting, but after 220 B.C. the *centuria praerogativa,* which enjoyed that right, was selected by lot from the *equites* and the *prima classis*.

Origin of the Order.—Although the *equites* were selected from the wealthiest citizens, service in the cavalry was so expensive that the state gave financial assistance (*aes equestre, aes hordearium*); hence the name *equites equo publico*. In later times, pay was substituted for the *aes hordearium,* three times as much as that of the infantry.

As the demands upon the services of the cavalry increased, it was decided to supplement the regulars by the enrolment of wealthy citizens who kept horses of their own. The origin of these *equites equo privato* dates back, according to Livy (v. 7), to the siege of Veii, when a number of young men came forward and offered their services. In later times vacancies in the ranks were filled in this manner, with the result that service in the cavalry, with either a public or a private horse, became obligatory upon all Roman citizens possessed of a certain income. Thus, at a comparatively early period, three classes of equites may be distinguished: (a) The patrician equites *equo publico* of the *sex suffragia*; (b) the plebeian equites in the twelve remaining centuries; (c) the equites *equo privato,* both patrician and plebeian.

The *equites* were chosen by the *curiae*, then in succession by the kings, by the consuls, and (after 443 B.C.) by the censors, by whom they were reviewed every five years in the Forum. Those whose physique and character, horses, and equipments were satisfactory, were bidden to lead their horse on (*traducere equum*), those who failed to pass the scrutiny were expelled from the corps. This inspection (*recognitio*) must not be confounded with the procession (*transvectio*) on July 15 from the temple of Mars to the temple of Castor, to commemorate the miraculous intervention of Castor and Pollux at the battle of Lake Regillus. Inspection and procession were discontinued before the end of the republic, but revived and combined by Augustus.

In theory, the twelve plebeian centuries were open to all free born youths of the age of seventeen, although in practice preference was given to the members of the older families. Other requirements were sound health, high moral character and an honourable calling. At the beginning of the republican period senators were included in the equestrian centuries. The only definite information as to the amount of fortune necessary for an *eques* refers to later republican and early imperial times, when it is known to have been 400,000 sesterces (about £3,500 to £4,000). The insignia of the *equites* were at first military—such as the purple-edged, short military cloak (*trabea*).

Later Development.—With the extension of the Roman dominions, the *equites* lost their military character. They remained at home, or only went out as members of the general's staff, their places being taken by the cavalry of the allies and subject populations. There grew up in Rome a class of wealthy men, who amassed large fortunes by speculation, and who handled state contracts and the farming of the public revenues. These tax-farmers (*see* PUBLICANI) were already in existence at the time of the second Punic War; their numbers and influence increased as provinces were added to the Roman dominions. The change of the *equites* into a body of financiers was promoted (a) by the lex Claudia (218 B.C.), which prohibited senators from engaging in commercial pursuits; (b) by the enactment in the time of Gaius Gracchus (*q.v.*) excluding members of the senate from the equestrian centuries. These two measures distinguished the landed aristocracy from the capitalists. The term *equites* came to be applied to all who possessed the property qualification of 400,000 sesterces.

As the *equites* monopolized the farming of the taxes, they came to be regarded as identical with the *publicani* not, as Pliny remarks, because any particular rank was necessary to secure a concession for farming the taxes, but because such an occupation was beyond the reach of all except those who were possessed of considerable means. At the time of the Gracchi, these *equites-publicani* formed a close financial corporation, keenly alive to their own interests. Although looked down upon by the senate, they had as a rule sided with it, as less hostile to them than the democratic party. To obtain the support of the capitalists, Gaius

Gracchus handed over to them the control (a) of the jury-courts, and (b) of the revenues of Asia.

(a) Hitherto, the list of jurymen, civil and criminal, had been composed exclusively of senators. The result was that charges of corruption and extortion failed, when brought against members of that order, even in cases where there was little doubt of their guilt. Popular indignation rendered a change in the composition of the courts imperative. By the *lex Sempronia* (123 B.C.) the list was drawn from free men over thirty years of age, who must possess the equestrian census and must not be senators. This measure increased the burden of the provincials, whose only appeal lay to a body of men whose interests were identical with those of the *publicani*. Provided he left the tax-gatherer alone, the governor might squeeze what he could out of the people, while on the other hand, if he were humanely disposed, it was dangerous for him to remonstrate.

(b) The taxes of Asia had formerly been paid by the inhabitants in a fixed sum. Gracchus ordered that the taxes should be increased, and that the farming of them should be put up to auction at Rome. By this arrangement everything was left in the hands of the capitalists.

From this time the existence of the equestrian order was officially recognized. The *ordo iudicum* (the official title) and the *ordo equester* were regarded as identical. Certain privileges of the *equites*, the gold ring, special seats in the theatre and the narrow band on the tunic, were probably due to Gracchus.

In 82 B.C. Sulla restored the right of serving as *iudices* to the senate, to which he elevated 300 of the most influential *equites*, whose support he thus hoped to secure. By the *lex Aurelia* (70 B.C.) the *iudices* were chosen in equal numbers from senators, *equites* and *tribuni aerarii* (*see* AERARIUM), the last-named being closely connected with the *equites*. About this time the influence of the equestrian order reached its height, and Cicero's great object was to reconcile it with the senate. In this he was successful at the time of the Catilinarian conspiracy. But the union did not last long; shortly afterwards the majority ranged themselves on the side of Julius Caesar, who did away with the *tribuni aerarii* as *iudices*, and replaced them by *equites*.

The Equites under the Empire.—Augustus undertook the thorough reorganization of the equestrian order on a military basis. The term *equites* was officially limited to the *equites equo publico*, although all who possessed the property qualification were still considered to belong to the "equestrian order." For the *equites equo publico* high moral character, good health, and the equestrian fortune were necessary. Although free birth was considered indispensable, the right of wearing the gold ring (*jus anuli aurei*) was frequently bestowed by the emperor upon freedmen, who thereby became *ingenui* and eligible as equites. Tiberius, however, insisted upon free birth on the father's side to the third generation. Extreme youth was no bar; the emperor Marcus Aurelius had been an eques at the age of six. The sons of senators were eligible by right of birth, and appear to have been known as *equites illustres*. The right of bestowing the *equus publicus* was vested in the emperor; once given, it was for life, and was only forfeitable through degradation for some offence, or the loss of the equestrian fortune.

Augustus divided the *equites* into six *turmae* (troops), each under the command of a *sevir*, who was appointed by the emperor. During their term of command the *seviri* had to exhibit games (*ludi sevirales*). It is not known whether the *turmae* contained a fixed number of *equites;* Augustus certainly went far beyond the earlier figure of 1,800. Thus, Dionysius of Halicarnassus mentions 5,000 *equites* as taking part in a review at which he himself was present. The old insignia were retained and seats in the circus added to those in the theatre. The old *recognitio* was replaced by the *probatio*, conducted by the emperor assisted by an advisory board of senators. The ceremony was combined with a procession, which, like the earlier *transvectio*, took place on July 15. As in earlier times, offenders were punished by expulsion. The *equites* were required to serve in certain subordinate posts; *e.g.*, the command of an auxiliary cohort, the tribunate of a legion, etc., on the nomination of the emperor. After this they were eligible for a number of positions, civil and military, chiefly those under the emperor's personal control. Their influence over taxation was greatly reduced, while their judicial authority increased owing to the imperial jealousy of the senate. Certain minor religious functions were reserved to them, and they were eligible for official posts of which it would have been unwise to deprive senators.

The control of the imperial correspondence and purse was at first in the hands of freedmen and slaves. The Emperor Claudius entrusted certain posts connected with these to the *equites;* in the time of Hadrian this became the regular custom. Thus a civil career was open to the *equites* without the obligation of preliminary military service, and the emperor was freed from the pernicious influence of freedmen. After the reign of Marcus Aurelius, equestrian officials were divided into: (a) *viri eminentissimi*, the prefects of the praetorian guard; (b) *viri perfectissimi*, the other prefects and the heads of the financial and secretarial departments; (c) *viri egregii*, first mentioned in the reign of Antoninus Pius, a title by right of the procurators generally. The power of the *equites* was at its highest in the time of Diocletian. After the transference of the capital to Constantinople, they sank to the position of a mere city-guard, under the control of the prefect of the watch. Their history may be said to end with the reign of Constantine the Great.

Mention may also be made of the *equites singulares Augusti*. The body-guard of Augustus, consisting of foreign soldiers (chiefly Germans and Batavians), abolished by Galba, was revived from the time of Trajan or Hadrian under the above title. It was chiefly recruited from the pick of the provincial cavalry, but contained some Roman citizens. It never left the city except to accompany the emperor. In the time of Severus, these *equites* were divided into two corps, each having its separate quarters, and was commanded by a tribune under the orders of the prefect of the praetorian guard. They were subsequently replaced by the *protectores Augusti*. *See* ROME: *History*.

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EQUITY. The term equity has two meanings, one professional, the other popular. When lawyers speak of equity they are thinking merely of that part of the law of England which is derived not from the custom of the realm nor the enactments of parliament but from the decisions of the old court of chancery. On the other hand, when the man in the street talks of equity he is thinking of ideal justice which is not regulated by the law and may be even contrary to the law. The popular meaning of equity is that which it originally bore in the court of chancery.

Fictions.—Sir Henry Maine has classified the agencies by which primitive law has been adapted to the requirements of an advancing society and an improving morality according to the order in which these agencies most forcibly exert their influence. First come fictions by which unavowed reforms of the primitive law are brought about either by the courts applying the old law on the assumption that a state of facts exists which in fact does not exist or by their so interpreting the old law as to make it apply to matters it was never intended to cover. The common law courts relied much on fictions of both kinds. As an example of the first, down to the Judicature Act of 1873, the law was that a trespass was not actionable unless it was perpetrated *vi et armis*. Whether the trespass was committed *vi et armis* or not, the common law courts allowed the plaintiff to plead that it was and refused to let the defendant call evidence to show that it was not. As an example of the second, the Statute *in consimili casu*, which was intended by the legislature merely to enable courts to give remedies for new forms of tort, was so applied as to give remedies for promises based on valuable consideration by treating breaches of these as torts. Hence the whole law of simple contracts.

The common law courts never went beyond fictions as a means of reforming the law; the court of chancery never appealed to them. It appealed openly to abstract justice. The king, as *pater*

patriae, had a duty to see that none of his subjects was denied a remedy where conscience required that he should have one, and this duty he delegated to his chancellor who became the keeper of the king's conscience and kept that conscience clean by insisting that every litigant coming before him should act as a conscientious man should. Hence the maxim that the king's bench was a court of law but the court of chancery a court of conscience.

For generations equity consisted in whatever the chancellor or the masters of the rolls thought just in any particular case. No attention was paid to precedent or to principle; even in the time of the Stuarts, nobody thought a knowledge of law necessary for a chancellor. Sir Thomas More was the first professional lawyer chancellor. His successors were sometimes lawyers, sometimes priests and sometimes laymen. The last layman chancellor was the famous earl of Shaftesbury in the reign of Charles II.

Precedent.—A change, however, was impending. Before Shaftesbury's time young practitioners in the chancery had begun to report the court's decisions. As soon as this took place old practitioners began to cite to chancellor all the decisions of previous chancellors which favoured the decision they desired. When the facts were identical, the chancellor felt bound, as a rule, to follow the decisions of his predecessors. As lawyers became the only chancellors, the practice grew. Lord Nottingham in William's reign observed this practice; Lord Hardwicke, a generation later, established it as binding and Lord Eldon in his long chancellorship consolidated it as part of the law of the land. After the Eldon era equity may be said to have been hardened into a set of principles as unalterable by subsequent decisions as those of the common law.

A legal remedy is given *ex debito justiciae;* an equitable remedy is given by grace of the king. When a plaintiff asks the court to grant him his legal remedy he is demanding his legal right—the right which the law gives him. If he can prove facts which establish his right to the remedy, the court has no option but to give it. But the court is never obliged to give an equitable remedy. There the plaintiff (formerly called the suitor or petitioner) prays for a remedy he is not by law entitled to, and he is given it by grace of the king in obedience to conscience. The court before granting an equitable remedy enquires into the conduct of all parties to the action, and where it is not satisfied that justice requires it, refuses the remedy or grants it subject to conditions. Thus equitable remedies are always in the discretion of the court.

Stipulations in Equity.—The principles regulating the exercise of this discretion are now fairly well settled. One is that "he who seeks equity must do equity." Thus a debtor who seeks to recover securities which he has deposited with an unregistered money-lender to cover a loan must repay the loan, though it is a bad debt in law, before the court will assist him. Again, "he who comes into equity must come with clean hands." Thus a trustee who has in breach of trust, though honestly, paid trust money to one not entitled to it cannot recover the money back, as he would have to rely on what was his own breach of trust. Again, "delay defeats equity." The Statutes of Limitation do not *prima facie* apply to actions for equitable remedies, but if a person knowing he has a claim against another unduly delays enforcing his claim, the court will refuse to entertain his action. Again, the remedy of the common law for breaches of contract or torts was damages and damages mean compensation. This did not appear to equity to be satisfactory. It held that A must purge his conscience in the first case by carrying out his promise specifically (*e.g.*, to sell land) and in the second case by surrendering all profits he made through his wrong (*e.g.*, breach of copyright). In other words, the equitable remedies were specific performance of the contract and restitution of the wrongful gains. Again, common law never gave a remedy till a wrong was done. Equity was always willing, where possible, to prevent a defendant soiling his conscience by doing what was wrong. Sometimes it refused to interfere unless the person complaining did not apply to it before the wrong was done. Thus A has an ancient light over B's land. B begins to build on his land on a plan that if completed must obstruct A's lights. A can claim damages at law only after his light is actually obstructed, but ordinarily if he wants his equitable remedy by injunction he must apply for it before obstruction has taken place (see *Stanley* v. *Shrewsbury*, L.R. 19 Equity 616). Thus, often the equitable remedy comes to an end as soon as the legal remedy begins. Under Lord Cairns' Act, equity can now give equitable damages for a contemplated wrong. (See *Leeds Industrial Society Ltd.* v. *Slack*, 1924, A.C., 1924.)

It used to be said that equity followed the law, which amounted to no more than this: that it followed the law when it saw no good reason not to do so. This maxim seems on the way to being reversed. Recent legislation has been all tending towards making the law follow equity. Thus now all interests in lands, save fee simples and absolute leases, are declared to be equitable. Moreover, the old notion of equity as justice independent of law is returning in the shape of judicial discretions. To take one example: formerly a restraint upon anticipation prevented a married woman or anyone else from alienating her separate property during coverture. Whether it does so now or not depends on the discretion of the court. How that discretion will be exercised in any particular case no counsel can tell. Selden complained in his time that what was equity depended on the length of the chancellor's foot. It seems that before long what is law will depend on the state of the judge's digestion. *See* CHANCERY. (J. A. St.)

EQUIVALENT, in chemistry, the proportion of an element which will combine with or replace unit weight of hydrogen. When multiplied by the valency it formerly gave the atomic weight; in 1905, however, the standard for the calculation of atomic weights was changed from hydrogen = 1 to oxygen = 16. (*See* ATOMIC WEIGHTS; and CHEMISTRY.) In a more general sense the term "chemical equivalent" is used to denote quantities of elements, compounds or radicals which combine with, displace or in any way cause the migration of unit weight of hydrogen. This more extended conception of the term is fundamental in volumetric analysis and indicates the amounts of each reagent to be taken for a normal solution, as, for example, NaOH, HCl, $\frac{1}{2}H_2SO_4$, $\frac{1}{2}Ba(OH)_2$, $HgNO_3$, $\frac{1}{5}KMnO_4$, $\frac{1}{6}K_2Cr_2O_7$.

ERARD, SEBASTIEN (1752–1831), French manufacturer of musical instruments, distinguished especially for the improvements which he effected in the harp and the pianoforte, was born at Strasbourg on April 5, 1752. He constructed (1780) in Paris his first pianoforte, one of the first manufactured in France. He was soon overwhelmed with commissions, and sent for his brother, Jean Baptiste, in conjunction with whom he established in the rue de Bourbon, in the Faubourg St. Germain, his famous piano manufactory. On the outbreak of the Revolution he went to London where he continued to make pianos. Returning to Paris in 1796, he began to build grand pianofortes, made in the English fashion, with improvements of his own. In 1808 he again visited London, where, two years later, he produced his first double-movement harp. In 1812 he returned to Paris where, in 1823, he crowned his work by producing his model grand pianoforte with the double escapement. He died at Passy on Aug. 5, 1831. (*See* also HARP and PIANOFORTE.)

ERASISTRATUS, *fl.* 300 B.C., Alexandrian anatomist, was born at Chios, and lived first at the court of Nicanor Seleucus and then at Alexandria, where he formed a school of anatomy. Like Herophilus, he traced the origin of the nerve trunks to the brain and distinguished sensory and motor nerves. But unlike Herophilus, he rejected the old humoral pathology and supposed that the arteries contained pneuma or "vital spirits" which, when it escapes, allows the blood to flow from the veins into the arteries, thus making it possible for the arteries to bleed. Any hindrance in the action of the pneuma, or any overflow of the blood into the arteries, resulted in disease, yet, curiously enough, he did not advocate blood-letting. Erasistratus is to be credited with a detailed knowledge of the convolutions of the brain, the investigation of the bile, spleen and liver, and of the anatomy of the heart, the naming of the trachea, and the invention of a catheter.

ERASMUS, DESIDERIUS (?1466–1536), the greatest humanist of the Renaissance, theologian, was born on the night of the 27/28 of October, probably in 1466; but his statements about his age are conflicting, and in view of his own uncertainty (*Ep.* x. 29, 466) the year of his birth cannot be definitely fixed.

His father's name seems to have been Rogerius Gerardus. He himself was christened Herasmus; but he assimilated the name to a fancied Greek original, which he Latinized into Desyderius. He styled himself Desiderius Erasmus Roterodamus (*Adagia*, 2nd ed., Paris, 1906), and believed that he was born at Rotterdam, though a contemporary tradition assigned Gouda, his father's native place, as the place of his birth[1].

His first schooling was at Gouda under Peter Winckel, who was afterwards vice-pastor of the church. In the dull round of "grammar" he was surpassed by his early friend and companion, William Herman. From Gouda the two boys went to the school attached to St. Lebuin's church at Deventer, which was one of the first in northern Europe to feel the influence of the Renaissance. Erasmus was there from 1475 to 1484, and when he left, had learnt from Johannes Sinthius (Syntheim) and Alexander Hegius, who had come as headmaster in 1483, the love of letters which was the ruling passion of his life. At some period, perhaps in an interval of his time at Deventer, he was a chorister at Utrecht under the famous organist of the cathedral, Jacob Obrecht.

About 1484 Erasmus' father died, leaving him and an elder brother Peter, both born out of wedlock, to the care of guardians, their mother having died of plague shortly before. Erasmus was eager to go to a university, but the guardians sent the boys to another school at Hertogenbosch to be prepared for a monastic life; the discipline was severe, directed to the subjugation of the spirit, and inspired Erasmus with a hatred of the pedagogic method of the day. Peter entered the monastery of Sion, near Delft; Erasmus after prolonged reluctance became an Augustinian canon in St. Gregory's at Steyn, a house of the same chapter near Gouda. There he seems to have been allowed to read the classics and the Fathers with his friends to his heart's content, and he formed a close friendship with Servatius Roger of Rotterdam. The monastery once entered, there was no drawing back; and Erasmus passed through the various stages which culminated in his ordination as priest on April 25, 1492.

The young humanist found a patron in Henry of Bergen, bishop of Cambrai; and about 1494 permission was obtained for him to leave Steyn and become Latin secretary to the bishop. Erasmus found the life of a court unfavourable to study. His friend, James Batt, a schoolmaster of Bergen, secured for him an opportunity to go to Paris university. The bishop consented and promised a small pension; and in August 1495 Erasmus entered the "domus pauperum" of the college of Montaigu, then under the rule of Jan Standonck, a leader of the *devotio moderna*, the Dutch movement for the purification of the monastic orders. Erasmus made the acquaintance of Robert Gaguin (1425–1502) and published a small volume of poems; and he became intimate with Johann Mauburnus (Mombaer). But the severe régime at Montaigu with its abstinence and discomfort was too hard for him. Every Lent he fell ill and had to return to Holland to recover. On his return to Paris in 1496, he lodged in the town, and took pupils. He was now occupied with some of the works which, later, made his fame; to this period belong the first drafts of the *Colloquies* and the *De Conscribendis Epistolis*.

Erasmus was then, and for a long time to come, dependent on the benevolence of patrons for the leisure he needed to satisfy his ardent craving for learning. The faithful Batt had sought a pension for him from Anne of Borsselen, the Lady of Veere, whose son Batt was now teaching. But as nothing promised at once, Erasmus accepted an invitation from one of his Paris pupils, William Blount, 4th Baron Mountjoy, to whom he was much attached, to visit England (1499–1500). In October he went to Oxford, where he found John Colet lecturing on the Epistle to the Romans. In Colet he found a kindred mind, and to Colet's influence must be ascribed the decision he then took to make serious theological study the real work of his life. He was happy in England, where he associated with Linacre Grocyn and More, as well as with Colet. Unfortunately a tiresome incident destroyed part of his happy impressions, for the small sum of money he had amassed in England was taken from him by the customs officer at Dover, as the law allowed no money to leave the country. Consequently he arrived in Paris (Jan. 1500) as poor as he left it.

In Paris he supported himself by pupils' fees and the dedications of books: the *Collectanea adagiorum*, a collection of short sayings from classical authors, in June 1500 to Mountjoy, and some devotional and moral compositions to Batt's patroness and her son. When the plague drove him from Paris, he went to Orleans or Tournehem or St. Omer, as the way opened. From 1502 to 1504 he was at Louvain, still declining to teach publicly; among his friends being the future Pope Adrian VI. He had been working hard at Greek, at the Fathers (above all at Jerome), and at the Epistles of St. Paul, fulfilling the promise made to Colet in Oxford, to give himself to sacred learning. But the bent of his reading is shown by the manuscript with which he returned to Paris at the close of 1504—Valla's *Annotations on the New Testament*, which Badius printed for him in 1505. In 1504 appeared at Antwerp his *Enchiridion Militis Christiani*. The book shows clearly the bent of his mind. It was a plea for a return to the source of Christianity in its primitive simplicity. He did not condemn, but he left aside as irrelevant the complicated mass of dogma and ceremonial of the church; he would return to the Bible and the early Fathers for the interpretation of Christian duty and Christian doctrine.

IN ENGLAND AND ITALY

In the autumn of 1505 Lord Mountjoy invited him again to England. He was introduced to William Warham, archbishop of Canterbury, Richard Foxe, bishop of Winchester and others. At length the opportunity came to fulfil his dream of seeing Italy. Baptista Boerio, the king's physician, engaged him to accompany his two sons thither as supervisor of their studies. In September 1506 he set foot on that sacred soil, and took his D.D. at Turin. For a year he remained with his pupils at Bologna, and then, his engagement completed, negotiated with Aldus Manutius at Venice for a new edition of his *Adagia* upon a very different scale. The volume of 1500 had been jejune, written when he knew nothing of Greek; 800 adages put together with scanty elucidations. In 1508 he had three thousand and more collected and gave the work a new title—*Chiliades adagiorum*.

To print the *Adagia* he had gone to Venice, where he lived with Andrea Torresano of Asola (Asulanus) and did the work of two men, writing and correcting proof at the same time. When it was finished, with an ample re-dedication to Mountjoy, a new pupil presented himself, Alexander Stewart, natural son of James IV. of Scotland—perhaps through a connection formed in early days at Paris. They went together to Siena and Rome and then on to Campania. When they returned to Rome, his pupil departed to Scotland; Erasmus also found a summons from Lord Mountjoy to England. At first Erasmus hesitated. He had made many friends in Aldus's circle—Marcus Musurus, John Lascaris, Baptista Egnatius, Paul Bombasius, Scipio Carteromachus; and his reception had been flattering, especially in Rome. In Rome he might have had the leisure which was so indispensable, but at price of the freedom to read, think, write what he liked. He decided, therefore, to go, though with regrets.

In the autumn he reached London, and in Thomas More's house in Bucklersbury wrote the witty satire which Milton found "in every one's hands" at Cambridge in 1628. The *Moriae encomium* remains the most read of the works of Erasmus, though he, himself, regarded it as of slight importance. In it kings and princes, bishops and popes alike are shown to be in bondage to Folly; and no class of men is spared. Its author was willing to be beholden to any one for leisure; but he would be no man's slave. For the next eighteen months he is lost to view; when he reappears in April 1511, he is leaving More's house and taking the *Moria* to be printed privily in Paris. Wherever they were spent, these must have been months of hard work. The long preparation and training, bought by privation and uncongenial toil, was over, and he was ready to apply himself to the scientific study of sacred letters. His English patrons were liberal. Fisher

[1]Erasmus himself possibly made his parent's story more romantic than it really was. His allusions to it supplied Charles Reade with the starting point for the novel he wrote on the troubled background of the day, *The Cloister and the Hearth*.

sent him in August 1511 to teach in Cambridge; Warham gave him a benefice, Aldington in Kent, and in violation of his own rule commuted it for a pension of £20 charged on the living; and the dedications of his books were fruitful. In Cambridge he completed his work on the New Testament, the Letters of Jerome, and Seneca; and then in 1514 he removed to Basle to superintend the publication of his works. The last few months spent in England had seen the production, generally supposed to be his, of the *Julius Exclusus*, the satire on the lately-deceased warrior pope, Julius II.

The origin of Erasmus's connection with Johann Froben is not clear. In 1511 he was preparing to reprint his *Adagia* with Jodocus Badius, who was also to have Seneca and Jerome. But in 1513 Froben, who had just reprinted the Aldine *Adagia*, acquired through a bookseller-agent Erasmus's amended copy which had been destined for Badius. Within a few months Erasmus went to Basle, bearing with him Seneca and the *Letters* of Jerome, the latter to be incorporated in the great edition which Johannes Amerbach and Froben had had in hand since 1510. In Germany he was widely welcomed and fêted. Through the winter of 1514–1515 Erasmus worked with the strength of ten; and after a brief visit to England in the spring, he had printed his New Testament containing the Greek text, with notes, and his own new Latin translation. It was dedicated to Pope Leo X., who accepted the dedication. Around him was a circle of students—the three sons of Froben's late partner, Johannes Amerbach, Beatus Rhenanus, Wilhelm Nesen, Ludwig Ber, Heinrich Glareanus, Nikolaus Gerbell, Johannes Oecolampadius—who were proud to serve him.

Though from this time forward Basle became the centre of occupation and interest for Erasmus, yet for the next few years he was mainly in the Netherlands. On the completion of the New Testament in 1516 he returned to his friends in England; but his appointment, then recent, as councillor to the young king Charles, brought him back to Brussels in the autumn. In 1514 he had refused a summons to return to his monastery at Steyn, and in the spring of 1517 he went for the last time to England, to receive a dispensation from wearing his canonical dress, obtained originally from Julius II. and recently confirmed by Leo X., and in 1518 he spent three months in Basle to set the second edition of the New Testament in progress. He lived much at Louvain, where he took great interest in the foundation of Hieronymus Busleiden's Collegium Trilingue. He was now at the height of his fame. The general ardour for the restoration of the arts and of learning created an aristocratic public, of which Erasmus was supreme pontiff. Luther spoke to the people and the ignorant; Erasmus had the ear of the educated class. His friends and admirers were distributed over all the countries of Europe, and his letters, those witty and humane letters which mirror the man's tolerant, liberal mind, were coveted by scholars and princes. He received many rich presents, and with these and the proceeds of his works, lived comfortably, though not luxuriously. The excessive delicacy of his constitution exacted some unusual indulgences. He could not bear the stoves of Germany, and required an open fireplace in the room in which he worked. He was afflicted with the stone, and obliged to be particular as to what he drank. Beer he could not touch. The white wines of Baden or the Rhine did not suit him; he could only drink those of Burgundy or Franche-Comté. He could neither eat, nor bear the smell of, fish. "His heart," he said, "was Catholic, but his stomach was Lutheran." For his constant journeys he required two horses, one for himself and one for his attendant. And he had to maintain amanuenses and couriers. Nevertheless he refused offers of preferment from many countries, because he was determined, at all costs, to maintain his liberty.

In November 1521 he settled permanently at Basle, as general editor and literary adviser of Froben's press. As a subject of the emperor, and attached to his court by a pension, it would have been convenient to him to have fixed his residence in Louvain. But the atmosphere of the university, overrun with Dominicans and Franciscans, united for once in their enmity to the new classical learning, inclined Erasmus to Basle. During the years of Erasmus's co-operation the Froben press took the lead of all the presses in Europe, both in the standard value of the works published and in typographical execution. The series of the Fathers alone issued from it contains Jerome (1516), Cyprian (1520), Pseudo-Arnobius (1522), Hilarius (1523), Irenaeus (Latin, 1526), Ambrose (1527), Augustine (1528), Chrysostom (Latin, 1530), Basil (Greek, 1532, the first Greek author printed in Germany), and Origen (Latin, 1536). In these editions, partly texts, partly translations, it is impossible to determine the respective shares of Erasmus and his many helpers. The prefaces and dedications are all written by him, and some of them, as that to the Hilarius, are of importance for the history of the times and of Erasmus.

In this "mill," as he calls it, Erasmus continued to grind incessantly for eight years. Besides his work as editor, he was always writing himself some book or pamphlet called for by the event of the day, by some general fray in which he was compelled to mingle, or by some personal assault which it was necessary to repel. These years at Basle saw a revised edition of the *Colloquies* (1522), and he continued to add to the book until the *Familiarum Colloquiorum Opus* in its final state (1526) contained twenty more dialogues. He also wrote at this time homiletic works, and the *Institutis Christiani Matrimonii* for Catherine of Aragon. He was besieged for dedications, and for letters. "I receive daily," he writes, "letters from remote parts, from kings, princes, prelates and men of learning, and even from persons of whose existence I was ignorant." Meanwhile he steadily refused to take definite sides against Luther, though he repeatedly said he was not acquainted with him and his works, and that his business was with the revival of letters. In 1524 the steady pressure on him induced him at last to enter into controversy with Luther. He chose a point on which they must always differ. Erasmus, whose life was spent in vindicating the dignity and liberty of the human spirit, would have nothing to do with the Lutheran determinism, and wrote the *De Libero Arbitrio* (1524), which drove Luther in *De Servo Arbitrio* to formulate his own doctrine more clearly.

Shortly after Froben's death (1527) the disturbances at Basle and the triumph of the reformers made it necessary for Erasmus to leave Basle in 1529. He selected Freiburg in the Breisgau, where he was received with public marks of respect by the authorities, who granted him the use of an unfinished palace intended for the late emperor Maximilian. Erasmus eventually bought a house of his own, and remained there six years. He returned to Basle in 1535. He lived now a very retired life, and saw only a small circle of intimate friends. A last attempt was made by the papal court to persuade him to declare against the Reformation. On the election of Paul III. in 1534, he had, as usual, sent the new pope a congratulatory letter. He received a complimentary answer, together with the nomination to the deanery of Deventer, the income of which was reckoned at 600 ducats, and an intimation that steps would be taken to provide for him the income, viz., 3,000 ducats, which was necessary to qualify for the cardinal's hat. The offer was made in the hope of obtaining the help of Erasmus as a mediator in the council projected to restore union in the Church. But Erasmus declined. In the winter of 1535–1536 he was confined entirely to his chamber, many days to his bed. He worked up to the end. His last letter is dated the 28th of June, 1536, and subscribed "Eras. Rot. aegra manu." He died on July 11, 1536, in his 70th year.

By his will, made on the 12th of February 1536, he left his fortune, with the exception of some legacies, to Bonifazius Amerbach, partly for himself, partly in trust for the benefit of the aged and the infirm, or to be spent in portioning young girls, and in educating young men of promise. He left none of the usual legacies for masses or other clerical purposes, and was not attended by any priest or confessor in his last moments.

PERSONALITY AND CHARACTER

Erasmus's features are familiar to all, from Holbein's many portraits or their copies. Beatus Rhenanus describes him as short of stature, but graceful in build. His complexion was fair; light blue eyes, and yellowish hair. Though his voice was weak, his enunciation was distinct; the expression of his face cheerful; his manner and conversation polished, affable, even charming. His

highly nervous organization made his feelings acute, and his brain incessantly active. Erasmus had many moods and each mood imprinted itself in turn on his words. Hence, on a superficial view, Erasmus is set down as the most inconsistent of men. Further acquaintance makes us feel a unity of character underlying this susceptibility to impressions. His seeming inconsistencies were the fruits of the many-sidedness of a highly impressible nature. In the words of J. Nisard, Erasmus was one of those "dont la gloire a été de beaucoup comprendre et d'affirmer peu."

This equal openness to every vibration of his environment is the key to the middle attitude which he adopted towards the religious conflict. He was accused by Catholics of collusion with the enemies of the faith. His powerful friends, the pope, Wolsey, Henry VIII., the emperor, called upon him to declare against Luther. Theological historians from that time forward have presented Erasmus in the odious light of a trimmer; yet it was not mere timidity or weakness which kept Erasmus neutral, but the reasonableness of his nature. His intellect revolted against the narrowness of party, and his whole being repudiated its clamorous and vulgar excesses. He loathed clerical fanaticism. And when out of Luther's revolt there arose a new fanaticism, Erasmus recoiled from the violence of the new preachers. "Is it for this," he writes to Melanchthon (*Ep.* xix. 113, 703), "that we have shaken off bishops and popes, that we may come under the yoke of such madmen as Otto and Farel?" In the words of Drummond: "Erasmus was in his own age the apostle of common sense and of rational religion. He did not care for dogma, and accordingly the dogmas of Rome, which had the consent of the Christian world, were in his eyes preferable to the dogmas of Protestantism. . . . From the beginning to the end of his career he remained true to the purpose of his life, which was to fight the battle of sound learning and plain common sense against the powers of ignorance and superstition, and amid all the convulsions of that period he never once lost his mental balance."

In the mind of Erasmus there was no metaphysical inclination; he was a man of letters, with a general tendency to rational views on every subject which came under his pen. He is at his weakest in defending free will against Luther, and indeed he can hardly be said to enter on the metaphysical question. He treats the dispute entirely from the outside. It is impossible in reading Erasmus not to be reminded of the rationalists of the 18th century. Erasmus has been called the "Voltaire of the Renaissance." But there is a vast difference in the relations in which they respectively stood to the church and to Christianity. Voltaire, though he did not originate, yet adopted a moral and religious scheme which he sought to substitute for the church tradition. He waged war, not only against the clergy, but against the church and its sovereigns. Erasmus drew the line at the first of these. He was not an anticipation of the 18th century; he was the man of his age, as Voltaire of his; though Erasmus did not intend it, he undoubtedly shook the ecclesiastical edifice in all its parts; and, as Melchior Adam says of him, "pontifici Romano plus nocuit jocando quam Lutherus stomachando." But though he remained Catholic and mourned the disruption, he was yet a true rationalist in principle. The principle that reason is the one only guide of life, the supreme arbiter of all questions, politics and religion included, has its earliest and most complete exemplar in Erasmus. He does not dogmatically announce the rights of reason, but he practically exercises them. Apart from the charm of style, the great attraction of the writings of Erasmus is this unconscious freedom by which they are pervaded.

In the annals of classical learning Erasmus may be regarded as intermediary between the humanists of the Latin Renaissance and the learned men of the age of Greek scholarship, between Angelo Poliziano and Joseph Scaliger. Erasmus, though justly styled by Muretus (*Varr.* Lectt. 7, 15) "eruditus sane vir, ac multae lectionis," was not a "learned" man in the special sense of the word—not an "érudit." He was a "man of letters"—the first who had appeared in Europe since the fall of the Roman empire. In editing a Father, or a classic, he had in view the practical utility of the general reader, not the accuracy required by the gild of scholars. It must be remembered that the commercial interests of Froben's press led to the introduction of Erasmus's name on many a title page when he had little to do with the book, *e.g.*, the Latin *Josephus* of 1524 to which Erasmus only contributed one translation of 14 pages; or the *Aristotle* of 1531, of which Simon Grynaeus was the real editor.

Of Erasmus's works the Greek Testament is the most memorable. Its influence upon opinion was profound and durable. As an edition of the Greek Testament it has no critical value. But it was the first, and it revealed the fact that the Vulgate, the Bible of the church, was not only a second-hand document, but in places an erroneous document. A shock was thus given to the credit of the clergy in the province of literature, equal to that which was given in the province of science by the astronomical discoveries of the 17th century. Even if Erasmus had had at his disposal the mss. subsidia for forming a text, he had not the critical skill required to use them. He had at hand a few late Basle mss., one of which he sent straight to press, correcting them in places by collations of others which had been sent to him by Colet in England. In four reprints, 1519, 1522, 1527, 1535, Erasmus gradually weeded out many of the typographical errors of his first edition, but the text remained essentially such as he had first printed it. The Greek text indeed was only a part of his scheme. An important feature of the volume was the new Latin version, the original being placed alongside as a guarantee of the translator's good faith. This translation, with the justificatory notes which accompanied it, became the starting-point of modern exegetical science. Erasmus did not solve the problem, but to him belongs the honour of having first propounded it.

Besides translating and editing the New Testament, Erasmus paraphrased the whole, except the Apocalypse, between 1517 and 1524. The paraphrases were received with great applause, even by those who had little appreciation for Erasmus. In England a translation of them made in 1548 was ordered to be placed in all parish churches beside the Bible. His correspondence is perhaps the part of his works which has the most permanent value; it comprises about 3,000 letters, which form an important source for the history of that period. For the same purpose his *Colloquia* may be consulted. They are a series of dialogues, written first for pupils in the early Paris days as formulae of polite address, but afterwards expanded into lively conversations, in which many of the topics of the day are discussed. Later in the century they were read in schools, and some of Shakespeare's lines are direct reminiscences of Erasmus.

His complete works have been printed twice; by the Froben firm under the direction of his literary executors (9 vols., Basle, 1540); and by Leclerc at Leiden (11 vols., 1703–06). The letters were edited by P. S. Allen (5 vols., 1906–12). For his life the chief contemporary sources are a *Compendium vitae* written by himself in 1524, and a sketch prefixed by Beatus Rhenanus to the Basle edition of 1540. Of his writings he gives an account in his *Catalogus lucubrationum,* composed first in January 1523 and enlarged in September 1524; and also in a letter to Hector Boece of Aberdeen, written in 1539. An elaborate bibliography, entitled *Bibliotheca Erasmiana* was undertaken by the officials of the Ghent University Library; it is divided into three sections, for Erasmus's writings, the books he edited, and the literature about him. *Listes sommaires* were issued in 1893; and since 1897 the completed volumes have been appearing at intervals. There is an excellent sketch of Erasmus's life down to 1519 in F. Seebohm's *Oxford Reformers* (3rd ed., 1887); and of the many biographies those by S. Knight (1726), J. Jortin (2 vols., 1758–1760) and R. B. Drummond (2 vols., 1873); Preserved Smith, *Erasmus, A Study of his Life, Ideals and Place in History* (Lond. and New York, 1923); J. Huizinga, *Erasmus* (New York, 1924) may be mentioned. There are also three volumes (1901–17) of translations by F. M. Nichols from Erasmus's letters down to 1517, with an ample commentary which amounts almost to a biography. *See* also P. S. Allen, *The Age of Erasmus* (Oxford, 1914); and Preserved Smith, *The Age of Erasmus* (New York, 1920). (M. PA.; X.)

ERASTUS, THOMAS (1524–1583), German-Swiss theologian, whose surname was Lüber, Lieber or Liebler, was born of poor parents on Sept. 7, 1524, probably at Baden, Aargau, Switzerland. His adopted name survives in the word "Erastian." He was physician to the count of Henneberg, Saxe-Meiningen, and in 1558 held the same post with the elector-palatine, Otto Heinrich, being at the same time professor of medicine at Heidelberg. His patron's successor, Frederick III., made him (1559) a privy councillor and member of the church consistory. In theology he followed Zwingli,

and at the sacramentarian conferences of Heidelberg (1560) and Maulbronn (1564) he advocated the Zwinglian doctrine of the Holy Communion, replying (1565) to the counter arguments of the Lutheran, Johann Marbach, of Strasbourg. He ineffectually resisted the efforts of the Calvinists, led by Caspar Olevianus, to introduce the Presbyterian polity and discipline, which were established at Heidelberg in 1570, on the Genevan model. One of the first acts of the new church system was to excommunicate Erastus on a charge of Socianianism, founded on his correspondence with Transylvania. The ban was not removed till 1575. In 1580 Erastus returned to Basel, where in 1583 he was made professor of ethics. He died on Dec. 31, 1583.

His name is permanently associated with a posthumous publication, written in 1568. Its immediate occasion was the disputation at Heidelberg (1568) for the doctorate of theology by George Wither or Withers, an English Puritan (subsequently archdeacon of Colchester), silenced (1565) at Bury St. Edmunds by Archbishop Parker. Withers had proposed a disputation against vestments, which the university would not allow; his thesis affirming the excommunicating power of the presbytery was sustained. Hence the Latin treatise of Erastus on excommunication, *Explicatio*, etc., published (1589) by Giacomo Castelvetri, who had married his widow. It consists of seventy-five *Theses,* followed by a *Confirmatio* in six books, and an appendix of letters to Erastus by Bullinger and Gualther, showing that his *Theses,* written in 1568, had been circulated in manuscript. An English translation of the *Theses,* with a brief life of Erastus (based on Melchior Adam's account), was issued in 1659, entitled *The Nullity of Church Censures;* it was reprinted as *A Treatise of Excommunication* (1682), and, as revised by Robert Lee, D.D., in 1844. The aim of the work is to show, on Scriptural grounds, that sins of professing Christians are to be punished by civil authority, and not by withholding of sacraments on the part of the clergy. In the Westminster Assembly a party holding this view included Selden, Lightfoot, Coleman and Whitelocke, whose speech (1645) is appended to Lee's version of the *Theses;* but the opposite view, after much controversy, was carried, Lightfoot alone dissenting. "Erastianism" denotes the doctrine of the supremacy of the state in ecclesiastical causes; but the problem of the relations between church and state is one on which Erastus nowhere enters. The only direct reply made to the *Explicatio* was the *Tractatus de vera excommunicatione* (1590) by Theodore Beza.

See A. Bonnard, *Thomas Éraste et la discipline ecclésiastique* (1894); Gass, in *Allgemeine deutsche Biog.* (1877); G. V. Lechler and R. Stähelin, in A. Hauck's *Realencyklop. für prot. Theol. u. Kirche* (1898).

ERATOSTHENES OF ALEXANDRIA (*c.* 276–*c.* 194 B.C.), Greek scientific writer, was born at Cyrene. He studied grammar under Callimachus at Alexandria, and philosophy under the Stoic Ariston and the Academic Arcesilaus at Athens, but returned to Alexandria as chief librarian. His two mathematical books *On means* (Περὶ μεσοτήτων), now lost, appear, from a remark of Pappus, to have dealt with "loci with reference to means." He devised a mechanical construction for two mean proportionals, reproduced by Pappus and Eutocius (Comm. on Archimedes). His *κόσκινον* or *sieve* (*cribrum Eratosthenis*) was a device for discovering all prime numbers. He laid the foundation of mathematical geography in his *Geographica.* His greatest achievement was his measurement of the earth. Being informed that at Syene (Assuan), on the day of the summer solstice at noon, a well was lit up through all its depth, so that Syene lay on the tropic, he measured, at the same hour, the zenith distance of the sun at Alexandria. He thus found the distance between Syene and Alexandria (known to be 5,000 stadia) to correspond to $\frac{1}{50}$ of a great circle, and so arrived at 250,000 stadia (which he seems subsequently to have corrected to 252,000) as the circumference of the earth. His *Erigone,* of which a few fragments remain, was probably a part of his astronomical poem *Hermes.*

Eratosthenes was the founder of scientific chronology in his *χρονογραφία* in which he endeavoured to fix the dates of the chief literary and political events from the conquest of Troy. An important work was his treatise on the old comedy, dealing with theatres and theatrical apparatus generally, and discussing the works of the principal comic poets themselves. Works on moral philosophy, history and a number of letters were also attributed to him.

The fragments were edited by Bernhardy (1822); poetical fragments, Hillier (1872); geographical, Seidel (1799) and Berger (1880); *τκαασταριςμοί*, Schaubach (1795) and Robert (1878). *See* Sandys, *Hist. Class. Schol.* (3rd ed. 1921).

ERBACH, a town of Germany, in the republic of Hesse, on the Mümling, 22 m. S.E. of Darmstadt. Pop. (1925) 3,466. It has long been the residence of the counts of Erbach, who trace their descent back to the 12th century. In 1532 the emperor Charles V. made the county a direct fief of the Empire. The county was mediatized in 1806.

Erbach has cloth mills and ivory-turning, for which last branch it possesses a technical school. Wool and cattle fairs are held twice a year. The castle contains an interesting collection of weapons and pictures, and in the chapel are the coffins of Einhard, the friend and biographer of Charlemagne, and his wife, Emma.

ERBIUM, a metallic element belonging to the rare-earth group. It was discovered in 1843 by Mosander who originally named the oxide terbia; the names terbia and erbia were interchanged a few years later by men working in this field. In 1878 Marignac separated erbium into erbium and "ytterbium," and in 1879 Soret and Cleve separated this purified erbium into holmium, erbium and thulium. Erbium occurs with its allied elements in the minerals gadolinite, euxenite, xenotime, etc. It has the symbol Er, atomic number 68, atomic weight 167·7. It is best separated by the crystallization of the bromates and by boiling the nitrate solution with sodium nitrite, when a basic erbium nitrate is precipitated before that of yttrium. Erbium forms a rose-pink oxide, Er_2O_3, which dissolves slowly in many acids, giving rose-coloured salts, solutions of which show a strong characteristic absorption spectrum. (*See* RARE EARTHS.)

ERCILLA Y ZÚNIGA, ALONSO DE (1533–1594), Spanish soldier and poet, distinguished himself in the campaign in Chile against the Araucanians, but, having quarrelled with one of his comrades, was condemned to death by his general, García Hurtado de Mendoza. The sentence was commuted to imprisonment, but Ercilla was speedily released and fought at the battle of Quiapo (Dec. 14, 1558). He returned to Spain in 1562 with the first 15 cantos of his epic poem, *La Araucana* (1569). Continuations appeared in 1578 and 1589-90. *La Araucana* reveals the qualities of an orator rather than a poet; it lacks symmetry and abounds in irrelevant episodes and mythological digressions. In spite of its defects, however, it remains the best artistic epic of its kind in Spain.

ERCKMANN-CHATRIAN, the joint name of two French writers who wrote in close collaboration. ÉMILE ERCKMANN (1822–1899) was born on May 20, 1822, at Phalsbourg and died at Lunéville on March 14, 1899. ALEXANDRE CHATRIAN (1826–1890) was born on Dec. 18, 1826 at Soldatenthal, Lorraine, and died at Villemomble, near Paris, on Sept. 3, 1890. In 1847 they began to write together, and continued doing so till 1889. They wrote *Histoires et contes fantastiques* (1849; reprinted from the *Démocrate du Rhin*), *L'Illustre Docteur Mathéus* (1859), *Madame Thérèse* (1863), *L'Ami Fritz* (1864), *Histoire d'un conscrit de 1813* (1864), *Waterloo* (1865), *Le Blocus* (1867), *Histoire d'un paysan* (4 vols., 1868–70), *L'Histoire du plébiscite* (1872), to *Le Grand-père Lebigue* (1880). Erckmann wrote some successful plays, among them being *Le Juif polonais* (1869) and *Les Rantzau* (1882). Without any special literary claim, the Erckmann-Chatrian stories are distinguished by simplicity and genuine descriptive power, particularly in the battle scenes and in connection with Alsatian peasant life. They are marked by a sincere democratic spirit. Some of the tales written after 1870 are strongly anti-German, but the main body of their work dealing with the Napoleonic wars is anti-imperialistic. The authors attacked militarism by depicting the horrors of war in the plainest terms.

See also J. Claretie, *Erckmann-Chatrian* (1883), in the series of "Célébrités contemporaines."

ERDÉLYI, JÁNOS (1814–1868), Hungarian poet and author, was born on April 1, 1814 at Kapos. His fame was made by his collection of Hungarian national poems and folk-tales, *Magyar Népköltési Gyüjtemény, Népdalok és Mondák* (Budapest, 1846–47). This work, published by the Kisfaludy Society, was supplemented by a dissertation upon Hungarian national poetry, afterwards partially translated into German by Stier (1850). He died on Jan. 23, 1868. A collection of folklore was published the year after his death, entitled *A Nép Költészete népdalok, népmesék és közmondások* (Budapest, 1869). This work contains 300 national songs, 19 folk-tales and 7,362 Hungarian proverbs.

See J. Erdélyi, and others, *The Folk-Tales of the Magyars*, publ. by the Folk-Lore Society (trans. and ed. by W. H. Jones and L. L. Kropf 1889); M. Lajos, *Janos Erdélyi 1814–1868* (Budapest, 1914).

ERDMANN, BENNO (1851–1921), German philosopher, was born on May 30, 1851, at Guhrau, in Prussian Silesia. Educated at Berlin and Heidelberg, he was appointed professor successively at Kiel (1878), Breslau (1884), Halle (1890), Bonn (1898) and Berlin (1909). He occupied himself mainly with Kantian philosophy and the investigation of thought-processes. He died on Jan. 7, 1921, in Berlin. His publications include: *Kants Kritizismus* (1878); *Nachträge zu Kants Kritik der reinen Vernunft* (1881); *Reflexionen Kants zur kritischen Philosophie* (1882–84); *Logik* (1892; 2nd ed., 1907); *Psych. Untersuchungen über das Lesen auf experimentaler Grundlage* (1898); *Immanuel Kant* (1904); *Wissenschaftliche Hypothesen über Leib und Seele* (1908) and *Reproduktions-psychologie* (1920).

See E. Wentscher in *Kant Studien*, vol. xxvi. (1921), and Überweg, *Gesch. der Philosophie* (bd. iv., 1923).

ERDMANN, DAVID (1821–1905), German Protestant theologian, was born on July 20, 1821, at Güstebiese, and was educated at Berlin. He was appointed professor of theology at Königsberg in 1856, and eight years later general-superintendent of Silesia at Breslau, becoming superior consistorial counsellor in 1889. Erdmann died at Dresden on March 11, 1905.

His chief works are: *Lieben und Leiden der ersten Christen* (1854); *Die Reformation und ihre Märtyrer in Italien* (1855), and *Luther und die Hohenzollern* (2nd ed., 1884). *See* also Eberlein, *Aus einem reichen Leben: Blätter der Erinnerung an D. Erdmann* (1907).

ERDMANN, JOHANN EDUARD (1805–1892), German philosophical writer, was born at Wolmar, Livonia, on June 13, 1805. He studied theology at Dorpat and afterwards at Berlin, where he fell under the influence of Hegel. From 1829 to 1832 he was a pastor in Wolmar. He qualified in philosophy at Berlin in 1834, and in 1836 became professor at Halle, where he died on June 12, 1892. Erdmann's fame rests on his elaborate *Grundriss der Geschichte der Philosophie* (2 vols., 1866, Eng. trans. 1892).

ERDMANN, OTTO LINNÉ (1804–1869), German chemist, son of Karl Gottfried Erdmann (1774–1835), the physician who introduced vaccination into Saxony, was born at Dresden on April 11, 1804. He studied at the University of Leipzig where in 1827 he became extraordinary professor, and in 1830 ordinary professor of chemistry. This office he held until his death at Leipzig on Oct. 9, 1869. The laboratory established at Leipzig under his direction in 1843 was long regarded as a model institution. As an investigator he is best known for his work on nickel and indigo and other dye-stuffs. With R. F. Marchand (1813–50) he also carried out a number of determinations of atomic weights. In 1828, in conjunction with A. F. G. Werther (1815–69), he founded the *Journal für technische und ökonomische Chemie*, which became in 1834 the *Journal für praktische Chemie*. He was also the author of *Über das Nickel* (1827), *Lehrbuch der Chemie* (1828), *Grundriss der Waarenkunde* (1833) and *Über das Studium der Chemie* (1861).

EREBUS, the "darkness" of the western region where lie Hades and the sunless Cimmerian land (Gr. ἔρεβος); in Hesiod (*Theog.* 123), personified as son of Chaos, brother and husband of Night, father of Αἰθήρ (upper air) and Day.

ERECH (in Sumerian *Uruk*, Greek *Orchoë*, modern Warka), an ancient city in Mesopotamia in 31° 30′ N., 46° E., on the west bank of the old bed of the Euphrates, now Shatt-ek-Kar, whose course runs some miles to the east. The city was partially excavated by Loftus in 1850 and 1854 and was recently visited by Weld who reported that it was almost inaccessible, so that it still awaits a modern excavator. The outer walls are about six miles in circumference, and enclose an area of about eleven hundred acres. Within this area there are three great mounds and numerous smaller ones. The temple of E-Anna, "the house of heaven," apparently the earlier name of the city and the principal shrine, stood on the bank of the river in the eastern part of the town. The walls here were built by Ur-Engur and are of huge size and still more or less intact. They are built of bricks with a course every four feet of reed mats, from which the Arabic name of Buwaniya is derived. The base of the *ziggurat*, or temple tower, is 200 ft. square, and stood together with the temple at the western corner of the great platform, which was built with its angles facing the cardinal points. It was here that Loftus uncovered a kind of mosaic made of painted cone heads and cone shaped pots, with narrow tips and shallow cavities. The walls are built of cones or pots with the heads outwards. To the west of the temple separated by a ravine in the centre of the city is the huge mound of Wuswas, which it has been suggested may have been the site of the palace of the Pre-Sargonic kings and *patesis* (prince-priests). A large number of valuable religious texts from the temple library have been discovered dating from as late as 70 B.C. They show the religious ideas of the priestly school at Erech. The town was strongly nationalist during the struggles against the Elamites at the end of the third millennium B.C., in strong contrast to its neighbour Larsa which had an Elamite dynasty, probably to hold Erech in check. The city continued to exist in Persian and later times and became like some of the modern Holy Cities a centre for the burial of the dead, but the ancient ruins which have as yet only been superficially examined are probably some of the most important in Mesopotamia.

BIBLIOGRAPHY.—W. K. Loftus, *Travels and Researches in Chaldaea and Susiana* (1857); S. Langdon in *Cambridge Ancient History*, vol. i. (1923) with bibliography.

ERECHTHEUM, a temple on the acropolis at Athens, socalled after the legendary founder of the city, Erechtheus, to whom a portion of it was dedicated. The date of the beginning of the building is uncertain; apparently, it was either just before the Peloponnesian War, 431 B.C., or immediately after the Peace of Nicias, 421 B.C. It remained, however, uncompleted until 409 B.C., when a commission was appointed to report upon its condition and carry it to completion. This was achieved, according to inscribed records, in 407 B.C. A fire seriously damaged it soon after it was finished, and extensive repairs were carried out in the first decade of the 4th century B.C. During the Roman period, probably towards the end of the 1st century A.D., the west end was reconstructed with the addition of the present windows. During the middle ages it served as a church, and after the Turkish occupation became the harem of the commandant. Lord Elgin carried away to London, 1801–03, one of the columns of the east portico and one of the caryatides. These were later replaced by terra-cotta replicas. The building was much injured during the siege of the Acropolis, 1827, and was partially reconstructed between 1838 and 1846. In 1852 the west wall fell during a storm. In the 20th century a great deal of work has been done in reconstructing the building, using as far as possible the original blocks which remained on the site, together with information gathered from the detailed references in the inscriptions containing an account of the completion between 409 and 407 B.C. This work still (1928) continues.

Architectural Features.—The fame of the Erechtheum depends largely upon the exquisite perfection of its details. Particularly noticeable is the delicate strength of the bases with the reeding and the guilloche or interlacing that decorate them. The Ionic capitals are the most exquisite that Greece has produced, and the band of anthemion decoration, which runs around the walls and circles the column shafts just below the capitals, is characteristically refined. Many traces of colour were found on this carving. The volutes or spirals of the capitals were picked out with blue and gold on a red ground. The anthemion band had a red background and in the egg and dart moulding the ground was

blue with the eggs gilded.

The Erechtheum, as originally completed, consisted of a rectangular cella or enclosed portion with a door and two windows opening on the east into an entrance portico of six columns. The western end of this enclosed portion is at a lower level and forms a narrow chamber entered from the north by a door of great richness under a portico with four columns at the front and one at each side. At the other end of the western chamber another door and a small flight of steps lead up to the famous caryatid porch at a higher level. The plan of the building seems obviously incomplete as the western wall meets both the northern portico and the caryatid porch in an awkward manner.

A recent stone by stone examination of the Erechtheum carried out under the direction of Gorham Stevens of the American School of Classical Studies at Athens seems to have proved, however, that the present plan, whatever its awkwardness, was the plan of the building as first built. Instead of the Roman windows of the present west front, there were, originally, merely wooden screens placed between columns. The same study has made more clear the original interior arrangement. The central foundation walls which suggested to earlier students the idea that the building was divided into nave and aisles like the Parthenon (*q.v.*) are now definitely known to belong to the interior reconstruction made when the building was turned into a Christian church in the 5th or 6th century. The roof is shown by the inscriptions to have been in one span from wall to wall with a central great girder, braced with diagonal braces in a wooden coffered ceiling.

Between the eastern and western portions a marble partition ran through the entire height, dividing the building into two portions, entirely separate, without communication. The western section was apparently divided by low screen walls into a passage leading from the north porch to the caryatid porch and two chambers to the east. From the passage a third door led south into the sacred precinct known as the Pandroseion. In the south-west corner of the passage, large blocks of marble bridged over a deep hole or crypt. During the mediaeval period a cistern was built under this portion of the building and destroyed all vestiges of what was below. It is probable, however, that here was located the legendary salt spring or sea and the mark of Poseidon's trident in the rock. In the wall above this corner there was a curious section of projecting stone like a canopy, with a recess in the wall above it as if for a sacred object. In the north portico a square hole in the floor gives access to a crypt below; immediately above this there was a similar hole through the ceiling and roof. Recent research has proved that around the hole in the floor there was a hollow altar. The opening in the roof at once suggests a connection with the sky powers and the altar would thus be that of Zeus Hypatos, mentioned by Pausanius. Deep depressions in the floor of the crypt under the hole would then be identified as marks of the thunderbolt of Zeus.

According to Pausanius the Erechtheum contained a shrine of Athena Polias, an altar dedicated to Poseidon and Erechtheus, one to Butes and one to Hephaestus, as well as the golden lamp of Callimachus and portraits of the family of the Butadae.

See Stuart and Revett, *Antiquities of Athens* (1825); W. Dörpfeld, "Der ursprungliche Plan des Erechtheion" in *Mitteil. Athen.* (1904); A. Choisy, *Etude sur l'Architecture Grecque, III.* (1884); and for a most thorough examination of the problems presented by the Erechtheum, and a restoration, together with the complete text and a translation of the inscriptions, *see* G. P. Stevens and others, J. M. Paton, ed., *The Erechtheum, Measured, Drawn and Restored* (1927). *See* also ATHENS. (T. F. H.)

ERECHTHEUS, in Greek legend, a mythical king of Athens, sometimes identified with Erichthonius, oftener distinguished from him. According to Homer, who knows nothing of Erichthonius, he was the son of the earth, brought up by Athena, with whom his story is closely connected. In the later story, Erichthonius, son of Hephaestus and *Ge* (Earth), was handed over by Athena to the three daughters of Cecrops—Aglauros (or Agraulos), Herse and Pandrosos—in a chest, which they were forbidden to open. Two of them disobeyed the injunction, and when they saw the child (which had the form of a snake, or round which a snake was coiled) they went mad with fright, and threw themselves from the Acropolis (or were killed by the snake). Athena herself then undertook the care of Erichthonius, who, when he grew up, drove out Amphictyon and took possession of the kingdom of Athens. Here he established the worship of Athena, instituted the Panathenaea, and built an Erechtheum. The Erechtheus of later times was supposed to be the grandson of Erechtheus-Erichthonius, and was also king of Athens. When Athens was attacked by Eumolpus (*q.v.*) victory was promised Erechtheus if he sacrificed one of his daughters. Eumolpus was slain and Erechtheus was victorious, but was himself killed by Poseidon, the father of Eumolpus, or by a thunderbolt from Zeus. The contest between Erechtheus and Eumolpus formed the subject of a lost tragedy by Euripides. The name Erichthonius (perhaps "good earth") and his connection with snakes may indicate that he is an earth-god.

See Eurip., frag. 925 (Nauck), *Ion*, 20, 268, 1427; Antigonus, *hist. mirab.*, 12; Ovid, Met., ii. 755; Apollodoros, iii., 188. Hyginus, *Poet. astron.* ii. 13; Pausanias i. 2. 5. 8; E. Ermatingen, *Die attische Autochthonensage* (1897); B. Powell, in *Cornell Studies*, xvii. (1906), Farnell, *Cults of the Greek States*, i. 270; Frazer's *Pausanias*, ii. 169 and the mythological dictionaries.

ERESHKIGAL, also known as ALLATU, the name of the chief Babylonian goddess of the nether-world where the dead are gathered. Her name signifies "lady of the nether-world." She is known to us chiefly through two myths, both symbolizing the change of seasons, but intended also to illustrate certain doctrines developed in the temple schools of Babylonia. One of these myths is the famous story of Ishtar's descent to Irkalla or Arālu, the lower world, and her reception by her sister who presides over it; the other is the story of Nergal's offence against Ereshkigal, his banishment to the kingdom controlled by the goddess and the reconciliation between Nergal and Ereshkigal through the latter's offer to have Nergal share the honours of the rule over Irkalla. The story of Ishtar's descent illustrates the possibility of an escape from Irkalla, while the other myth reconciles the existence of two rulers of Irkalla—a goddess and a god.

Originally a goddess was supposed to be in control of Irkalla, corresponding to Ishtar in control of fertility and vegetation on earth. Ereshkigal is therefore the sister of Ishtar and from one point of view her counterpart, the symbol of nature during the non-productive season of the year. As the doctrine of two kingdoms, one of this world and one of the world of the dead, becomes crystallized, the dominions of the two sisters are sharply differentiated from one another. The addition of Nergal represents the harmonizing tendency to unite with Ereshkigal as the queen of the nether-world, the god who, in his character as god of war and of pestilence, passes judgment upon the souls who arrive in Irkalla and thus becomes the one who presides over the dead. Ereshkigal was also worshipped by the Hittites as early as the 17th century B.C.

ERETRIA (mod. *Aletria*), an ancient coast town of Euboea about 15 m. S.E. of Chalcis, opposite to Oropus. Eretria, like its neighbour Chalcis (*q.v.*), founded colonies in the west and north of Greece. It also acquired dependencies among the Cyclades and had close alliance with Miletus. Defeated by Chalcis in the Lelantine War, it lost importance, and its interference in the Ionian revolt (498) brought upon it the vengeance of the Persians, who destroyed it shortly before the battle of Marathon (490). The city was soon rebuilt, and was a member of both the Delian Leagues. The Athenians twice rescued it from the tyrants suborned by Philip of Macedon (354 and 341). Under Macedonian and Roman rule it fell into insignificance; for a short period under Mark Antony, it became a possession of Athens. Eretria was the birthplace of the tragedian Achaeus and of the "Megarian" philosopher Menedemus.

The modern village, which is sometimes called Nea Psará because the inhabitants of Psará, off Chios, were transferred there in 1821, is on unhealthy low-lying ground near the sea. The ancient site was excavated by the American School of Athens (1890–95). At the foot of the Acropolis lies the theatre, where only seven rows of seats remain, but much of the scena is preserved: beneath which there runs a tunnel, which has raised in-

teresting questions, the orchestra being at present about 12 ft. below that of the rooms in the scena. Near by are a temple of Dionysus, a large altar and a gymnasium. In 1900 a temple of Apollo Daphnephoros was found. The wall of the Acropolis remains to the height of eight courses; other walls, to north and south connect it with the harbour and mole.

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ERETRIAN SCHOOL OF PHILOSOPHY. This Greek school was the continuation of the Elian school, which was transferred to Eretria by Menedemus. It was of small importance, and in the absence of certain knowledge must be supposed to have adhered to the doctrines of Socrates. (*See* Menedemus.)

ERFURT, a city of Germany, in Prussian Saxony, on the Gera and the railway, about midway between Gotha and Weimar. Pop. (1925) 135,219. The origin of Erfurt (Med. *Erpesfurt, Erphorde,* Lat. *Erfordia*) is obscure, but in 741 it was sufficiently important for St. Boniface to found here a bishopric, which was, however, reabsorbed in that of Mainz. In 805 the place received certain market rights from the emperor Charlemagne. Later the overlordship was claimed by the archbishops of Mainz, on the strength of charters granted by the emperor Otto I., and they succeeded in upholding their claims to it in spite of many vicissitudes. In 1255, however, the archbishop granted the city municipal rights, and Erfurt became practically a free town. Its power was at its height early in the 15th century, when it joined the Hanseatic League. It had acquired by force or purchase various countships and other fiefs in the neighbourhood, and ruled a considerable territory; and its wealth was so great that in 1378 it established a university, the first in Europe that embraced the four faculties. Feuds with Mainz and the religious struggles of the 16th century caused its decay and during the Thirty Years' War Erfurt was for a while occupied by the Swedes. In 1664 it was captured by the troops of the archbishop of Mainz, and remained in the possession of the electorate till 1802, when it came into the possession of Prussia. In 1808 Napoleon and the emperor Alexander I. of Russia, with the kings of Bavaria, Saxony, Westphalia and Württemberg met here at the congress of Erfurt, and here in 1850 the parliament of the short-lived Prussian Northern Union (known as the Erfurt parliament) sat.

The city, which is dominated on the west by the two citadels of Petersberg and Cyriaxburg, is irregularly built, the only feature in its plan being the Friedrich Wilhelmsplatz. On the south-western side of this square is the Domberg, an eminence on which stand, side by side, the cathedral and the great church of St. Severus with its three spires (14th century). The cathedral (*Beatae Mariae Virginis*) was begun in the 12th century, but the nave was rebuilt in the 13th in the Gothic style. The chancel (1349–72), with the 14th-century crypt below, rests on massive substructures, known as the *Cavate*. The cathedral contains, besides fine 15th century glass, some very rich portal sculptures and bronze castings, among others the coronation of the Virgin by Peter Vischer. Besides the cathedral and St. Severus, Erfurt possesses several very interesting mediaeval churches; among these may be mentioned the Predigerkirche, dating from the latter half of the 12th century; the Reglerkirche, with a 12th century tower; and the Barfüsserkirche, a Gothic building containing fine 14th century monuments. All these were originally monastic churches. Of the former religious houses there survive a Franciscan convent, and an Ursuline convent. The Augustinian monastery, in which Luther lived as a friar, is now used as an orphanage, while a statue of the reformer stands in the chief street. At one time Erfurt had a university, whose charter dated from 1392; but it was suppressed in 1816, and its funds devoted to other purposes, among these being the endowment of an institution founded in 1758 and called the academy of sciences, and the support of the library, which now contains 60,000 volumes and over 1,000 manuscripts. On the west and south-west new quarters have grown up. Erfurt possesses a picture gallery and an antiquarian collection.

The educational establishments of the town include a school of agriculture, and an academy of music. The most notable industry of Erfurt is the culture of flowers and of vegetables. This industry had its origin in the large gardens attached to the monasteries. It has also manufactures of rolling stock, machines, furniture, woollen goods, ladies' mantles, boots, musical instruments, agricultural implements, leather, tobacco, chemicals, etc. Brewing, bleaching and dyeing are also carried on on a large scale.

ERGOT, a drug consisting of the sclerotium (or hard resting condition) of a fungus, *Claviceps purpurea,* parasitic on the pistils of many grasses, but obtained almost exclusively from rye. In the ear of rye infected with ergot there exudes a sweet, yellowish mucus, which after a time disappears. The ear loses its starch and ceases to grow, and its ovaries become permeated by the mycelium of the fungus which forms the sclerotium in autumn.

The drug consists of curved dark-purple grains ⅓ to 1½in. long, and 1 to 4 lines broad, having two lateral furrows, a rancid taste, and fishy odour, intensified by potash solution.

The active principle of ergot is the alkaloid ergotine which is given intra-muscularly. Other ingredients are a fixed oil, present to the extent of 30%, ergotinic acid, a glucoside, trimethylamine, which gives the drug its unpleasant odour, and sphacelinic acid, a non-nitrogenous resinoid body.

Ergot has no external action. Given internally the drug itself and ergotine cause contraction of unstriped muscle generally but act particularly on that of the arterioles, bronchioles and uterus. By its action on the blood-vessels it raises blood pressure and is locally and remotely haemostatic. By its action on the bronchioles it may induce a condition resembling asthma. With regard to uterine muscle ergot is the most powerful known stimulant of the pregnant uterus. The action is a double one. At least four of its constituents act directly on the muscular fibre of the uterus, whilst the ergotine acts through the nerves. Of great practical importance is the fact that ergotine causes rhythmic contractions such as naturally occur, whilst the sphacelinic acid produces a *tonic* contraction of the uterus, which is unnatural and endangers the life of the foetus.

Chronic poisoning, or *ergotism,* used frequently to occur amongst the poor fed on rye infected with the *Claviceps.* There were two types of ergotism. In the gangrenous form various parts of the body underwent gangrene from arrest of their blood-supply. In the spasmodic form the symptoms were nervous. The disease began with cutaneous itching, tingling and formication, which gave place to loss of cutaneous sensation, first observed in the extremities. Amblyopia, deafness and mental failure also occurred. With weakness of the voluntary muscles went intermittent spasms which weakened the patient and ultimately led to death by implicating the respiratory muscles. The last known "epidemic" of ergotism occurred in Lorraine and Burgundy in the year 1816, but sporadic cases are still met with.

ERIC XIV. (1533–1577), king of Sweden, was the only son of Gustavus Vasa and Catherine of Saxe-Lauenburg. He became king in 1561, and owing to his morbid fear of the nobility, he gave his confidence to Göran Persson, an upstart. Having quarrelled with, and imprisoned, the royal duke John, Eric harassed the aristocracy, and finally in 1566 imprisoned many of them at Uppsala. He murdered Nils Sture with his own hand and ordered the despatch of other prisoners. The order for the detention of the prisoners was ratified by the estates after the murders had taken place, and probably in ignorance of them, under pressure from Göran Persson. Two years later Eric's insanity was so apparent that a committee of senators was appointed to govern the kingdom, and finally on Sept. 30, 1568, he was replaced by the royal duke John, who became John III. In spite of several rebellions, John retained his throne, and on Feb. 24, 1577, Eric died suddenly in his prison at Orbyhus, poisoned, it is said, by his governor, Johan Henriksen.

See *Sveriges Historia,* vol. iii. (1880); Robert Nisbet Bain, *Scandinavia,* cap. 4–6 (1905); Eric Tegel, *Konung Eriks den XIV. historia* (1751).

ERICACEAE, in botany, a family of plants belonging to the higher or sympetalous division of dicotyledons. They are

mostly woody plants, with a slender creeping stem as in bilberry (blueberry), *Vaccinium* (fig. 1), or forming low bushes as in the heaths, or sometimes becoming tree-like, as in species of *Rhododendron*. The leaves are alternate, opposite or whorled in arrangement, and in form and structure show well-marked adaptation to life in dry or exposed situations. Thus in the true heaths they are needle-like, with the margins often rolled back to form a groove or an almost closed chamber on the under side. In others such as *Rhododendron* they are often leathery and evergreen, the strongly cuticularized upper surface protecting a water-storing tissue situated above the green layers of the leaf. The flowers are sometimes solitary and axillary or terminal as in *Andromeda*, but are generally arranged in racemose inflorescences at the end of the branches as in *Rhododendron*, or on small lateral shoots as in *Erica*. They are hermaphrodite and generally regular with parts in 4's or 5's, thus: sepals 4 or 5, petals 4 or 5, stamens 8 or 10 in two series, the outer opposite the petals, and carpels 4 or 5. The corolla is usually more or less bell-shaped, and in the heaths persists in a dry state in the fruit. The petals with the stamens are situated on the outer edge of a honey-secreting disk. The anthers show great variety in shape, the halves being often more or less free and often appendaged; they open to allow the escape of the pollen by

FIG. 1.—BILBERRY (VACCINIUM MYRTILLUS), CLOSELY ALLIED TO THE HUCKLEBERRY AND VERY COMMON IN BRITAIN

AFTER DR. JOHN FLEMING'S DRAWING, BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 2.—RHODODENDRON (RHODODENDRON ARBOREUM)

a terminal pore or slit. The carpels are united to form a 4- or 5-chambered ovary, which bears a simple elongated style ending in a capitate stigma; each ovary chamber contains one to many ovules attached to a central placenta. The brightly coloured corolla, the presence of nectar and the scent render the flowers attractive to insects, and the projection of the stigma beyond the anthers favours crossing. The fruit is generally a capsule containing many seeds, as in *Erica* or *Rhododendron* (fig. 2); sometimes a berry, as in *Arbutus*.

The family falls into four distinct tribes, characterized by the relative position of the ovary and by the fruit and seed. They are:—

1. *Rhododendroideae*, characterized by capsular fruit, seed with a loose coat, deciduous petals and anthers without appendages. It consists mainly of the large genus *Rhododendron* (in which *Azalea* is included), which is chiefly developed in the mountains of eastern Asia, many species occurring on the Himalayas. *Dabeocia*, St. Dabeoc's heath, occurs in Ireland. In eastern America, *Kalmia* (laurel) is the prominent genus after *Rhododendron*.

2. *Arbutoideae*.—Fruit a berry or capsule, petals deciduous and anthers with bristle-like appendages, chiefly north temperate to arctic in distribution. *Arbutus Unedo*, the strawberry-tree, so-called from its large scarlet berry, is southern European extending into south Ireland. *Arctostaphylos* (bearberry) and *Andromeda* are arctic and alpine genera occurring in Britain and also extending from the arctic into the mountainous regions of northern United States. *Epigaea repens* is the trailing arbutus or mayflower of Atlantic America.

3. *Vaccinioideae*.—Ovary inferior, fruit a berry. Extends from the north temperate zone to the mountains of the tropics. *Vaccinium*, the largest genus, has three British species: *V. Myrtillus* is the bilberry (*q.v.*), blueberry or whortleberry, *V. Vitis-Idaea* the cowberry, and *V. Oxycoccos* the cranberry (*q.v.*). There are 20 species recognized in the United States.

4. *Ericoideae*.—Fruit usually a capsule, seeds round, not winged; corolla persisting round the ripe fruit; anthers often appendaged. The largest genus is *Erica*, the true heath (*q.v.*), with 500 species, the majority confined to the Cape; others occur on the mountains of tropical Africa and in Europe and north Africa, especially the Mediterranean region. *E. cinerea* (purple heather) and *E. Tetralix* (cross-leaved heath) are common British heaths. *Calluna* is the ling or Scotch heather. The genus is not represented in the United States.

ERICHSEN, SIR JOHN ERIC, BART. (1818–1896), British surgeon, born on July 19, 1818, at Copenhagen, was the son of Eric Erichsen, a member of a well known Danish family. He studied medicine at University college, London, and in Paris, and lectured on general anatomy and physiology at University college hospital. In 1848 he was appointed assistant surgeon at University college hospital, in 1850 became full surgeon and professor of surgery, and in 1875 he joined the consulting staff. His *Science and Art of Surgery* (1853) went through many editions. He was created a baronet in 1895, having been for some years surgeon-extraordinary to Queen Victoria. As a surgeon his reputation was world wide. He died at Folkestone on Sept. 23, 1896.

ERICSSON, JOHN (1803–1889), Swedish-American naval engineer, was born at Langbanshyttan, Wermland, Sweden, on July 31, 1803. Showing from his earliest years a strong mechanical bent, young Ericsson, at the age of 12, was employed as a draughtsman by the Swedish Canal Company. From 1820 to 1827 he served in the army, where his drawing and military maps attracted the attention of the king, and he soon attained the rank of captain. In 1826 he went to London, at first on leave of absence from his regiment, and in partnership with John Braithwaite constructed the "Novelty," a locomotive engine for the Liverpool and Manchester railway competition at Rainhill in 1829, when the prize, however, was won by Stephenson's "Rocket." The number of Ericsson's inventions at this period was very great. Among other things he worked out a plan for marine engines placed entirely below the water-line. Such engines were made for the "Victory," for Captain (afterwards Sir) John Ross's voyage to the Arctic regions in 1829, but they did not prove satisfactory. In 1833 his caloric engine was made public.

In 1836 he took out a patent for a screw-propeller, and though the priority of his invention could not be maintained, he was afterwards awarded a one-fifth share of the £20,000 given by the Admiralty for it. At this time Capt. Stockton, of the U.S. Navy, gave an order for a small iron vessel to be built by Laird of Birkenhead, and to be fitted by Ericsson with engines and screw. This vessel reached New York in May 1839. A few months later

Ericsson followed his steamer to New York, and there he resided for the rest of his life, establishing himself as an engineer and a builder of iron ships. In 1848 he was naturalized as a citizen of the United States. Defensive armour for ships of war had long occupied his attention, and he had constructed plans and a model of a vessel lying low in the water, carrying one heavy gun in a circular turret mounted on a turn-table. In 1854 he sent his plans to the French emperor, Louis Napoleon, who declined to use them.

During the American Civil War, the Navy department invited proposals for the construction of armoured ships. Ericsson's design was accepted and the first armoured turret ship, the "Monitor," was launched on Jan. 30, 1862. On March 9, she fought the celebrated action with the Confederate ram "Merrimac." The peculiar circumstances in which she was built, the great importance of the battle, and the decisive nature of the result gave the "Monitor" an exaggerated reputation, which further experience did not confirm. In later years Ericsson devoted himself to the study of torpedoes and sun motors. He published *Solar Investigations* (1875) and *Contributions to the Centennial Exhibition* (1877). He died in New York on March 8, 1889, and in the following year on the request of the Swedish government, his body was sent to Stockholm and thence into Wermland, where, at Filipstad, it was buried on Sept. 15.

A *Life of Ericsson* by William Conant Church was published in New York in 1890 and in London in 1893.

ERIDANUS, in astronomy, a large constellation (*q.v.*) of the southern hemisphere, stretching from near Rigel at the heel of Orion (*q.v.*) to Achernar (α Eridani), not far from the South Polar Circle. α Eridani is the only star (*q.v.*) at present of the first magnitude in this constellation. The double star θ Eridani is now of the 3rd magnitude, but is identified with the *Achernar* (the shining one) of Al-Sufi who described it as of the first magnitude; it has therefore decreased considerably in brilliancy within historic times, and has thus surrendered its title of "the shining one" to α Eridani.

That o_2 Eridani is a ternary system was discovered by Herschel in 1783; it consists of a star of magnitude 4·5, associated with a close pair of about the 10th magnitude and 82″ distant from it.

Eridanus fluvius is the name under which the constellation appears in the catalogue of Tycho Brahe, Eridanus being a Greek river-god and also an ancient name for the river Po, in Italy. In the older catalogues it appeared simply as "the river" stars: *Stellae Fluminis*, according to Ulugh Beg, and the ἀστερισμὸς Ποταμοῦ according to Ptolemy who catalogued 34 stars in it.

ERIDU (modern Abu Shahrein) in 31° N. and 46° E., an ancient city of Mesopotamia. The report of Taylor's excavations in 1855 were the only source of information about this important city until R. Campbell Thompson carried out excavations in 1918. He found a long brick stamp of the eighth king of Larsa Nur-Adab, commemorating his work at Eridu, thus confirming Taylor's previous identification. The city was stated in ancient texts to be on the edge of the sea. This had been interpreted to mean the Persian gulf; Thompson found large quantities of fresh water mussels, but sea shells were also found and probably both were used for food (*see* MESOPOTAMIA: *Ancient Geography*). There was evidence of late stone age burials and early Kassite graves, but after the time of Hammurabi the city became of little importance, probably owing to the silting up of the lake. In ancient times Eridu was undoubtedly closely connected with Lagash, probably owing to water communications between the two cities. It was never the seat of a dynasty and did not even possess a Patesi—originally a position corresponding more or less to mediaeval "prince-bishop," but which later became the equivalent of a local governor of a dependent city state. It is possible however that in prehistoric times it may have occupied a more important position, and Hall has suggested that there may even have been at one time a Sumerian federation with its head either at Nippur or Eridu. In later times throughout the whole of Sumerian history there were two important schools of religious thought, one of them being associated with Eridu, and the other Nippur, Eridu being associated with the cult of Ea the earth god. From the geographical point of view the city is of special interest in its relation to the old sea line, and the evidence which it affords of the changes that have taken place in southern Mesopotamia since early times.

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ERIE, a city of Pennsylvania, U.S.A., in the north-western corner of the State, on Lake Erie; a port of entry, the county-seat of Erie county, and an important manufacturing and commercial city. It is on Federal highways 6, 19 and 20; has an airport; and is served by the Bessemer and Lake Erie, the New York Central, the Nickel Plate, and the Pennsylvania railways, by motor-bus lines and an interurban electric railway and by lake steamers. The population in 1920, including the area annexed just after the Federal census was taken, was 102,093, of whom about 22% were foreign-born white (largely from Germany, Poland, Italy and Russia); and was estimated locally at 137,000 in 1928.

Erie has a fine harbour, protected from the severest storms by the peninsula of Presque Isle, a natural breakwall 11m. long and from 300ft. to 2·5m. across, and equipped with modern facilities for loading and unloading. The largest carriers on the Great Lakes can enter and leave the harbour without a tow. The city covers about 20 sq.m. of level ground, about 570ft. above sea-level. Most of the streets are 60 or 100ft. wide, and they cross at right angles. There are 18 municipal parks, with an aggregate area of 218ac.; and Presque Isle, with its 3200ac. of virgin forest, fine bathing beaches and excellent fishing, is a State park. East and west of the city for 12m., the lake shore is lined with summer homes and cottages. There is a municipal bathing pool, two municipal and two private golf courses, a community playhouse, a local symphony orchestra and a stadium which seats 15,000. Natural gas is used for domestic fuel. The city has a planning commission. In 1927 the assessed valuation of property was $142,468,828.

The manufacturing industries are large, numerous and diversified, with an output for the Erie district valued at $120,000,000 annually. The Erie works of the General Electric Company, occupying 300ac. and employing normally 6,500 persons, makes electric locomotives, railway motors, generators, transformers, air compressors and various kinds of equipment, castings and patterns. Other leading factory products are boilers, engines, tanks, wringers, precision tools, castings of all kinds, blast furnaces, stoves, asbestos products, silks, paper, aluminium utensils, hospital and sterilizing equipment, kitchen and laundry appliances, steam shovels and travelling cranes. The commerce of the port amounted in 1924 to 2,527,361 tons (valued at $44,839,382), consisting largely of incoming pulpwood from Canada, grain, flour, and iron ore from north-western ports, and shipments of coal (bituminous and anthracite) received by rail from the Pennsylvania, Ohio and West Virginia fields. The city ships by rail large quantities of grapes and other fruits, fish and manufactured products. Bank clearings in 1926 amounted to $429,618,517.

A United States Naval Reserve unit, stations of the Coast Guard Service and of the Weather bureau, a State armory, and a State fish hatchery are located at Erie. It is the headquarters of the State harbour and fish commission, and the seat of the State soldiers' and sailors' home, which occupies a beautiful site on a bluff overlooking both the lake and the city. Near by there is a monument erected to General Anthony Wayne, who died here on Dec. 15, 1796.

In 1753 the French built a stockade and blockhouse, called Ft. Presque Isle, on the site of Erie, and around it grew up a village. The village was abandoned, probably because of an epidemic of small-pox, in 1758, and the fort in 1759. It was occupied by the British in 1760; captured by the Indians on June 22, 1763, during the Conspiracy of Pontiac; regained by the British, under Col. Lionel Bradstreet, in 1764; and passed into the possession of the United States in 1785. The town was laid out in 1795, by General Andrew Ellicott, first surveyor-general of the United States, who had laid out Washington after the plan of L'Enfant. It became the county seat when Erie county was erected in 1803;

was incorporated as a borough in 1805, and as a city in 1851. Here, in six months, were built most of the vessels with which Commodore Oliver H. Perry won his naval victory over the British off Put-in-Bay on Sept. 10, 1813. In 1913 Perry's flagship, the "Niagara," was raised from the bottom of Misery Bay, on the shore of Presque Isle, where his fleet was sunk following the declaration of peace. It was rebuilt and re-equipped and anchored at the Public Dock, where it is maintained as a historic exhibit. The first iron battleship on the Great Lakes, the "Wolverine," now used as a naval training ship, was built at Erie in 1843, out of plates and equipment hauled by oxen from Pittsburgh, and this is still its home port. A replica of the blockhouse built by General Wayne, which protected the harbour in the early days and while Perry's fleet was under construction, has been erected on the original site. In 1850 the population of Erie was 5,858; in 1870, 19,646; in 1890, 40,634; in 1910, 66,525; and between 1910 and 1920 it increased 40·4%. Since 1910 the area of the city has increased nearly threefold.

ERIE CANAL: *see* New York State Barge Canal System.

ERIE, LAKE is the fourth largest of the Great Lakes of North America. Bordering on it are the States of Michigan, Ohio, Pennsylvania and New York, and the Province of Ontario, Canada. Its dimensions, surface elevations, etc., are as follows: length 240m.; width, 57m.; maximum depth, 210ft.; area in square miles of water surface, 4,990 in United States and 4,950 in Canada; drainage basin in square miles, 23,570 in the United States and 11,110 in Canada; standard low water, 570ft. above mean sea-level; lowest mean monthly stage (since 1860), 569·90ft., for year 1926, mean monthly stage, 570·98ft.; highest recorded stage (1838), 575·11ft.; mean surface, 67 years (1860–1926), above mean sea-level, 572·43ft.; mean surface below surface of Lake Huron, 8·54ft.; mean surface above mean surface of Lake Ontario, 326·33ft.; average season of navigation, from March 27 to Dec. 20; receives water from upper lakes via the Detroit river; discharges water into Lake Ontario via Niagara river.

Lake Erie is comparatively shallow and the storms which sweep over it quickly raise dangerous seas. As a result, the water level in the harbours, particularly those near each end of the lake, fluctuates markedly under the influence of the winds, varying with their direction, strength and persistence. Navigation from Lake Huron to Lake Erie passes through the St. Clair river, Lake St. Clair and the Detroit river. There are no locks in these rivers as the difference in elevation of the two lakes is small and currents in the connecting channel are moderate. The channels permit vessels of 20ft. to navigate them when the lakes are at standard datum. (*See* Great Lakes.) Navigation from Lake Erie to Lake Ontario passes through the Welland canal, constructed and operated by the Dominion of Canada. The present Welland canal affords a depth of 14ft. at normal lake levels. The new Welland ship canal, under construction by Canada, is 25m. in length, with seven locks, each having a lift of 46½ft., and one guard lock. The portions of this canal first excavated were given a depth of 25ft.; the later contracts provide for a depth of 27 feet. The depth over the sills of the locks is 30ft., to provide for subsequent enlargement of the canal reaches. The estimated cost of the new Welland ship canal, when completed, is $115,600,000. The New York State barge canal has one of its Great Lakes connections at Tonawanda, N.Y., on the Niagara river, but also maintains terminals at Buffalo. This canal is planned to accommodate boats with a loaded draught of 10½ft. and, because of overhead bridges, the superstructure of these boats must not extend more than 15ft. above the water-line.

The cheap transportation afforded by modern bulk freight carriers on the Great Lakes has made it possible to bring the iron ore of the Lake Superior region to Lake Erie ports to meet the coal from Pennsylvania and West Virginia. The important steel industry of the Lake Erie region, including the Pittsburgh district, results. The movement of iron ore to Lake Erie ports averages about 45,000,000 tons per year. Coal, to meet the industrial and domestic needs of the upper lakes region, is brought by rail from the mines of Pennsylvania and West Virginia, and furnishes part return cargoes. The total movement of coal on Lake Erie amounts to about 33,000,000 tons yearly. Limestone, used as a flux in ore furnaces, is another bulk commodity moving on Lake Erie in large quantities; some 5,000,000 tons are transported yearly. Practically all of this stone comes from the peninsula of Michigan on Lake Huron. The quality is excellent and an unlimited supply is available at the water's edge. Wheat and other grain from the prairie provinces of Canada and the great grain belt of the United States furnish enormous cargoes to eastern markets and for export. About 50% of the Canadian wheat is transhipped to boats suitable for passage through the present Welland and St. Lawrence canals to Montreal and Quebec; the remainder moves by rail from Canadian and United States ports on Lake Erie. Most of the United States wheat is transhipped via barge line and railroad from Buffalo, or milled at Buffalo or other Lake Erie ports. The maximum movements of wheat occur during the first and last months of the navigation season. With the opening of navigation, there is a rush of grain from the elevators at Duluth, Superior, Ft. William and Port Arthur, where it has been held in winter storage. There is then some movement from July on, but on or about Sept. 1 the tremendous flow of wheat from the Canadian provinces begins. The heaviest flow is usually during November. The traffic in short tons on Lake Erie for the period 1922–26 was as follows:

Year	Grain	Coal	Lime-stone	Iron Ore	Miscel-laneous	Total
1922	9,455,159	22,202,207	3,604,458	35,495,391	3,857,425	74,614,640
1923	7,282,784	36,245,782	5,288,734	48,833,267	4,077,989	101,728,556
1924	9,365,184	28,155,378	4,732,684	25,313,684	14,547,780	82,114,710
1925	8,852,966	30,209,286	4,816,734	42,950,324	5,590,526	92,419,836
1926	7,248,673	33,316,230	4,915,814	46,789,973	4,755,471	97,026,161

Originally a few harbours were formed by natural bays, but for the most part the harbours were found within the mouths of streams and were obstructed by bars at the entrances. As a result of Government, municipal and private work, numerous harbours have been improved to accommodate the present large lake vessels. The harbour works have consisted in dredging entrance and inner harbour channels and protecting them by piers and revetments, and in constructing breakwaters in the lake and deepening the enclosed areas in order to afford anchorage and mooring facilities and form commodious harbours outside of the

Port	Tonnage of commodities (short tons)						Total tonnage of commerce	Total value in dollars
	Iron ore	Coal	Grain	Limestone	Sand and gravel	All others		
Sandusky	..	6,760,137	..	..	890,230	29,288	7,679,655	40,797,563
Toledo .	1,747,350	14,14 ,358	117,150	..	402,298	72,389	16,479,545	77,474,958
Huron .	1,334,306	609,174	..	27,316	..	652	1,971,448	7,746,743
Lorain .	4,165,723	2,067,655	..	556,824	84,100	36,555	6,910,857	26,592,802
Cleveland	10,577,394	529,294	9,317	1,043,277	301,300	526,887	12,986,469	204,535,363
Fairport .	2,393,216	672,564	255,845	822,561	..	50,748	4,194,934	35,422,063
Ashtabula	10,297,352	1,977,724	..	683	4,561	164,499	12,444,819	62,612,996
Conneaut	10,656,429	2,104,479	..	..	..	39,395	12,800,303	53,622,373
Erie .	1,169,376	1,140,117	81,105	59,737	190,092	405,153	3,045,580	36,345,861
Buffalo .	4,448,827	3,016,738	6,785,256	1,366,864	629,079	815,934	17,062,698	498,405,298
Other ports	..	297,990	..	1,039,552	..	112,311	1,449,853	3,121,930

contracted harbours within streams. Nearly all the commerce of the lake centres at the mouth of the Detroit river, from which it radiates to the Welland canal, Niagara river and the various lake ports. The greater portion of traffic proceeds to the north of the island region in the western end of the lake, through Pelee passage between Point Pelee and Pelee island; this is the most important channel of the lake and is suitably marked by the Canadian Government. The most important ports of the United States on Lake Erie, with the water-borne tonnage of principal commodities in 1926, are shown in the accompanying table. Cleveland, Ashtabula and Conneaut are the most important iron ore ports. Toledo leads all the rest in its water shipments of soft coal and Buffalo is by far the largest grain port.

Lake Erie and its hinterland were the scenes of many conflicts of great importance in the early days of the settlement of the North American continent. Perry's famous victory over the British, at Put-in-bay near Sandusky, O., in Sept. 1813, was of far-reaching importance in securing the north-west for the United States at the Treaty of Ghent. Few naval battles had more momentous results. The name of Perry, his heroism and genius, will for ever inspire the American navy. (E. JA.)

ERIE RAILROAD COMPANY operates one of the leading trunk-line railroads connecting New York city with Chicago, Ill. The original company, the New York and Erie Railroad Company, incorporated by a special act of the legislature of the State of New York, April 24, 1832, met with financial reverses and was succeeded in 1861 by the Erie Railway Company, which was succeeded in 1878 by the New York, Lake Erie and Western Railroad Company, which latter was succeeded in turn by the present Erie Railroad Company, incorporated in New York in 1895 as the result of a reorganization of its predecessor company. The company operates 2,460 m. of railway, extending from Jersey City, N.J. (its main terminal) to Scranton, Pa., Rochester and Buffalo, N.Y., Cleveland and Cincinnati, O., and Chicago, Ill. The Erie Railroad Company owns the entire capital stock or holds under perpetual leases a large number of subsidiary lines which it operates, and owns a substantial majority of the capital stock of the New York, Susquehanna and Western and the New Jersey and New York railroads with a mileage of some 256 m. which are operated independently. It also owns the entire capital stock of four large coal companies with mines (both bituminous and anthracite) in eight counties in Pennsylvania, from which it receives a portion of its fuel supply and a large amount of coal traffic. Since the reorganization of 1895 almost $100,000,000 of revenue has been spent on the property, the road has been virtually rebuilt, grades have been reduced, heavier rails, bridges and stone ballast installed and double tracking completed until the Erie was in 1929 a first-class double-track, low-grade line between Jersey City, N.J., and Chicago, Ill.

For the year ending December 31, 1928 the total operating revenues were $124,724,273, of which merchandise contributed $77,203,615; coal $26,086,404; and passenger traffic $11,250,264. The surplus for the year was $8,282,847. The operating ratio for 1928 was 77·49 as compared with 81·86 in 1927. The company's investment was stated at $529,387,773. Capital stock consisted of $47,904,400, 4% non-cumulative first preferred, $16,000,000, 4% non-cumulative second preferred, and $151,116,700 common.

Beside a large anthracite traffic and a large general merchandise traffic, the Erie is second in number of commuters handled daily in and out of Greater New York. It also maintains a standard fast passenger service between New York, Buffalo, Cleveland, Chicago, and intermediate points. It is one of the so-called Van Sweringen group of railroads. (J. J. BE.)

ERIGENA, JOHANNES SCOTUS (*c.* 815–*c.* 877), mediaeval philosopher and theologian, was known to his contemporaries as Johannes Scotus (Scottus) or John the Scot, but in his versions of Dionysius the Areopagite he styles himself Johannes Ierugena. Eleventh century manuscripts have *Iohannes Ierugina, Erugena* and *Eriugena,* formed apparently on the analogy of Graiugena ("Greek-born"), and seemingly connected with Erin, the name for Ireland. Ierugena suggests the Greek ἱερός, ἱερὸς νῆσος being a common name for Ireland. (Prudentius, bishop of Troyes, definitely states that he was of Irish extraction.) The form *Erigena* is late and was not combined with *Johannes Scotus* until the 16th century.

Of Erigena's early life nothing is known. Bale quotes the story that he travelled in Greece, Italy and Gaul, and studied not only Greek, but also Arabic and Chaldaean, but Erigena's knowledge of Greek, though competent, is not such as to compel us to conclude that he actually visited Greece. It is certain, however, that Charles the Bald invited him to France shortly before 847 and made him head of the court school. The latter part of his life is involved in obscurity, and the story that he was invited to Oxford by Alfred the Great and that he afterwards taught at the abbey of Malmesbury has only the minimum of possibility.

Erigena marks the transition from the older Platonizing philosophy to the more rigid scholasticism, and is one of the most interesting of mediaeval writers. Utilizing especially Origen, Basil, Gregory of Nyssa, Augustine, Boethius and Maximas, he transforms them with the monistic colouring of the pseudo-Dionysius, and elaborates the first complete synthesis of the Middle Ages. Logically, but not intentionally, he is a pantheist, following in the wake of the pseudo-Dionysius whom he regards as the convert of St. Paul. Although he believes that authority and reason cannot be contradictory, he boldly asserts that reason must be the criterion. He does not start with the datum of theology as the completed body of truth requiring only interpretation; his fundamental thought is that of the universe, nature, or God, as the ultimate unity which works itself out into the rational system of the world. All things, including man, are parts of the system and are to be explained by reference to it; for explanation of a thing is determination of its place in the universal or all. Religion or revelation is one factor in the divine process, a stage of the ultimate rational life.

Erigena's first work was a treatise on the eucharist, no longer extant, and often wrongly identified with the *De corpore et sanguine Domini* of Ratramnus. But from the fragments on St. John's Gospel and from his contemporaries, it would appear that Erigena advanced the doctrine that the eucharist was merely symbolical or commemorative. His orthodoxy was not suspected at the time, and a few years later he was selected by Hincmar, archbishop of Rheims, to defend the doctrine of liberty of will against the extreme predestinarianism of the monk Gottschalk. The extant treatise, *De Divina Praedestinatione,* composed on this occasion (*c.* 851) was at once suspected. It was assailed by Drepanius Florus, canon of Lyons, and Prudentius of Troyes, and was condemned by two Councils—of Valence (855) and Langres (859). It starts with the bold affirmation that philosophy, and religion are fundamentally one and the same, and goes on to assert that because God is independent of time, predestination can only be asserted of Him inasmuch as by His free-will he allows the activities of creatures. It cannot involve any notion of necessity either in God or in man. In any case, predestination could only be to grace and happiness, for evil is merely negation of good; and moreover, if God knew evil, He would cause it because His knowledge and His will are identical.

Erigena's next work (*c.* 858) was a Latin translation of the works of the pseudo-Dionysius (*see* DIONYSIUS AREOPAGITICUS) undertaken at the request of Charles the Bald from the manuscripts of the abbey of St. Denys, Paris, which Dionysius was said to have founded. It has been preserved and fragments of Erigena's commentary on the original have been discovered. His great work, *De divisione naturae,* written *c.* 865–870, was condemned by a council at Sens, by Honorius III. (1225), and by Gregory XIII. in 1585. In it he maintains that *Natura* is the name for the totality of all things, containing in itself being and non-being, and covering (1) that which creates and is not created; (2) that which is created and creates; (3) that which is created and does not create; (4) that which neither is created nor creates. The first is God as the source of all things, the last is God as the final end of all things. The second and third together compose the created universe, which is the manifestation of God, God *in processu, Theophania.* The second covers the primordial ideas, archetypes, immutable relations, divine acts of will,

according to which individual things are formed. The third is the world of individuals, the effects of the primordial causes, without which the causes have no true being. Neither the ideas nor individual creatures have any self-independent existence; they are only in God; and each thing is a manifestation of the divine. God alone, the uncreated creator of all, has true being. He is the true universal, all-containing, infinite and incomprehensible. True theology must be negative, for God is above truth, wisdom, goodness, etc. (In this sense, He is nothing, and hence the nothing out of which things are created is identifiable with the divine nature.) Nevertheless the world, as the revelation of God, tells us something of the divine essence. We recognize His being in the being of things, His wisdom in their order, His life in their constant motion. Thus God is for us a Trinity—the Father as substance of being, the Son as wisdom, the Spirit as life. In man, the noblest of creatures, this Trinity is reflected in *intellectus, ratio* and *sensus.*

From the infinite essence of God emanates the realm of ideas in the Platonic sense. These ideas, which constitute a divine self-determination, are eternally created and are maintained in unity by the divine Logos. The highest idea is that of *goodness;* things *are,* only if they are good; being without well-being is naught. *Essence* participates in goodness—that which is good has being, and is therefore to be regarded as a species of good. *Life,* again, is a species of essence, *wisdom* a species of life, and so on, always descending from genus to species in logical fashion.

Under the moving influence of the spirit, the ideas manifest themselves in created things. Manifestation is part of the essence of the causes; as the causes are eternal, timeless, so creation is eternal, timeless. The Mosaic account, then, is allegorical. Paradise and the Fall have no spatial or temporal being. Only after the introduction of sin did man lose his spiritual body and acquire the animal nature with its distinction of sex.

The most remarkable and at the same time the most obscure portion of the work is that in which the final return to God is handled. Naturally, sin is a preliminary to this redemption, but Erigena has great difficulty in accounting for it. If God is true being, then sin can have no substantive existence; it cannot be said that God knows of sin, for to God, knowing and being are one. In the universe of things, *as* a universe, there can be no sin; there must be perfect harmony. Sin, in fact, results from the will of the individual who falsely represents something as good which is not so. This misdirected will is punished by finding that the desired objects are vain, and hell is the inner state of the sinful will. The result of punishment is the final purification and redemption of all, even animals and devils. The ultimate goal is *deificatio* or resumption into the Divine Being, when the individual soul is raised to a full knowledge of God, and where knowing and being are one. Erigena's doctrines seem to have influenced such divers thinkers as Heric and Remigius of Auxerre, Gerbert, Berengerius, Gilbert de la Porée, Abelard, Alan of Lille, the Chartres men, Amalric of Bene and Nicholas of Cusa. Hugh of St. Victor utilized his translation of the pseudo-Dionysius.

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ERIGONE, in Greek mythology, daughter of Icarius, the hero of the Attic deme Icaria. Her father, who had been taught by Dionysus to make wine, gave some to some shepherds, who became intoxicated. Their companions thinking they had been poisoned, killed Icarius and buried him under a tree on Mount Hymettus (or threw his body into a well). Erigone, guided by her faithful dog Maera, found his grave and hanged herself on the tree. Dionysus sent a plague on the land, and all the maidens of Athens, in a fit of madness, hanged themselves like Erigone. Icarius, Erigone, and Maera were set among the stars as Boötes (or Arcturus), Virgo, and Procyon. The festival called Aeora (the "Swing") was subsequently instituted to propitiate Icarius and Erigone. Various small images (Lat. *oscilla*) were suspended on trees and swung backwards and forwards and offerings of fruit were made (Hyginus, *Fab. 130, Poët. astron.* ii. 4; Appolodoros iii. 191–2). The story was probably intended to explain the origin of these *oscilla.*

ERIN (ĕr-ụn, Eng. ēr′ĭn), an ancient name for Ireland. The oldest form of the word is Ériu (Mid. Irish *Hériu,* dative *Hérinn*), of which Érinn is the dative case. Ériu was itself almost certainly a contraction from a still more primitive form *Iveriū* for an older **Iveriō* (or **Piveriō; cf.* Πιέριος, Πιερία) for when the name of the island was written in ancient Greek it appeared as Ἰουερνία (Ivernia), and in Latin as *Iberio, Hiberio* or *Hibernia,* the first syllable of the word Ériu being thus represented in the classical languages by two distinct vowel sounds separated by *b* or *v.* Of the Latin variants, *Iberio* is the form found in the most ancient Irish mss., such as the *Confession* of St. Patrick, and the same saint's *Epistle to Coroticus.* Further evidence to the same effect is found in the fact that the Welsh name for Ireland was Iwerddon, whence the Breton *Yuerdon,* a learned borrowing from Welsh. In later Gaelic literature the primitive form Ériu became the dissyllable Éire; hence the Norsemen called the island the land of Éire, *i.e.,* Ireland, the latter word being originally pronounced in three syllables. (*See* IRELAND.) Nothing is known as to the meaning of the word in any of its forms, and Whitley Stokes's suggestion that it may have been connected with the Sanskrit *avara,* meaning "western," is admittedly no more than conjecture. There was, indeed, a native Irish legend, worthless from the standpoint of etymology, to account for the origin of the name. According to this myth there were three kings of the Dedannans reigning in Ireland at the coming of the Milesians, named MacColl, MacKecht and MacGrena. The wife of the first was Eire, and from her the name of the country was derived. Curiously, Ireland in ancient Erse poetry was called "Fodla" or "Banbha," and these were the wives of the other two kings in the legend.

ERINNA, Greek poet, friend of Sappho, flourished about 600 (according to Eusebius, 350 B.C.). Although she died at the age of 19, her poems were among the most famous of her time. Of her best known poem Ἠλακάτη (the *Distaff*), written in a mixture of Aeolic and Doric, which contained 300 hexameter lines, only four lines are now extant. Three epigrams in the Palatine anthology, also ascribed to her, probably belong to a later date.

The fragments have been edited (with those of Alcaeus) by J. Pellegrino (1894).

ERINYES (ĕ-rēn-ü-es), less correctly ERINNYES, in Greek mythology, the name given to the avenging deities, probably personified curses, but possibly in their origin ghosts of the murdered (Lat. *Furiae*). According to Hesiod (*Theog.,* 185) they were the daughters of Earth, and sprang from the blood of the mutilated Uranus; in Aeschylus (*Eum.,* 321) they are the daughters of Night, in Sophocles (*O.C.,* 40), of Darkness and Earth. Sometimes one Erinys is mentioned, sometimes several. Euripides first spoke of them as three in number, to whom later Alexandrian writers gave the names Alecto (unceasing in anger), Tisiphone (avenger of murder), Megaera (jealous).

Their home is the world below, whence they ascend to earth to pursue the wicked. They punish all offences against the laws of human society, such as perjury, violation of the rites of hospitality, and, above all, the murder of relations. Though just, they are merciless and take no account of mitigating circumstances. Being deities of the underworld, they are often identified with spirits of the fertility of the earth, as the Semnai or Eumenides (*q.v.*) at Athens. (*See* DEMETER.) In Aeschylus, the Erinyes are represented as awesome, Gorgon-like women wearing

long black robes, with snaky locks, bloodshot eyes, and claw-like nails. Later, they are winged maidens of serious aspect, in the garb of huntresses, with snakes or torches in their hair, carrying scourges, torches or sickles.

See J. E. Harrison, *Prolegomena to the Study of Greek Religion* (1903); E. Rohde, *Psyche;* A. Rapp, in Roscher's *Lexikon;* and J. A. Hild in Daremberg-Saglio, s.v. FURIAE.

ERIS, in Greek mythology, a sister of the war-god Ares (Homer, *Iliad,* iv. 440), and in the Hesiodic theogony (225) a daughter of Night. In the later legends of the Trojan war, Eris, not having been invited to the marriage festival of Peleus and Thetis, flings a golden apple, the "apple of discord," among the guests, to be given to the most beautiful. The claims of the three deities, Hera, Aphrodite and Athena, are decided by Paris in favour of Aphrodite, who as a reward assists him to gain possession of Helen (Hyginus, *Fab.,* 92; Lucian, *Charidemus,* 17). Hesiod also mentions (*Works and Days,* 24) a beneficent Eris, the personification of honourable rivalry. In Virgil (*Aeneid,* viii. 702) and other Roman poets, Eris is represented by Discordia.

ERISTIC, the art of disputation, especially that form of it which aims at personal triumph rather than at the discovery of truth (Greek ἔρις, strife). The Eristics were a group of Sophists led apparently by Euclid of Megara (hence their other name, the Megarians), who were specially addicted to dialectical puzzles (mostly borrowed or adapted from the Eleatics) and other debating tricks. It was through them and their like that the name of Sophist, otherwise an honourable name, eventually fell into disrepute. *See* MEGARIAN SCHOOL, and SOPHISTS.

ERITH, an urban district in the Dartford parliamentary division of Kent, England, 15 m. E. by S. of London, on the Southern railway. Pop. (1921) 31,558. It lies on the south bank of the Thames and extends up the hills above the shore, many villas having been erected on the higher ground. The church of St. John the Baptist (restored) goes back to Norman times and contains many interesting early monuments and brasses. Erith has large engineering and gun factories, and in the neighbourhood are gunpowder, oil, glue and manure works, as well as large brick fields from which sand and loam are also exported. The southern outfall works of the London main drainage system are at Crossness in the neighbouring lowland called Plumstead marshes. To the west of Erith lie Abbey Wood and Belvedere (the ancient district of Lessness or Lessnes Heath), with the county technical college and secondary school, and the home (1856) for aged merchant seamen in Belvedere park. The tract of Bostall Heath (155 ac.) below Plumstead is maintained by the London county council as an open space. Erith is the headquarters of several yacht clubs. Erith, the name of which is derived from Anglo-Saxon meaning the old, or shore, *hythe* or haven, is mentioned in a Latin charter of the seventh century in connection with a gift of land made by the bishop of the East Saxons. It was anciently a borough, and was granted a market and fairs in 1313. Down to the close of the 17th century it was of some importance as a naval station. Erith council maintains tramway and electricity undertakings and recreation grounds and parks, including Franks park (40 ac.). The district lies within the metropolitan police district of Greater London.

ERITREA (*ā-rē-trā'ą*), an Italian colony on the African coast of the Red sea. Area, 45,734 sq.m. Pop. (1925) 410,000, including 4,251 Europeans, of whom 3,901 were Italians. It extends from Ras Kasar, a cape 110 m. S. of Suakin, in 18° 2′ N., as far as Ras Dumeira (12° 42′ N.), in the Strait of Bab-el-Mandeb, a coastline of about 650 miles. The colony is bounded inland by the Anglo-Egyptian Sudan, Abyssinia and French Somaliland. The colony corresponds neither to ethnic nor geographical divisions, and its frontiers, like so many other frontiers in Africa, are almost entirely arbitrary lines. The Dahlak archipelago and other groups of islands along the coast belong to Eritrea.

Physical Features.—The coast-line is of coral formation and is in the neighbourhood of Massawa, thickly studded with small islands. The chief indentations are Annesley bay, immediately south of Massawa, and Assab bay in the south. The colony consists of two widely-differing regions. The northern division, which is the main part of the colony is mostly part of the Abyssinian plateau, reached from the coast by a steep escarpment. The southern division is part of the Afar or Danakil country. These two regions are connected by a narrow strip of land behind Annesley bay, where the Abyssinian hills approach close to the sea. Southward from this bay the coast-line trends south-east so that at Tajura bay the distance between the Abyssinian hills and the sea is over 200 miles. The Afar country is part of the East African rift-valley, and in the southern parts of the valley its surface is diversified by ranges of hills, frequently volcanic, and by lakes. Here the frontier is drawn 60 kilometres (37·28 m.) from the coast line, so that most of the Afar country belongs to Abyssinia. The volcano of Alid (2,985 ft.) is in Italian territory. Around it is a vast lava field.

At Annesley bay the narrow coast plain is succeeded by foothills separated by small valleys through which flow innumerable streams. From these hills the ascent to the plateau which constitutes northern Eritrea is very steep. This tableland, which has a general elevation of about 6,500 ft. is fairly fertile despite a desert region—Sheb—to the south-east of Keren. It is characterized by rich, well-watered valleys, verdant plains and flat-topped hills with steep sides, running in ranges or isolated. The highest hills in Eritrean territory rise to about 10,000 feet. The plateau is known by various names, the region directly west of Massawa being called Hamasen. To the west and north the plateau sinks in terraces to the plains of the Sudan, and eastward falls more abruptly to the Red sea, the coast plain, known as the Samhar, consisting of sandy country covered with mimosa and, along the khors, with a somewhat richer vegetation.

The colony contains no navigable streams. For a short distance the Setit (known in its upper course as the Takazze), a tributary of the Atbara forms the frontier, as does also in its upper course the Gash or Mareb (*see* ABYSSINIA). The Mareb, often dry in summer, in the floods is a large and impassable river. The Baraka (otherwise Barka) and Anseba rise in the Hamasen plateau, near Asmara, within a short distance of each other. The Baraka flows west and then north; the Anseba, which has a more easterly course, also flows northward and joins the Baraka a little north of 17° N. A few miles below the confluence the Baraka enters Sudan territory, and after heavy rain discharges some of its water into the Red sea north of Tokar. The watershed separating the Nile basin from the Red sea streams lies between the Mareb and the Khor Baraka.

In the coast zone the heat and humidity are excessive during most of the year, June, September and October being the hottest months. Rains occur between November and April, during which time the temperature is lower. At Massawa the mean temperature is 86° F, but in summer the thermometer often rises to 120° F in the shade, and the mean for July is 94° F. Rainfall at Massawa is not more than 8 in. a year; at Arsab not more than 2 inches. In the region comprising the slopes of the plateau and up to about 6,000 ft. heat and humidity still prevail, but the temperature is lower and the rainfall rises to 14 inches. On the high plateau the climate is generally moderately cool, with a yearly mean of 67° F. Slight rain falls in the spring and abundant monsoon rains from June to September. On the plateau the climate is suitable for European settlement. Above 8,500 feet the climate becomes sub-alpine in character.

In the low country the flora differs little from that of tropical Africa generally, whilst on the plateau the vegetation is characteristic of the temperate zone. The olive tree grows on the high plateau and covers the flanks of the hills to within 3,000 ft. of sea level. The sycamore fig-tree grows to enormous proportions in parts of the plateau. Lower down durra, maize and bultuc grow in profusion. In the northern part of the colony, especially along the Khor Baraka, the dom palm flourishes. The fauna includes, in the low country, the lion, panther, elephant, camel and antelope of numerous species. On the plateau the fauna is that of Abyssinia (*q.v.*).

Inhabitants.—The inhabitants of the plains and foothills are for the most part semi-nomad shepherds, living on durra and milk. In the north these people are largely of Arab or Hamitic stock,

such as the Beni-Amer, but include various negro tribes. Afar and Somali form the population of the southern regions. The inhabitants of the plateau are Abyssinians. Some 115,000 of the Abyssinians are Copts, the rest are Mohammedans; and Islam is the faith of most of the other tribes. The languages spoken by the Abyssinians are Tigrai and Tigre. A warlike race, they have settled down under Italian rule. They furnish the defence force of the colony (5,000 strong in 1927). Among the native industries are mat-weaving, cotton-weaving, silver-working and rudimentary iron and leather working. (*See* AFARS; SOMALILAND; ABYSSINIA.)

Towns and Communications.—The chief and only good port is Massawa (*q.v.*). Assab is a roadstead in the Danakil country. Zula (*q.v.*), on the shores of Annesley bay, is identified with the ancient Adulis. On the plateau are Asmara (*q.v.*), the capital, Keren (Cheren), Agordat, Adi Kaleh, Adi Urgi and Barentu, all headquarters of administrative divisions. A railway from Massawa climbs to and crosses the highlands. The section to Asmara, 75 m., completed in 1912, rises to 7,765 ft., the altitude of Asmara. Thence the railway was continued via Keren to Agordat (reached in 1926), and Tessenei, the centre of the cotton-growing area. From Agordat a high road goes west to Kassala in the Sudan. From Keren another main road runs south to Adowa, in Tigre (Abyssinia). In the south, from Assab a road runs west to tap the trade of central Abyssinia. Besides these principal routes there are many secondary roads and camel and mule paths. Every valley leading to the plateau has its ancient way; one of the most frequented is from Annesley bay up the valley of the Hadas river. There is a well-developed telegraphic system, Massawa being in communication by land lines with Adis Ababa and by cable and wireless with the outer world. Massawa is also a regular port of call for several steamship lines.

Agriculture and Trade.—Agriculture is practically confined to the highlands. The Abyssinians are good agriculturists and cultivate cereals (wheat, barley, durra), beans and peas, coffee and other food crops. Linseed and other oil seeds, flax fibres, dates and tobacco are other products. The chief wealth of the people consists, however, in their sheep, cattle, camels, donkeys and other live stock. State-aided attempts to settle Italian agriculturists on the soil began in 1890; the first experiments were a failure. About 1,900 private individuals succeeded in making profitable farms near Asmara, and their example was copied. But as the Abyssinians held nearly all the best land the scope for Italians was limited. The coast zone produces salt, and there are valuable pearl and mother-of-pearl fisheries off the Dahlak archipelago.

For many years Italian capitalists showed a disinclination to invest money in the colony, and enterprise by other Europeans was discouraged. The chief industry, which owes its inception to the Italians, is cotton growing in the valleys of the Gash and Baraka rivers. After many years of experimenting, suitable varieties of cotton were found, ginneries were built at Asmara and Massawa, and a beginning was made with irrigation works in the Gash area in 1915. The Gash ends in an inland delta in the Kassala province of the Sudan, and an agreement, made in 1925 with the Sudan Government, regulated the use of its waters by the two countries. In 1926–27 some 6,000 ac. were under cotton and the production of lint 478,000 lb. This was nearly double the output in 1922.

The external trade developed at first slowly; in 1901 it was valued at about £450,000; in 1911 at about £1,175,000, and in 1913 at over £1,500,000. After the World War development was more rapid and the external trade in 1926 was valued at £3,730,000 (imports £2,370,000; exports £1,360,000). These figures include the transit trade with Abyssinia and the Sudan. The excess of imports over exports was a constant and marked feature of external trade. Besides cotton goods and food stuffs the imports included machinery, railway material and all the goods required in the development of the colony. The most valuable exports were skins and hides, coffee, linseed and vegetable ivory (the nut of the dum palm) in which there was a marked growth. Other exports of value were salt, potash, a little gold (from mines near Asmara), mother-of-pearl and pearls. Trade is mainly with Italy.

Administration and Revenue.—A civil administration was established in 1898. The governor is responsible to the minister of the colonies and is assisted by a body consisting of the heads of departments. There is no legislative council and no direct representation of the people, though, in purely local matters, village headmen, councils of elders and tribal chiefs aid the Italian officials. The colony is divided into commissariats, each with their local organizations. In the administration special attention is devoted to health, education and public works. There is an independent judiciary with the right of appeal for non-natives to the Rome court of cassation. The civil laws for the natives are those sanctioned by local usage and they are administered by native tribunals, with the right of appeal to the colonial court of appeal.

Revenue is derived from customs duties, direct taxation and other sources. For 35 years Eritrea was a charge on the Italian treasury, largely because of the expenditure on the military establishment. From 1920, however (when the State contribution was 6,650,000 lire, in a total budget of 24,121,000 lire), the cost of civil administration was almost met by local revenue. The budget of 1927–28 was balanced at 42,550,000 lire, the civil expenditure being returned at 26,330,000 lire and military expenditure at 16,125,000 lire. No subsidy was required from Italy.

(F. R. C.)

History.—Traces of the ancient Eritrean civilization are scarce. During the prosperous periods of ancient Egypt, Egyptian squadrons asserted their rule over the west Red Sea coast, and under the Ptolemies the port of Golden Berenice (Adulis?) was an Egyptian fortress, afterwards abandoned. During the early years of the Roman empire, Eritrea formed part of an important independent state—that of the Axumites (Assamites). At the end of the reign of Nero, and perhaps even earlier, the king of the Axumites ruled over the Red Sea coast from Suakin to the Strait of Bab-el-Mandeb, and traded constantly with Egypt. This potentate called himself "king of kings," commanded an army and a fleet, coined money, adopted Greek as the official language, and lived on good terms with the Roman empire. The Axumites belonged originally to the Hamitic race, but the immigration of the Himyaritic tribes of southern Arabia speedily imposed a new language and civilization. Therefore the ancient Abyssinian language, Geez, and its living dialects, Amharic and Tigrina, are Semitic, although modified by the influence of the old Hamitic Agau or Agao. Adulis (Adovlis), slightly to the north of Zula (*q.v.*), was the chief Axumite port. From Adulis started the main road, which led across the high plateau to the capital Axomis (Axum). Along the road are still to be seen vestiges of cities and inscribed monuments, such as the Himyaritic inscriptions on the high plateau of Kohait, the six obelisks with a Saban inscription at Toconda, and an obelisk with an inscription at Amba Sait. After the rise of the Ethiopian empire the history of Eritrea is bound up with that of Ethiopia (*see* ABYSSINIA), but the documents of the Portuguese expedition of the 16th century and other Ethiopian records show that all the country north of the Mareb enjoyed relative autonomy under a vassal of the Ethiopian emperor.

Michael, counsellor of Solomon, who was king of the country north of the Mareb, usurped the throne of Solomon during the reign of the Emperor Atzié Jasu II. (1729–53), and, after proclaiming himself ras of Tigré and "protector of the empire," ceded the North Mareb country to an enemy of the rightful dynasty. Hence a long struggle between the dispossessed family and the occupants of the North Mareb throne. The coast regions had meantime passed from the control of the Abyssinians. In the 16th century the Turks made themselves masters of Zula, Massawa, etc., and these places were never recovered by the Abyssinians. In 1865 Massawa and the neighbouring coast was acquired by Egypt, the khedive Ismail entertaining projects for connecting the port by railway with the Nile. The Egyptians took advantage of the civil war in Abyssinia to seize Keren and the Bogos country in 1872, an action against which the negus Johannes (King John), newly come to the throne, did not then protest. In 1875 and 1876 the Egyptians, who sought to increase their conquests, were defeated by the Abyssinians at Gundet and Gura. Walad Michael, the hereditary ruler of Bogos, fought as ally of King John at Gundet and of the Egyptians at Gura. For two years Walad Michael continued to harass the border, but in Dec.

1878 he submitted to King John, by whose orders he was (Sept. 1879) imprisoned upon an amba, or flat-topped mountain, whence he only succeeded in escaping in 1890. In 1879 his territory was given by King John to Ras Alula, who retained it until, in August 1889, the Italians occupied Asmara.

An Egyptian garrison remained at Keren in the Bogos country until 1884, when in consequence of the revolt of the Mahdi it was withdrawn, Bogos being occupied by Abyssinia on Sept. 12 of that year. On Feb. 5, 1885, an Italian force, with the approval of Great Britain, occupied Massawa, the Egyptian garrison returning to Egypt. This occupation led to wars with Abyssinia and to the establishment of the colony in its present limits. For Italo-Abyssinian relations *see* ITALY and ABYSSINIA.

The purchase of Assab and the neighbouring region for £1,880, from the Sultan Berehan of Raheita for use as a coaling station by the Italian Rubattino Steamship Company, in March 1870, formed the nucleus of Italy's colonial possessions. This purchase was protested against by Egypt, Turkey and Great Britain, but eventually, the British opposition being overcome and that of Egypt and Turkey disregarded, Assab, by a decree of July 5, 1882, was declared an Italian colony. Between 1883 and 1888 various treaties were concluded with the sultan of Aussa ceding the Danakil coast to Italy and recognizing an Italian protectorate over the whole of his country—through which passes the trade route from Assab bay to Shoa.

On Jan. 1, 1890, the various Italian possessions on the coast of the Red sea were united by royal decree into one province under the title of the Colony of Eritrea—so named after the Erythraeum Mare of the Romans. At first the government of the colony was purely military, but after the defeat of the Italians by the Abyssinians at Adowa (1896), the administration was placed upon a civil basis. The frontiers were further defined by a French-Italian convention (Jan. 24, 1900) fixing the frontier between French Somaliland and the Italian possessions at Raheita, and also by various agreements with Great Britain and Abyssinia. A tripartite agreement between Italy, Abyssinia and Great Britain, dated May 15, 1902, placed the territory of the Kanama tribe, on the north bank of the Setit, within Eritrea. A convention of May 16, 1908, settled the Abyssinian-Eritrean frontier in the Afar country, the boundary being fixed at 60 km. from the coast. The task of reconstructing the administration on a civil basis and of developing the commerce of the colony was entrusted to Signor F. Martini, who was governor for nine years (1898–1906). Under civil rule the colony made steady though somewhat slow progress and has become economically prosperous. The native forces, known as *Ascari,* rendered useful services in the wars against Abyssinian and other tribes, and in the Libyan War. On Aug. 2, 1928, a private agreement arranged for the cession to Abyssinia of a free zone at the port of Assah, and the construction of a road thence to Addis Ababa.

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For Afar consult W. Munzinger, "A Journey through the Afar Country" in *Journ. Royal Geog. Soc.* for 1869; V. Bottego, "Nella Terra dei Danakil," in *Boll. Soc. Geog. Italiana,* 1892; Count C. Rossini, "Al Rágali" in *L'Espl. Comm.* of Milan, 1903-04; and articles by G. Dainelli and O. Marinelli in the *Riv. Geog. Italiana* of Florence for 1906–08, dealing with the volcanic regions.

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ERIVAN or **IRWAN,** (1) the capital town of Armenian S.S.R. situated in 40° 16′ N., 44° 35′ E., 234 m. by rail south-west of Tiflis, on the Zanga river, from which a great number of irrigation canals are drawn. Altitude, 3,170 feet. Pop. (1926) 62,180. After the creation of the Armenian Republic, an Armenian University was founded at Erivan, and also an Armenian National Museum and an Institute of Music. The population has increased markedly and there are several industrial undertakings including the making of machinery, wine and brandy distilling, rice preparation, brick, leather and furniture factories. In 1928 a factory for extracting glycerine from the oil of cotton was successfully established. A new hydro-electric station, designed by the Armenian architect, Tamarian, was opened in 1926. The old Persian portion of the town consists mainly of narrow crooked lanes enclosed by mud walls, which effectually conceal the houses, and the modern Russian portion is laid out in long ill-paved streets. On a steep rock, rising about 600 ft. above the river, stand the ruins of the 16th-century Turkish fortress, containing part of the palace of the former Persian governors, a handsome but greatly dilapidated mosque, a modern Greek church and a cannon foundry. One chamber, called the Hall of the Sardar, bears witness to former splendour in its decorations. The finest building in the city is the mosque of Hussein ali Khan, familiarly known as the Blue Mosque from the colour of the enamelled tiles with which it is richly encased. At the mosque of Zal Khan a passion play is performed yearly illustrative of the assassination of Hussein, the son of Ali. Erivan is an Armenian episcopal see, and has a theological seminary. Armenians, Persians and Tatars are the principal elements in the population, besides some Russians and Greeks. The town fell into the power of the Turks in 1582, and was taken by the Persians under Shah Abbas in 1604, besieged by the Turks for four months in 1615, and reconquered by the Persians under Nadir Shah in the 18th century. In 1780 it was successfully defended against Heraclius, prince of Georgia; and in 1804 it resisted the Russians. At length in 1827 Paskevich took the fortress by storm, and in the following year the town and government were ceded to Russia by the peace of Turkman-chai. A Tatar poem in celebration of the event has been preserved by the Austrian poet, Bodenstedt, in his *Tausend und ein Tage im Orient* (1850). (2) an administrative district of the Armenian S.S.R. with the town of Erivan as its centre. It has an area of 3,975 sq.km. and a population (1926) of 175,816. The district is noted for its vineyards and for its apples, apricots and melons.

ERLANGEN, a town of Germany, in the republic of Bavaria, on a fertile plain, at the confluence of the Schwabach and the Regnitz, 11 m. N.W. of Nuremberg, on the railway from Nuremberg to Bamberg. Pop. (1925) 29,597. In 1017 Erlangen was transferred from the bishopric of Würzburg to that of Bamberg; in 1361 it was sold to the king of Bohemia. It became a town in 1398 and passed into the hands of the Hohenzollerns, burgraves of Nuremberg, in 1416. It owes the foundation of its prosperity chiefly to the French Protestant refugees who settled here on the revocation of the edict of Nantes and introduced various manufactures. In 1810 it came into the possession of Bavaria. Erlangen was for many years the residence of the philosophers Johann Gottlieb Fichte and Friedrich Wilhelm von Schnelling. It is divided into an old and a new town. Upon the market place stand the town hall and the former palace of the margraves of Bayreuth, now the main building of the university. The latter was founded by the margrave Frederick (d. 1763), who, in 1742, established a university at Bayreuth, but in 1743 removed it to Erlangen. The chief industries of Erlangen are the manufacture of electrical apparatus, horn ware, leather, paper, brushes and gloves. The beer of Erlangen is famous throughout Germany and large quantities are brewed and exported.

ERLANGER, CAMILLE (1863–1919), French composer, was born in May, 1863, and studied at the Paris Conservatoire. He made his reputation in 1896 with *Saint-Julien l'Hospitalier,* a dramatic legend, the libretto of which was founded on the story of Flaubert. His other more important works were *Le Juif Polonais* (1900), *Aphrodité* (1906) and *La Sorcière* (1912).

ERLE, SIR WILLIAM (1793–1880), English lawyer and judge, was born at Fifehead-Magdalen, Dorset, on Oct. 1, 1793,

and was educated at Winchester and at New college, Oxford. Having been called to the bar at the Middle Temple in 1819 he went the western circuit, became counsel to the Bank of England, sat in parliament from 1837 to 1841 for the city of Oxford, and was made a judge of the common pleas in 1845. He was made Chief Justice of the Common Pleas in 1859, retired in 1866 and died at Bramshott, Hampshire, on Jan. 28, 1880.

See E. Manson, *Builders of our Law* (1904).

ERLKÖNIG or **ERL-KING,** a mythical character in modern German literature, does not exist in ancient German mythology. The name is linguistically merely the perpetuation of a blunder in Herder's *Stimmen der Völker* (1778), where it is used in the translation of the Danish song of the *Elf-King's Daughter* as equivalent to the Danish *ellerkonge, ellekonge,* or *elverkonge,* king of the elves; the true German word would have been *Elbkönig* or *Elbenkönig*, afterwards modified to *Elfenkönig* by Wieland in his *Oberon* (1780). Herder was probably misled by the Danish word *elle* signifying both elf and alder tree (Ger. *Erle*). His mistake has been perpetuated by both English and French translators, who explain the myth in the tree-worship of early times, or in the vapoury emanations round alder trees at night. The legend was adopted by Goethe as the subject of one of his finest ballads, and has been treated as a musical theme by Reichardt and Schubert.

ERMANARIC (*fl.* 350–376), king of the East Goths, belonged to the Amali family, and was the son of Achiulf. His name occurs as Ermanaricus (Jordanes), Aírmanareiks (Gothic), *Eormenric* (A. Sax.), Jörmunrek (Norse), Ermenrîch (M.H. German). His vast kingdom eventually extended from the Danube to the Baltic and from the Don to the Theiss, but in his later days the west Goths threw off his yoke, and, on the invasion of the Huns, rather than witness the downfall of his kingdom, Ermanaric is said by Ammianus Marcellinus to have committed suicide. His fate early became the centre of popular tradition, which found its way into the narrative of Jordanes or Jornandes (*de rebus geticis,* chap. 24), who compared him to Alexander the Great and certainly exaggerated the extent of his kingdom. In German legend Ermanaric became the typical cruel tyrant, and references to his crimes abound in German epic and in Anglo-Saxon poetry. He is made to replace Odoacer as the enemy of Dietrich of Bern, his nephew, and his history is related in the Norse *Vilkina* or *Thidrekssagà,* which chiefly embodies German tradition. The tale is told with variations by Saxo Grammaticus (*Historia Danica,* ed. Müller, p. 408, etc.), and in the Icelandic poems, the *Lay of Hamtheow, Gudrun's Chain of Woe,* and in the prose *Edda.*

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ERMELAND or **ERMLAND** (*Varmia*), a district in East Prussia, extending from the Frisches Haff inland towards the Polish frontier. It is a well-wooded sandy tract of country, has an area of about 1,650sq.m., a population of 240,000, and is divided into the districts of Braunsberg, Heilsberg, Rössel and Allenstein.

Ermeland was originally one of the 11 districts of old Prussia and was occupied by the Teutonic Knights, being made in 1250 one of the four bishoprics of the country under their sway. The bishop of Ermeland shortly afterwards declared himself independent of the order, and became a prince of the empire. In 1466 Ermeland, together with West Prussia, was by the peace of Thorn attached to the crown of Poland, and the bishop had a seat in the Polish senate. In 1772 it was again incorporated with Prussia.

See Hipler, *Literaturgeschichte des Bisthums Ermeland* (Braunsberg, 1873); the *Monumenta historiae Warmiensis* (Mainz, 1860–64, and Braunsberg, 1866–72, 4 vols.); and Buchholz, *Abriss einer Geschichte des Ermlands* (Braunsberg, 1903).

ERMELO, a magisterial district of the Transvaal, bordering on Swaziland, and including the sources of the Vaal, Olifants, Komati and Usuto rivers. The general elevation of the region is over 5,000 feet. The principal occupations are pastoralism and agriculture. A considerable amount of maize is grown. Coal and gold are also found. Ermelo is the chief town of the district; 26° 31′ S., 29° 59′ E.; altitude, 5,689 feet. Population (1921), 2,742 Europeans, 1,804 coloured. The town is 171 m. by rail from Johannesburg. Adjoining the town lands is a Government experimental farm, devoted chiefly to pastoral problems, though about 1,000 ac. are under plantation. (R. U. S.)

ERMINE, an alternative name for the stoat (*Putorius ermineus*), applicable in its proper sense only when the animal is in its white winter coat. This animal measures 10in. in length exclusive of the tail, which is about 4in. long, and bushy towards the point. The fur in summer is reddish brown above and white beneath, changing in the winter of northern latitudes to snowy whiteness, except at the tip of the tail, which at all seasons is black. In Scottish specimens this change in winter is complete, but in those found in southern England, it is usually only partial. The white colour is protective; it also retains heat better than a dark covering. The colour change seems to be due, not to a moult, but to phagocytes devouring the pigment-bodies of the hair. *See* further the articles COLOURS OF ANIMALS and PHAGOCYTOSIS.

BY COURTESY OF THE NEW YORK ZOOLOGICAL SOCIETY

THE ERMINE, OR STOAT

This animal has a greatly valued fur, which in summer is reddish brown, changing in winter, in the north, to snow white, all except the tail, which remains black

The species is a native of the temperate and subarctic zones of the Old World, and is represented in America by a closely allied form. It inhabits thickets and stony places, and frequently makes use of the deserted burrows of moles and other underground mammals. It feeds on rats, water-rats and rabbits, which it pursues with pertinacity and boldness. It takes readily to water, and will even climb trees in pursuit of prey. The female brings forth five young ones about the beginning of summer. The winter coat of the ermine forms one of the most valuable of commercial furs, and is imported in enormous quantities from Norway, Sweden, Russia, and Siberia. (*See* FUR; FUR-BEARING ANIMALS.)

ERMINE STREET. Documents and writers of the 11th and succeeding centuries occasionally mention four "royal roads" in Britain—Icknield Street, Erning or Ermine Street, Watling Street and Foss Way—as standing apart from all other existing roads and enjoying the special protection of the king. Unfortunately these authorities are not at all agreed as to their precise course; the roads themselves do not occur as specially privileged in actual legal or other practice, and it is likely that the category of Four Roads is the invention of a lawyer or an antiquary. The names are, however, attested to some extent by early charters which name them among other roads, as boundaries. From these charters we know that Icknield Street ran along the Berkshire downs and the Chilterns, that Ermine Street ran more or less due north through Huntingdonshire, that Watling Street ran north-west across the midlands from London to Shrewsbury, and Foss diagonally to it from Lincoln or Leicester to Bath and mid-Somerset. This evidence only proves the existence of these roads in Saxon and Norman days. But they all seem to be much older. Icknield Street is probably a prehistoric ridgeway along the downs, utilized perhaps by the Romans near its eastern end, but in general not Roman.

Ermine Street coincides with part of a line of Roman roads leading north from London through Huntingdon to Lincoln. This line is followed by the Old North Road through Cheshunt, Buntingford, Royston and Huntingdon to Castor near Peterborough; and thence it can be traced through lanes and byways past Ancaster to Lincoln. Watling Street is the Roman highway from

London by St. Alban's (Verulamium) to Wroxeter near Shrewsbury (Viroconium). Foss is the Roman highway from Lincoln to Bath and Exeter. Hence it has been supposed, and is still frequently alleged, that the Four Roads were the principal highways of Roman Britain. This, however, is not the case. Icknield Street is not Roman and the three roads which follow Roman lines, Ermine Street, Watling Street and Foss, held no peculiar position in the Romano-British road system (*see* BRITAIN: *Roman*). In later times, the names Ermine Street, Icknield Street and Watling Street have been applied to other roads of Roman or supposed Roman origin. This, however, is wholly the work of Elizabethan or subsequent antiquaries and deserves no credence.

The derivations of the four names are unknown. Icknield, Ermine and Watling may be from English personal names; Foss, originally Fos, seems to be the Lat. *fossa* in its occasional mediaeval sense of a bank of upcast earth or stones, such as the *agger* of a road. (F. J. H.)

ERMOLDUS NIGELLUS, a monk of Aquitaine, accompanied King Pepin, son of the emperor Louis I., on a campaign into Brittany in 824. Banished from Pepin's court on a charge of inciting the king against his father, he retired to Strasbourg, where he sought to regain the emperor's favour by writing a poem on his life and deeds. About 830 he obtained his recall, and has been identified with Hermoldus, who appears as Pepin's chancellor in 838. His poem, *In honorem Hludovici imperatoris,* consists of four books and deals with the life and exploits of Louis from 781 to 826. He also wrote two poems in imitation of Ovid.

His writings are published in the *Monumenta Germaniae historica, Scriptores,* Band 2 (Hanover, 1826 fol.); by J. P. Migne in the *Patrologia Latina,* tome 105 (Paris, 1844); and by E. Dümmler in the *Poëtae Latini aevi Carolini,* Band 2 (Berlin, 1881–1884). *See* W. O. Henkel, *Über den historischen Werth der Gedichte des Ermoldus Nigellus* (Eilenburg, 1876); W. Wattenbach, *Deutschlands Geschichtsquellen,* Band 1 (Berlin, 1904); and A. Potthast, *Bibliotheca historica,* pp. 430–431 (Berlin, 1896).

ERNE, name of a river and two lakes in north-west Ireland. The river rises in Lough Gowna, Co. Longford, flows north through Lough Oughter, and then broadens into Upper Lough Erne, a shallow sheet of water 13 m. long, thickly studded with islands. It winds past the town of Enniskillen and enters Lough Erne, which is 18 m. long and 5 m. in extreme width. The island of Devenish is celebrated for its antiquarian remains (*see* ENNISKILLEN). The river then runs westward to Donegal bay, with falls at Ballyshannon (*q.v.*). The area of the Erne basin is *c.* 1,600 sq.m., and the length of the Erne valley *c.* 70 m.

ERNEST I. (ERNST ANTON KARL LUDWIG), duke of Saxe-Coburg-Gotha (1784–1844), son of Francis, duke of Saxe-Coburg-Saalfeld, was born on Jan. 2, 1784. At the time of his father's death (Dec. 9, 1806) the duchy of Coburg was occupied by Napoleon, and Ernest did not come into his inheritance till after the Peace of Tilsit (July 1807). He threw himself with vigour into the war of liberation against the French. After the battle of Leipzig he was given the command of the V. army corps and reduced Mainz by blockade; he also commanded the Saxon troops during the campaign of 1815. At the congress of Vienna he received the principality of Lichtenberg which was slightly enlarged after the second peace of Paris. These territories he sold to Prussia in 1834. In 1826, in the division of the territories of the duchy of Saxe-Gotha which followed the death of its last duke (Feb. 1825), he had received the duchy of Gotha, ceding that of Saalfeld to the duke of Meiningen; and he now exchanged his style of Ernest III. of Saxe-Coburg-Saalfeld for that of Ernest I. of Saxe-Coburg-Gotha. In 1821 he had given a constitution to Coburg, but he did not interfere with the traditional system of estates at Gotha. He died on January 29, 1844. Under Duke Ernest the house of Coburg gained its great international position. His younger brother Leopold (*q.v.*) became king of the Belgians; his brother Ferdinand (b. 1785) married the wealthy princess Antoinette von Kohary (1816) and was the father of the duchess of Nemours and of the future King Ferdinand of Portugal. Of his sisters, Antoinette (1779–1824) married Duke Alexander of Württemberg; Juliane [Alexandra Feodorovna] (1781–1860) married the Russian tsarevitch Constantine, from whom she was, however, divorced in 1820; and Victoria (1786–1861), wife of Edward Augustus, duke of Kent, became the mother of Queen Victoria of England. Duke Ernest was twice married: (1) in 1817 to Louise, daughter of Duke Augustus of Saxe-Gotha, whom he finally divorced in 1826; (2) in 1831 to Maria, daughter of Duke Alexander of Württemberg. Of his sons, by his first wife, Ernest succeeded him in the duchy, and Albert married Queen Victoria (*see* ALBERT, FRANCIS CHARLES, etc).

ERNEST II., duke of Saxe-Coburg-Gotha (1818–1893), was born at Coburg on June 21, 1818, the eldest son of Duke Ernest I., whom he succeeded in 1844. His own character and the influence of the king of the Belgians made him one of the most liberal princes in Germany. He was able to bring to a satisfactory conclusion disputes with the Coburg estates. In 1848 he anticipated the demands of the people of Gotha for a reform, and in 1852 introduced a new constitution by which the administration of his two duchies was assimilated in many points. His greatest services to Germany were performed during the years of reaction after 1849; almost alone among the German princes he remained faithful to the Liberal and National ideals, and he allowed his dominions to be used as an asylum by the writers and politicians who had to leave Prussia and Saxony. The marriage of his niece, the English princess Victoria with Frederick, the heir to the Prussian throne, caused the Conservative party to look with increased suspicion on the Coburg influence. After 1860 he became the chief patron and protector of the *National Verein,* and allowed his court to become the centre of the rising national agitation. In 1862 he agreed that in war his troops should be placed under the command of the king of Prussia. The democratic leanings of the Coburg court, which were shared by the crown prince Frederick, were a serious embarrassment to Bismarck. The opposition was accentuated when the duke allowed his dominions to be used as the headquarters of the agitation in favour of Frederick, duke of Augustenburg, who claimed the duchies of Schleswig and Holstein, and it was at this time that Bismarck is reported to have said that if Frederick the Great had been alive the duke would have been in the fortress of Spandau. In 1863 he was present at the *Fürstentag* in Frankfort, and from this time was in more frequent communication with the Austrian court, where his cousin Alexander, Count Mensdorff, was minister. But in 1866 he at once placed his troops at the disposition of Prussia; Bismarck had in an important letter explained to him his policy and tactics. The Hanoverian army, in its attempt to march south and join the Bavarians, had to pass through Thuringia, and the battle of Langensalza was fought in the immediate neighbourhood of Gotha. His troops took part in the battle, which ended in the rout of the Prussians, the duke, who was not present during the fight, in vain attempting to stop it.

With the year 1866 the political rôle which Ernest had played ended, but he quoted with great satisfaction the words used in 1871 by the emperor William at Versailles, that "to him in no small degree was due the establishment of the empire." He was a man of varied tastes, a good musician—he composed several operas and songs—and a keen sportsman. He died at Reinhardsbrunn on Aug. 22, 1893. In 1842 the duke married Alexandrine, daughter of the grandduke of Baden; there were no children by this marriage and the succession to Saxe-Coburg-Gotha passed therefore to the children of his younger brother Albert, the British prince consort, whose marriage contract precluded him from succeeding to the dukedom; the duchy came therefore to his second son, Alfred, duke of Edinburgh (1844–1900). *See* ALBANY, DUKES OF; SAXE-COBURG-GOTHA.

Duke Ernest published his memoirs, *Aus meinem Leben und aus meiner Zeit* (3 vols., 1887–89, Eng. trans. by P. Andreae, 1888–90).

See also Sir T. Martin, *Life of H.R.H. the Prince Consort* (1875–80); Hon. C. Grey, *Early Years of the Prince Consort* (1867); A. Ohorn, *Herzog Ernst II., ein Lebensbild* (Leipzig, 1894); and E. Tempeltey, *Herzog Ernst von Koburg und das Jahr 1866* (1898).

ERNEST AUGUSTUS (1771–1851), king of Hanover and duke of Cumberland fifth son of George III., King of England, was born at Kew on June 5, 1771. He studied at Göttingen, entered the Hanoverian army, and served as a leader of cavalry

when war broke out between Great Britain and France in 1793. When Hanover withdrew from the war in 1795 he returned to England, being made lieutenant-general in the British army in 1799. In the same year he was created duke of Cumberland and Teviotdale and granted an allowance of £12,000 a year. A stanch Tory, the duke objected to all proposals of reform, especially to the granting of any relief to the Roman Catholics, and had great influence with his brother the prince regent, afterwards King George IV., in addition to being often consulted by the Tory leaders. In 1810 he was severely injured by an assailant, probably his valet Sellis, who was found dead; and subsequently two men were imprisoned for asserting that the duke had murdered his valet. Recovering from his wounds, Cumberland again proceeded to the seat of war; as a British field-marshal, he was in command of the Hanoverian army during the campaigns of 1813 and 1814, being present, although not in action, at the battle of Leipzig. In May 1815 Ernest married his cousin, Frederica (1778–1841), daughter of Charles II. duke of Mecklenburg-Strelitz and widow of Frederick, prince of Solms-Braunfels, a union which was very repugnant to his mother Queen Charlotte, and was disliked in England, where the duke's strong Toryism had made him unpopular. The duke resented the refusal of parliament to increase his allowance from £18,000 to £24,000 a year, and retired for some years to Berlin. On the accession of George IV., with whom he had considerable influence, he returned to England. When William IV. died in June 1837, the crowns of Great Britain and Hanover were separated; and Ernest, as the nearest male heir of the late king, became king of Hanover. He cancelled the constitution which William had given in 1833, and the constitution which he sanctioned in 1840 was characteristic of his own illiberal ideas. His reign was a stormy one, and serious trouble between king and people had arisen when he died at Herrenhausen on Nov. 18, 1851 (*see* HANOVER: *History*). Ernest, who is generally regarded as the ablest of the sons of George III., left an only child, George, who succeeded him as king of Hanover.

See C. A. Wilkinson, *Reminiscences of the Court and Times of King Ernest of Hanover* (1886); von Malortie, *König Ernst August* (Hanover, 1861); and the various histories of Great Britain and Hanover for the period.

ERNEST AUGUSTUS, DUKE OF CUMBERLAND (1845–1923), only son of George V. of Hanover (*q.v.*), who was deposed in 1866, following the events of the Seven Weeks' War, was born at Hanover on Sept. 21, 1845. He was a grandson of the Ernest Augustus, king of Hanover noticed above. Ernest Augustus lived at Gmünden, and after his father's death maintained his claim to the Hanoverian throne. He bore the titles of duke of Cumberland, and duke in Brunswick and Lüneburg. He married Princess Thyra of Denmark. When William, duke of Brunswick, died (1884) without issue, Ernest Augustus claimed the duchy as the next heir, but the Federal diet refused to sanction his accession to the ducal throne because he persisted in the Hanoverian claim. Brunswick was therefore placed under a regency. In 1902 he expressly stated to the German emperor his acquiescence in the imperial régime, and thenceforward received the income from his inheritance. He resigned his claim to the duchy of Brunswick in favour of his son Ernest Augustus in 1906. The decision of the Federal Council was, however, reaffirmed in 1907.

Prince Ernest Augustus presently entered the Prussian army, and the difficulties, in so far as Brunswick was concerned, were ended by his marriage (May 24, 1913), to the only daughter of Wilhelm II., Victoria Louise. He then asked for a reversal of the former decisions of the Federal Council. The Council agreed on Oct. 27 to the prince's accession, and on Nov. 3 the young duke and duchess made their State entry into Brunswick. The decision was attacked in the *reichstag* because the duke of Cumberland had never renounced the throne of Hanover. Ernest Augustus, duke of Brunswick, abdicated, with other German princes in 1918. His father died at Gmünden on Nov. 14, 1923.

ERNESTI, JOHANN AUGUST (1707–1781), German theologian and philologist, was born Aug. 4, 1707, at Tennstädt in Thuringia. He was educated at the celebrated Saxon cloister school of Pforta, and at the universities of Wittenberg and Leipzig. After minor appointments, he was named professor *extraordinarius* of ancient literature in the university of Leipzig (1742), professor *ordinarius* of rhetoric (1756), and professor *ordinarius* in the faculty of theology (1759). He died at Leipzig on Sept. 11, 1781.

To Ernesti and to Gesner is due the credit of having formed, by discipline and by example, philologists greater than themselves, and of having kindled the national enthusiasm for ancient learning. In his *Institutio Interpretis N. T.* (1761), Ernesti admits in the sacred writings as in the classics only one acceptation, and that the grammatical, convertible into the logical and historical. Consequently he censures all mystical interpretation as well as extreme rationalism. At the same time, as a dogmatician, he clung to the traditions of the Lutheran Church.

His chief works are:—*Initia doctrinae Solidioris* (1736); editions, mostly annotated, of Xenophon's *Memorabilia* (1737), Cicero (1737–39), Suetonius (1748), Tacitus (1752), the *Clouds* of Aristophanes (1754), Homer (1759–64); *Antimuratorius sive confutatio disputationis Muratorianae de rebus liturgicis* (1755–58); *Neue theologische Bibliothek*, vols. i. to x. (1760–69); *Institutio interpretis Nov. Test.* (3rd ed., 1775); *Neueste theologische Bibliothek*, vols. i. to x. (1771–75); *Opuscula oratoria* (1762); *Opuscula philologica et critica* (1764); *Opuscula theologica* (1773).

ERNLE, ROWLAND EDMUND PROTHERO, 1ST BARON (1852–), British agriculturist and writer, was born in Clifton-on-Teme on Sept. 6, 1852, son of Canon Prothero, rector of Whippingham. He was educated at Marlborough and Balliol college, Oxford, and became a fellow of All Souls. From 1894 to 1899 Prothero edited *The Quarterly Review*. Twenty years as chief agent to the duke of Bedford gave him a thorough insight into agricultural questions. In 1913 he was a member of the royal commission on railways, and sat on the departmental committees on the home production of food (1914) and the increased price of commodities (1915). He entered parliament for Oxford university in 1914, and was president of the Board of Agriculture under Lloyd George, 1916–19, when he resigned and was raised to the peerage.

Among his works are *Pioneers and Progress of English Farming* (1888); *Life and Correspondence of Dean Stanley* (1893); *Letters of Edward Gibbon* (1896); *Letters and Journals of Lord Byron* (1898–1901); *Psalms in Human Life* (1903); *The Pleasant Land of France* (1908); *English Farming, Past and Present* (1912); and *The Land and Its People* (1925).

ERNST, HEINRICH WILHELM (1814–1865), German violinist and composer, was born at Brünn, Moravia, on May 6, 1814, and was educated at the conservatorium of Vienna, studying the violin under Joseph Böhm and Joseph Mayseder, and composition under Ignaz von Seyfried. In 1832 he went to Paris, where he formed an intimacy with Stephen Heller, which resulted in their charming joint compositions—the *Pensées fugitives* for piano and violin. In 1843 he paid his first visit to London. The impression which he then made as a violinist was more than confirmed in the following year, when his rare powers were recognized by the musical public. After a long illness, he died at Nice, Oct. 8, 1865. As a violinist Ernst was distinguished by his great mastery of technique, loftiness of conception, and intensely passionate expression. He wrote, in addition to many fantasias and salon pieces for the violin, a concerto (F sharp minor) of great technical difficulty which is still sometimes heard, and two string quartets.

ERNST, PAUL (1866–), German author, was born at Elbingerode on March 7, 1866, and educated locally and at the universities of Göttingen, Tübingen, Berlin and Berne. After early experiments in journalism, farming and the local administrative service, he later devoted himself exclusively to literature. Attached for a time to the *Düsseldorfer Schauspielhaus*, he wrote many dramas: *Lumpenbagasch and Im Chambre séparée* (1898), *Demetrios* (1905); *Das Gold* (1906); *Canossa* (1908); *Brunhild* (1909); *Ariadne auf Naxos* (1914); *Chriemhild* (1918), which, however, suffer from a certain stiffness and artificiality. He also wrote many narrative poems and short stories, and in 1924 commenced to publish his great classical epic, *Das Kaiserbuch*. He was most at home, however, in the short story, in which he imitated the manner of the Italian renaissance with great dexterity

(*Sechs Geschichten* [1900]; *Prinzessin des Ostens* [1902]; *Hochzeit* [1913]; *Die Taufe* [1916], etc.). His style is less well adapted to the novel, but his semi-autobiographical *Der Schmale Weg zum Glück* (1903) met with some success. Ernst was the leading representative of the German neo-classic school, and as such strongly opposed to the expressionism of his day. His theories, which he evolved scientifically and followed conscientiously, are set out in his *Der Weg zur Form* (1906), a very interesting literary manifesto. Two political works, *Der Zusammenbruch des Marxismus* (1918) and *Der Zusammenbruch des deutschen Idealismus* (1920) show the evolution of his mind from Socialism to Conservatism. His collected works (15 vols.) were published 1916–22.

See R. Faesi, *Paul Ernst und die neuklassizischten Bestrebungen im Drama* (1913); W. Mahrholz, *Paul Ernst* (1917).

ERODE, a town of British India, in the Coimbatore district of Madras, on the right bank of the river Cauvery, here crossed by a railway girder bridge. Pop. (1921) 22,911. Here the South Indian railway joins the South-Western line of the Madras railway, 243 m. from Madras. The town is a centre of trade and industry, dealing in rice, cotton, saffron, chillies, etc. There is an industrial school.

EROS (ĕr′ŏs), in Greek mythology, god of love. He is not mentioned in Homer; in Hesiod (*Theog.* 120) he is a primeval god, son of Chaos. This cosmic Eros is further elaborated in Orphic cosmogony. A cult of Eros existed at Parium and at Thespiae in Boeotia. He was god, not simply of passion, but of fertility. Later mythology makes him the son of Aphrodite by Zeus, Ares, or Hermes. His brother is Anteros, the god of mutual love; he is sometimes described as the opponent of Eros. The chief associates of Eros are Pothos and Himeros (longing and desire); he himself is in constant attendance on Aphrodite. Later writers (Euripides being the first) assumed the existence of a number of Erotes (like the Roman Amores and Cupidines). Plato and other philosophers allegorize Eros. In Alexandrian poetry he degenerates into a mischievous child, an idea possibly connected with the importance of children in magic and cult. (*See* also CUPID.)

In art Eros is represented as a beautiful youth or a baby archer. The rose, the hare, the cock, and the goat are frequently associated with him. The most celebrated statue of him was at Thespiae, the work of Praxiteles.

BIBLIOGRAPHY.—J. E. Harrison, *Prolegomena* (1903); Farnell, *Cults*, ii., p. 625; articles in the classical dictionaries; A. D. Nock in *Class. Rev.*, xxxviii., 152; C. T. Seltman in *Ann. Brit. School at Athens*, xxvi., p. 88.

EROS, an asteroid of exceptional interest owing to its close approaches to the earth. In 1898 the number of known asteroids had mounted up to over four hundred, and as there was considerable monotony in their appearance and in the nature of their orbits many astronomers were beginning to question whether the time spent in searching for them and in calculating their movements was worth while. Then came a discovery, which might never have been made had the search been abandoned, that gave full compensation for all the time thus spent. On Aug. 13, 1898, Dr. G. Witt, at the Urania Observatory, Berlin, discovered photographically a faint asteroid of the 11th magnitude that was retrograding at the unprecedented rate of half a degree per day; this unusual motion caused it to be widely observed, and after a short interval Dr. Berberich of the Berlin Rechen-Institut published elements which proved to be very near the truth. The new body was designated at first 1898 DQ, but subsequently received the permanent number 433 and the name Eros (masculine names are given only to asteroids with very exceptional orbits, feminine ones being the rule).

Its period of revolution is 643 days, as compared with 687 for Mars. It was already known that a few asteroids come nearer to the sun at their perihelia than Mars at its aphelion; but Eros's *mean* distance is considerably less than that of Mars. As its eccentricity is 2/9, its least distance from the sun is only 1·13 astronomical units, so that it can approach the earth within 14 million miles, a much smaller distance than that of any other planetary body except the moon. The distance is rendered less by the fact that the point where Eros crosses the plane of the earth's orbit (descending node) is distant only 2¼° from the perihelion point; since the orbit is inclined some 10¾° to that of the earth, the least distance would be twice as great if the node were 90° away from the perihelion.

Unfortunately very near approaches of Eros to the earth are rare; they occur only when the planet passes perihelion about the date Jan. 22, of any year. It was unlucky that the conditions were the most favourable possible in Jan. 1894, 4½ years before the discovery; indeed subsequent examination of the immense stores of photographic plates exposed at Harvard College Observatory revealed 17 images of Eros at the opposition of 1893–94, and four images on plates taken at Arequipa, Peru, at the opposition of 1896. These images were used to give a better determination of the orbit, but the opportunity was missed of obtaining observations for the solar parallax.

The synodic period of Eros (that is, the average interval between one opposition and the next) is 845½ days, or two years and 115 days. Three synodic periods fall short of seven years by about three weeks; it follows that there was an approach to favourable conditions at the opposition at the end of 1900; and a parallax campaign was carried on at that time at the leading observatories of the northern hemisphere, the southern hemisphere being excluded owing to the high north declination of Eros (*see* article PARALLAX). Another very favourable opposition will occur in 1931. A convenient measure of the value of an opposition for parallax purposes is given by the number of days that elapses between the planet's passage through perihelion and the earth's passage through the longitude of that perihelion.

The following figures are from *Monthly Notices* of the Royal Astronomical Society for Feb. 1901; it gives the interval in days, the minus sign indicating that the planet comes first to the longitude, the plus sign that the earth comes first:— 1894, −0·40 days; 1901, +17·42; 1923–24, −23·24; 1931, −7·65; 1938, +7·95; 1945, +23·53; 1968, −17·13; 1975, −1·54; 1982, +14·05. These are all the oppositions up to the year 2000, for which the interval is less than 24 days. Dr. Witt's later value for 1931 is −5·91 days, so that the table needs a correction of +1¾ days at that point. The correction in 1975 may be about twice as great, which would change the sign of the interval without greatly altering its magnitude. It will be seen that 81 years brings back a recurrence of conditions, this being equal to 46 revolutions of Eros.

It will be seen that the 1931 apparition is the best one till 1975 (though 1938 is not much inferior to it) and extensive preparations are already being made to utilize it to the utmost; these include accurate observations of many stars near the planet's track, to serve as points of reference. A valuable by-product of the parallax investigation is a determination of the mass of the moon; the moon causes the earth to describe a small circle the radius of which is about 3,000 miles in a monthly period; this motion produces a wave in the apparent motion of Eros, with the same period. A peculiarity in the apparent motion of Eros at a perihelion opposition is that, unlike most of the superior planets, it does not retrograde, since its linear velocity, even when multiplied by the cosine of its inclination, exceeds that of the earth. Eros was unique in this respect when discovered, but Albert, Alinda, and Ganymede have since been found to share the peculiarity.

The motion of Eros, as seen from Mars, would be very curious; each planet might witness a transit of the other across the sun, while at other times each would see the other in the polar constellations. Owing to the large eccentricities of their orbits, each would in turn gain on the other in longitude. Their synodic period, or average interval between their conjunctions, is 27·6 years; but the unequal rates of motion would cause large variations in the intervals. The least distance of Mars from Eros is about 21 million miles, half as great again as Eros's least distance from the earth. Owing, however, to the slow secular movements of nodes and perihelion points, there must have been times in the distant past when very close approaches of Eros and Mars were possible; and it has been conjectured that Mars was responsible for introducing Eros into its present orbit at such an encounter. While this is possible, Eros's small perihelion distance stands less in need of explanation since it has been found to be common to three other

planets (Albert, etc.).

The perturbations of Eros by the earth are very considerable. Prof. H. N. Russell published some computations about them in *Astron. Journ.* Nos. 483, 484. The largest term is $747'' \sin (7g - 4g')$ where g, g' are the mean anomalies of Eros, and the earth. The apparent shift in the position of Eros is magnified by its proximity, and the total displacement from one extreme to the other may amount to nearly three degrees; this shift will in time give a very accurate value of the earth's mass in terms of that of the sun, and hence of the sun's distance. But the period of the term is 41½ years, and the method will scarcely reach its full efficiency till two or three of these periods have elapsed. However, in 1921 Herr Noteboom published a determination of the sun's parallax by this method, for which he found the small probable error of $\cdot 001''$, his value being $8'' \cdot 799$. Prof. Russell also indicated the principal terms of the perturbations of Eros by Mars; the three largest, omitting one of very long period, have coefficients $11''\cdot 59$, $22''\cdot 81$, $11''\cdot 85$, and periods 40·8 years, 78·0 years and 85·5 years. The period of the first is so close to that of the large earth-term as to require a long interval to elapse before they can be separated.

The diameter of Eros is conjectured to be about 17 miles, assuming its albedo to be the same as that of Pallas. It appears somewhat brighter than the seventh magnitude at the most favourable oppositions, and somewhat fainter than the 11th at the most unfavourable ones; its mass would be 1/167,000,000 of the earth's, assuming its density equal to that of the moon. Its angular diameter may be $\frac{1}{4}''$ in Jan. 1931, an amount that would be measurable with a large interferometer. Such measures might also decide whether the planet's outline is circular or irregular; there appears to be no reason to expect such small bodies to be spherical, since gravity would be weak compared with cohesion. The fact that the light of Eros shows irregular variability lends colour to the hypothesis of non-sphericity. In Feb. 1901 the light-range exceeded a magnitude; the period being 5 hours 16 minutes; there were two unequal maxima and minima in this period, but three months later the light-variation almost disappeared. The variation was noticed again in 1903, but was absent in 1907. It is suggested in explanation that the axis of the planet is highly inclined; when the pole of rotation is central on the disc there would be no light-variation. It may also be noted that if the axis of rotation were not a principal axis it would shift within the body.

Eros will be easily seen with binoculars at the beginning of 1931. The nearest approach to the earth, 16½ million miles, is near the midnight between Jan. 30 and 31. (A. C. D. C.)

EROSION OF LAND. The process of removal of portions of the earth's crust by natural agencies, of which the most important is water. The wastage of the sea coast, or coast erosion, is described in the article COAST PROTECTION AND RECLAMATION; it is brought about in the main by the action of the sea waves but also, in part, by the disintegration or degradation of cliffs by atmospheric agents such as rain and frost and by tidal scour. In rivers and estuaries the erosion of banks is caused by the scouring action of the river stream, particularly in times of flood and, in the case of estuaries, also by the tidal flow on the ebb tide when river and tide-water combine in their erosive action. (*See* RIVER ENGINEERING.) The land surface generally is subjected to a continuous process of erosion by the action of rain, melting snow, ice and frost, the resulting detritus and sediment being carried by small streams into the rivers and thence to the ocean (*see* GEOLOGY). In some arid and desert tracts wind has an important effect in bringing about the erosion of rocks by driving sand; and the surface of sand dunes, where not held together and protected by vegetation, is subject to erosion and change by the drifting of blown sand.

ERPENIUS (original name VAN ERPE), **THOMAS** (1584–1624), Dutch Orientalist, was born at Gorcum, in Holland, on Sept. 11, 1584. He studied at Leiden, and by the advice of Scaliger took up oriental languages whilst taking his course of theology. He afterwards travelled in England, France, Italy and Germany. During his stay at Paris he contracted a life-long friendship with Casaubon and took lessons in Arabic from an Egyptian, Joseph Barbatus, otherwise called Abu-dakni. At Venice he perfected himself in the Turkish, Persic and Ethiopic languages. After a long absence, Erpenius returned to his own country in 1612, and in 1613 was appointed professor of Arabic and other oriental languages, Hebrew excepted, in the University of Leiden. There he caused new Arabic characters to be cut at a great expense, and erected a press in his own house. In 1619 the curators of the University of Leiden instituted a second chair of Hebrew in his favour. He was preparing an edition of the Koran with a Latin translation and notes, and was projecting an oriental library, when he died on Nov. 13, 1624. Among his works may be mentioned his *Grammatica Arabica,* published originally in 1613 and often reprinted; *Rudimenta linguae Arabicae* (1620); *Grammatica Ebraea generalis* (1621); *Grammatica Chaldaica et Syria* (1628); and an edition of Elmacin's *History of the Saracens.*

ERROLL (or ERROL), **FRANCIS HAY,** 9TH EARL OF (d. 1631), Scottish nobleman, was the son of Andrew, 8th earl, and of Lady Jean Hay, daughter of William, 6th earl. He succeeded to the earldom (cr. 1453) in 1585, was early converted to Roman Catholicism, and as the associate of Huntly joined in the Spanish conspiracies against the throne of Elizabeth. An intercepted letter led to his denunciation as a rebel by the council in 1589. He engaged with Huntly and Crawford in a rebellion in the north of Scotland, but their forces surrendered at Aberdeen on the arrival of the king in April; and in July Erroll gave himself up to James, who refrained from exacting any penalty. In September he entered into a bond with Huntly for mutual assistance.

In 1590 he displeased the king by marrying, in spite of his prohibition, Lady Elizabeth Douglas, daughter of the earl of Morton. He was imprisoned on suspicion of complicity in the attempt made by Gray and Bothwell to surprise the king at Falkland in June 1592; and though he obtained his release, he was again proclaimed a rebel. After a failure to apprehend him in March 1593, Erroll and his companions were sentenced to abjure Romanism or leave the kingdom; and on their non-compliance were in 1594 declared traitors. On Oct. 3 they defeated at Glenlivet a force sent against them under Argyll; though Erroll himself was severely wounded, and Slains castle, his seat, razed to the ground. The rebel lords left Scotland in 1595. Erroll returned to Scotland secretly in 1596, and made his peace with the Kirk. In 1602 he was appointed a commissioner to negotiate the union with England. Between 1608 and 1611 he was in prison as an "obstinate papist." Erroll died on July 16, 1631, and was buried in the church of Slains.

See *The Erroll Papers* (Spalding Club Miscellany, vol. ii. 211); Andrew Lang, *Hist. of Scotland,* vol. ii.; *Hist. MSS. Comm. MSS. of Earl of Mar and Kellie;* D. Calderwood's *Hist. of the Church of Scotland;* John Spalding's *Memorials* (Spalding Club, 1850); *Treason and Plot,* by M. A. S. Hume (1901); *Collected Essays* of T. G. Law, ed. by P. H. Brown (1904).

ERROR. The words "error excepted" or "errors and omissions excepted" (contracted to "E.E.," "E. & O.E.") are frequently placed at the end of a statement of account or an invoice, so that the accounting party may reserve the right to correct any errors or omissions which may be subsequently discovered, or make further claims in respect of them. In mathematics, "error" is the deviation of an observed or calculated quantity from its true value. The calculus of errors leads to the formulation of the "law of error," which is an analytical expression of the most probably true value of a series of discordant values. (*See* MISTAKE; CONTRACT; PROBABILITY.) For the legal process known as a "writ of error," *see* WRIT and APPEAL.

ERSCH, JOHANN SAMUEL (1766–1828), the founder of German bibliography, was born at Grossglogau, in Silesia, on June 23, 1766, and studied at Halle. He was the author of many important bibliographical works and, with Johann Gottfried Gruber (*q.v.*), of the *Allgemeine Encyklopädie der Wissenschaften und Künste* (Leipzig, 1818, *seq.*) which he continued as far as the 21st volume. The accuracy and thoroughness of this monumental encyclopaedia make it still an important book of reference. Ersch died at Halle on Jan. 16, 1828.

ERSE or **IRISH,** the native language of Ireland (*q.v.*). *See* CELTIC LANGUAGES.

ERSKINE, HENRY (1746–1817), lord advocate of Scotland, the second son of the 10th earl of Buchan, and brother of the lord chancellor Erskine, was born in Edinburgh on Nov. 1, 1746. He was educated at the universities of St. Andrews, Glasgow and Edinburgh, and was admitted a member of the faculty of advocates in 1768. He was lord advocate in 1783 under Fox's and North's ministry, and again under Grenville in 1806. He retired in 1811 and died at Almondel, Linlithgowshire, on Oct. 8, 1817. Erskine's reputation will survive as the finest and most eloquent orator of his day at the Scottish bar; added to a charming forensic style was a most captivating wit, which, as Lord Jeffrey said, was "all argument, and each of his delightful illustrations a material step in his reasoning." Erskine was also the author of some poems, of which the best known is "The Emigrant" (1783).

See Lieut.-Col. A. Fergusson's *Henry Erskine* (1882).

ERSKINE, JOHN, of Dun (1509–1591), Scottish reformer, the son of Sir John Erskine, laird of Dun, was born in 1509, and was educated at King's College, Aberdeen. At the age of twenty-one Erskine was the cause—probably by accident—of a priest's death, and was forced to go abroad, where he came under the influence of the new learning. It was through his agency that Greek was first taught in Scotland by Petrus de Marsiliers at Montrose. Erskine was a close friend of George Wishart, the reformer, from whose fate he was saved by his wealth and influence, and of John Knox, whose advice openly to discountenance the mass was given in the lodgings of the laird of Dun. Erskine frequently acted as mediator both between the catholic and reforming parties, and among the reformers themselves. In 1560 he was appointed—though a layman—superintendent of the reformed church of Scotland for Angus and Mearns, and in 1572 he gave his assent to the modified episcopacy proposed by Morton at the Leith convention. He was more than once elected moderator of the general assembly (first in 1564), and he was amongst those who in 1578 drew up the *Second Book of Discipline.* From 1579 he was a member of the king's council. He died in 1591.

See the "Dun Papers" in the *Spalding Club Miscellany,* vol. iv. (1849), and the article in the *Dict. Nat. Biog.*

ERSKINE, JOHN, of Carnock (1695–1768), Scottish jurist, son of Lieut.-Colonel John Erskine, was in 1737 appointed professor of Scots law in the University of Edinburgh. In 1754 he published his *Principles of the Law of Scotland.* He retired from his chair in 1765, and the rest of his life was spent in the preparation of his great work, the *Institutes of the Law of Scotland,* which he did not live to publish. He died at Cardross, Perthshire, on March 1, 1768. Erskine's *Institutes* (1773; many later eds.) has always been esteemed of the highest authority on the law of Scotland. The *Principles,* being more concise and direct, retained its place as the text-book on Scots law, and was frequently re-edited.

ERSKINE, THOMAS, of Linlathen (1788–1870), Scottish theologian, was born on Oct. 13, 1788. He became in 1810 a member of the Edinburgh faculty of advocates, and belonged to the brilliant legal circle of the Edinburgh of that day, which included Cockburn, Jeffrey, Scott and others. In 1816 he succeeded to the family estate of Linlathen, near Dundee, and devoted himself to theology. As an interpreter of the mystical side of Calvinism and of the psychological conditions which correspond with the doctrines of Grace, Erskine excelled. He died at Edinburgh on March 20, 1870.

His principal works *Remarks on the Internal Evidence for the Truth of Revealed Religion* (1820), an *Essay on Faith* (1822), and the *Unconditional Freeness of the Gospel* (1828), have all passed through several editions, and have also been translated into French. Two vols. of his letters, edited by William Hanna, D.D., with reminiscences by Dean Stanley and Principal Shairp, appeared in 1877.

ERSKINE, THOMAS ERSKINE, 1st Baron (1750–1823), lord chancellor of England, was the third son of the 10th earl of Buchan, and was born in Edinburgh on Jan. 10, 1750. He was educated at the high school of Edinburgh and the grammar school at St. Andrews, and in 1764 became a midshipman. In 1768 he left the navy and bought a commission in the 1st Royals, but promotion here was no better; he married in 1770, the daughter of Mr. Moore, M.P. for Marlow. A chance interview with Lord Mansfield decided him to try the law, and he entered Lincoln's Inn in 1775. He read with Buller and Wood, and was called to the bar in 1778. He made an instant success, getting a brief at once, owing to the chance of his having been a sailor, for Baillie, accused of libel in a pamphlet on the management of Greenwich hospital. Erskine was the junior of five counsel; and it was his good fortune that the prolixity of his leaders consumed the whole of the first day, thereby giving the advantage of starting afresh next morning. He made use of this opportunity to deliver a speech of wonderful eloquence, skill and courage, which captivated both the audience and the court. The rule was discharged, and Erskine's fortune was made. He received, it is said, 30 retainers before he left the court. In 1781 he delivered another remarkable speech, in defence of Lord George Gordon—a speech which gave the death-blow to the doctrine of constructive treason.

In 1783, when the Coalition ministry came into power, he was returned to parliament as member for Portsmouth. He and Eldon made their maiden speeches together on Fox's India bill, and both were failures; Erskine was never a success in parliament. He became a K.C. in 1783, four and one-half years from his call, and was the first counsel to give up his circuit and only take special retainers. In 1783 he received a patent of precedence. His first special retainer was in defence of Dr. W. D. Shipley, dean of St. Asaph, who was tried in 1784 at Shrewsbury for seditious libel—a defence to which was due the passing of the Libel Act 1792, laying down the principle for which Erskine here unsuccessfully contended, that it is for the jury, and not for the judge to decide the question whether or no a publication is a libel. In 1789 he was counsel for John Stockdale, a bookseller, who was charged with seditious libel in publishing a pamphlet in favour of Warren Hastings, whose trial was then proceeding; and his speech on this occasion, probably his greatest effort, is a consummate specimen of the art of addressing a jury. Three years afterwards he brought down the opposition alike of friends and foes by defending Thomas Paine, author of *The Rights of Man*—holding that an advocate has no right, by refusing a brief, to convert himself into a judge. As a consequence he lost the office of attorney-general to the prince of Wales, to which he had been appointed in 1786; the prince, however, subsequently made amends by making him his chancellor.

In 1794 he conducted the defence in the Parliamentary Reform cases; he secured the acquittal in turn of Hardy, by a magnificent speech, of Home, Horne Tooke and Thelwall. The attorney-general then gave it up, and the other prisoners were discharged. This gained Erskine enormous popularity. In 1806 he was made lord chancellor in Grenville's ministry, for which he was totally unfitted. The rest of his life was unhappy; he never received office again, and he made his financial position worse by an imprudent second marriage. But in the defence of Queen Caroline he returned to his old eminence. On this he made his last speech in the House of Lords, and for his last few years he was again the popular idol. He died at Almondell, Linlithgowshire, on Nov. 17, 1823, of pneumonia, caught on the voyage to Scotland.

Erskine's great forensic reputation was, to a certain extent, a concomitant of the numerous political trials of the day, but it was also due to his impassioned eloquence and undaunted courage, which so often carried audience and jury and even the court along with him. As a judge he did not succeed; and it has been questioned whether under any circumstances he could have succeeded. For the office of chancellor he was plainly unfit. As a lawyer he was well read, but by no means profound. His strength lay in the keenness of his reasoning faculty, in his dexterity and the ability with which he disentangled complicated masses of evidence, and above all in his unrivalled power of fixing and commanding the attention of juries. He was probably the greatest advocate the English bar has ever seen.

In 1772 Erskine published *Observations on the Prevailing Abuses in the British Army,* a pamphlet which had a large circulation, and in later life, *Armata,* an imitation of *Gulliver's Travels.* His most noted speeches have repeatedly appeared in a collected form. *See* Campbell's *Lives of the Chancellors;* Moore's *Diaries;* Fergusson's *Henry Erskine* (1882); Dumerit's *Henry Erskine, a Study* (Paris, 1883); Lord Brougham's *Memoir,* prefixed to Erskine's *Speeches* (1847); Romilly's *Memoirs;* the *Croker Papers;* Lord Holland's *Memoirs.*

ERUBESCITE: *see* BORNITE.

ERYSIPELAS—synonyms, *the Rose, St. Anthony's Fire*—an acute contagious disease, characterized by a spreading inflammation of the skin, caused by *streptococcus erysipelatis.* Erysipelas is endemic in most countries, and epidemic at certain seasons, particularly the spring of the year. The disease seems to depend in all cases upon the existence of a wound or abrasion. In the so-called idiopathic variety, of which *facial erysipelas* is the best known, the point of entry is probably an abrasion by the lachrymal duct.

The skin in a mild case of erysipelas is red and oedematous and may show small vesications. The edge of the patch is often raised and distinct and extends from day to day. As the disease advances the portions of skin first attacked become less inflamed and slight desquamation occurs. The inflammation in general disappears after a week or ten days, but recrudescences are common if the streptococcus is very virulent or the patient's resistance low; suppuration or even gangrene may occur. In such cases the local condition becomes subordinate to a general septicaemia. In all cases of erysipelas constitutional symptoms are severe, temperatures of 105°F. and delirium being common.

Although the termination is usually favourable, serious and occasionally fatal results follow from inflammation of the membranes of the brain, and in some rare instances sudden death has occurred from suffocation arising from oedema glottidis, the inflammatory action having spread into and extensively involved the throat. One attack of this disease, so far from giving protection, appears to leave the patient susceptible to others. A fatal form occasionally attacks new-born infants, particularly in the first four weeks of their lives. In epidemics of puerperal fever this form of erysipelas has been specially found to prevail.

The treatment of erysipelas is that of a severe bacterial toxaemia. Strength must be maintained and local applications may be soothing, but administration of antistreptococcus serum appears to be the rational treatment.

ERYTHRAE, one of the Ionian cities of Asia Minor, situated on a small peninsula stretching into the Bay of Erythrae, at an equal distance from the mountains Mimas and Corycus, and directly opposite the island of Chios. In the peninsula excellent wine was produced. The town was said to have been founded by Ionians under Knopos, son of Codrus. Never a large city, it sent only eight ships to the battle of Lade. The Erythraeans owned for a considerable time the supremacy of Athens, but towards the close of the Peloponnesian war they threw off their allegiance to that city. After the battle of Cnidus, however, they received Conon, and paid him honours in an inscription, still extant. The ruins include well preserved Hellenistic walls with towers, of which five are still visible. The acropolis (280 ft.) has the theatre on its north slope, and eastwards lie many remains of Byzantine buildings.

ERYTHRITE, the name given to (1) a mineral composed of a hydrated cobalt arsenate, and (2) in chemistry, a tetrahydric alcohol (*see* ERYTHRITOL). (1) The mineral has the formula $Co_3(AsO_4)_2 \cdot 8H_2O$, and crystallizes in the monoclinic system. It sometimes occurs as radially-arranged groups of brilliant crimson blade-shaped crystals. On exposure to light the colour and lustre deteriorate. Cleavage flakes are soft (H=2), sectile and flexible; specific gravity 2·95. The mineral is, however, more often found as an earthy encrustation with a peach-blossom colour, and in this form was early known as cobalt-bloom. It occurs as a product of alteration of smaltite ($CoAs_2$) and other cobaltiferous arsenides. The finest crystallized specimens are from Schneeberg in Saxony. The earthy variety has been found in Thuringia, Cornwall, Cobalt (Ont.) and some other places.

ERYTHRITOL is an alcohol, allied to the carbohydrates (*q.v.*), and having four alcoholic (hydroxyl groups)—a tetrahydric alcohol. It is also known by many synonyms; *e.g.*, butanesterol, erythrite, erythrol, erythromannite, erythroglucin and phycite. Its formula is $HO \cdot CH_2 \cdot CH(OH) \cdot CH(OH) \cdot CH_2 \cdot OH$. Erythritol crystallizes from water in large lustrous quadratic prisms having a sweet taste; it melts at 126° C and boils at 330° C.

In chemical constitution, erythritol is analogous with tartaric acid and like this acid exists in a racemoid form, resolvable into dextro- and levo-rotatory modifications, and in a non-resolvable inactive form which is identical with the naturally occurring variety found free in the alga *Protococcus vulgaris* and in combination with orsellinic acid in many lichens, especially in *Roccella tinctoria* and *montagnei.* Oxidation with dilute nitric acid furnishes erythrose which probably consists of a mixture of an aldose and a ketose (*see* CARBOHYDRATES). Further oxidation gives rise to mesotartaric acid. The four stereoisomeric forms of erythritol have been synthesised from divinyl (Griner 1893).

ERZBERGER, MATTHIAS (1875–1921), was born on Sept. 20, 1875, in Buttenhausen, in the Swabian Alps. Having entered the teaching profession, he soon became interested in politics. He joined the staff of the Stuttgart Catholic paper *Deutsches Volksblatt* and was elected member of the *Reichstag* at the age of 28. The Centre Party, to which he belonged, came into existence as a mainly religious association during the "Kulturkampf" (Bismarck's quarrel with the Catholic Church). When this particular dispute had been settled the Centre party assumed a rather complex political character. Erzberger, being anti-bureaucratic by temperament, began his career as a severe critic of the Colonial Office, whose chief spokesman, Dr. Helfferich, later on became his violent enemy. When Prince Bülow's incongruous Conservative-Liberal coalition broke down and the Centre Party again became a quasi-government party (1909), Erzberger had gained a leading position in its councils.

During the World War Erzberger built up a big organization to enlighten neutral opinion, addressing himself primarily to Catholics. He elaborated many plans for the reconstruction of Europe. He did not openly oppose submarine warfare, though he greatly feared America's entry into the war. In the summer of 1917 he realized that Austria was collapsing. He knew of the famous Czernin memorandum (April 12, 1917) and has even been falsely accused of having brought it to light. His insight into the Austrian situation and his disillusion about the submarine warfare made him take the initiative in bringing about the declaration of the *Reichstag* on July 19, which proclaimed Germany's intention to fight for a peace without annexations. His impetuous methods resulted in the overthrow of Bethmann Hollweg, who sympathized with the movement, and the accession to power of Michaelis, who supported the militarists and whose famous interpretation of the resolution destroyed such chances as the appeal might have had. Erzberger, never daunted by failure, played a part in the unsuccessful peace efforts of the Vatican.

Erzberger's great political chance came in Sept. 1918, when Prince Max of Baden formed a parliamentary government. Erzberger had outlined the programme for this coalition of National-Liberals, Liberals, Centrists and Socialists. He became secretary of State without portfolio. He was asked to lead the armistice commission when general headquarters insisted on an armistice. He did not succeed in getting terms based on the Wilson principles, which Germany had accepted. He has been held up to obloquy for this failure, but it may be doubted whether the most brilliant diplomatist would have fared better at the hands of a victorious general.

When Erzberger came home, the old régime had gone. He remained head of the armistice commission, but participated in the reorganization of the Centre Party, which gained 90 seats at the election of 1919. He entered the cabinet formed by Scheidemann, as minister without portfolio. When that Government, influenced by Brockdorff-Rantzau and the German delegation, desired to reject the peace terms, Erzberger dissented, distrusting the capacity of the German people to stand another prolonged strain, and fearing greatly for German unity. He pressed his point with his customary energy and perhaps, too, with some want of tact. He is alleged to have said openly that another government would sign the treaty, if Scheidemann refused, and it is quite possible that his utterances may have reassured the Allies of the small risk they ran when presenting an ultimatum (June 16). The Government did resign, and Erzberger became chancellor of the Exchequer in the Bauer Government formed by Socialists and Centrists which

signed the peace.

Up to that time the individual States had owned the railways and drawn the direct taxes, especially the income-tax; the Reich had to be satisfied mainly with indirect taxation. The wrangles between the States and the central authority had filled the pages of German history, the States always succeeding in holding their own. Erzberger took the railways for the Reich and established its control over taxation. He succeeded where Bismarck had failed. He organized an imperial inland revenue service and introduced a system of income and property taxes which, though somewhat socialistic in its main features, was the first real system of imperial finance Germany has had. He had realized as early as Sept. 1918 the necessity of creating a League of Nations and drafted a statute for it.

His activities during the World War, his participation in the armistice and the peace negotiations, and his financial policy made Erzberger the best hated man in Germany. His feud with the bureaucrats was of old standing. The capitalist classes hated him for his confiscatory financial legislation; and to the Prussian Protestant he was the international Catholic, who spoke with a broad Swabian accent. The federalists loathed him on account of his centralizing tendencies, and the militarists tried to make him the scapegoat for their want of success. All the enemies of the new order of things realized, however, that whatever his faults might be, he was a man of action and not a dreamer. He was the first political expert who knew how to lord it over the technical expert.

Karl Helfferich, a former secretary of State whose financial war policy Erzberger had strongly criticized, fathered these attacks in a pamphlet *Fort mit Erzberger,* in which Erzberger was accused of all sorts of petty underhand financial misdemeanours and even of having committed perjury. Erzberger sued Helfferich, but did not succeed in clearing himself as completely as the facts of the case probably warranted. He immediately resigned. The verdict assumed that he had committed perjury, but the same court, enquiring later on whether the facts established should lead to a public prosecution, came to a negative finding. It was then considered that in some way or other Erzberger would be completely rehabilitated. The feeling against him was so intense, however, that an abortive attempt upon his life was made during the proceedings. A few months after, when taking a holiday, he was foully murdered on Aug. 26, 1921, by Schulz and Tillessen, two members of secret associations, who got safely away to Hungary.

Erzberger was probably the most gifted man of action German democracy has so far produced. He acted with the light-hearted impetuosity of a child: there was no situation to which he did not consider himself equal. He quickly saw the main point, and when he saw it, he acted, being quite free from those mental impediments which so often paralyse intelligent men. He very often did not visualize the ultimate consequences of his actions, but this did not trouble him as he was quite sure that he could deal with them when they arose. His jaunty manner equally antagonized the deep thinker and the well-bred bureaucrat. He was often careless and inaccurate in details, for though details interested him greatly, he had not always a just sense of "values." Being rather insensitive himself, he often failed to consider other people's susceptibilities, and being simple though very shrewd, he was not a good judge of men and did not understand complicated minds, nor the impression he made upon them. He was a man of the people and he looked like it. As such he was loathed by all to whom a statesman must be "decorous." He was almost a genius. But he lacked the magnetism and the charm indispensable to a really great leader.

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ERZERUM, the chief town of an important vilayet of the same name in Asiatic Turkey. Pop. (1927), 77,966. It is a military station and a fortress of considerable strategical value, closing the roads from Kars, Olti and other parts of the frontier. Several important routes from Trebizond and various parts of Anatolia converge towards it from the west. It is situated at the eastern end of an open bare plain, 30 m. long and about 12 m. wide, bordered by steep, rounded mountains and traversed by the Kara Su, or western Euphrates, which has its source in the Dumlu Dagh a few miles north of that town, which lies at an elevation of 6,250 ft. above sea-level, while the near hills rise to 10,000 ft. The scenery in the neighbourhood is striking, lofty bare mountains being varied by open plains and long valleys dotted with villages. Just east of the town is the broad ridge of the Deveboyun ("Camel's Neck"), across which the road passes to Kars. To the south is the Palanduken range, from which emerge numerous streams, supplying the town with excellent water. In the plain to the north the Kara Su traverses extensive marshes which afford good wildfowl shooting in the spring. The great altitude accounts for very severe winter cold, occasionally 10° to 25° below zero F, accompanied by blizzards (*tipi*) sometimes fatal to travellers overtaken by them. The summer heat is moderate (59° to 77°).

The town is surrounded by an earthen *enceinte* or rampart with some forts on the hills just above it, and others on the Deveboyun ridge facing east, the whole forming a position of considerable strength. The old walls and the citadel have disappeared. Inside the ramparts the town lies rather cramped, with narrow, crooked streets, badly drained and dirty; the houses are generally built of dark grey volcanic stone with flat roofs, the general aspect, owing to the absence of trees, being somewhat gloomy. The water-supply from Palanduken is distributed by wooden pipes to numerous public fountains.

Situated on the main road from Trebizond into north-west Persia, the town has always a large caravan traffic, principally of camels, but since the improvement of communications in Russia this has declined. A good carriage-road leads to the coast at Trebizond, the journey being made in five or six days. There are also roads to Kars, Bayazid, Erzingan and Kharput. Blacksmiths' and coppersmiths' work is better here than in most Turkish towns; horse shoes and brasswork are also famous. There are several tanneries, and Turkish boots and saddles are largely made. Jerked beef (*pasdirma*) is also prepared in large quantities for winter use. The plain produces wheat, barley, millet and vegetables. Wood fuel is scarce, the present supply being from the Tortum district, whence surface coal and lignite are also brought, but the usual fuel is *tezek* or dried cow-dung.

Erzerum is a town of great antiquity, and has been identified with the Armenian Garin Kalakh, the Arabic Kalikale, and the Byzantine Theodosiopolis of the 5th century, when it was a frontier fortress of the empire—hence its name *Erzen-er-Rum.* It was captured by the Seljuks in 1201, when it was an important city, and it fell into Turkish possession in 1517.

Battles of 1916. This brilliant feat of arms, which ended in the capture of the famous fortress by the Russians, and the rout of the Turks, on Feb. 16, 1916, is described under CAUCASUS, CAMPAIGNS IN THE, 1914–1918.

ERZGEBIRGE, a mountain chain extending from the Elbe to Elstergebirge on the frontier between Saxony and Bohemia (Ger. *Erz,* ore, *Gebirge,* mountain). Its length from east-north-east to west-south-west is about 80 m. and its average breadth about 25 miles. The southern slope is generally steep and rugged, forming in some places a perpendicular wall from 2,000 to 2,500 ft. in height; while the northern, divided at intervals by valleys of great fertility or wildly romantic, slopes gradually towards the great German plain. The central part of the chain forms a plateau of an average height of more than 3,000 ft., at the extremities of which are situated the highest summits of the range:—in the south-east the Keilberg (4,062 ft.); in the north-east the Fichtelberg (3,950 ft.); and in the south-west the Spitzberg (3,650 ft.). Between the Keilberg and the Fichtelberg, at about 3,300 ft., is Gottesgab, the highest town in Bohemia. Geologically, the Erzgebirge range consists mainly of gneiss, mica, schist and phyllite. It is famous for its mineral wealth, which consists principally of silver and lead, tin, nickel, copper and iron. Gold

is found in several places, and some arsenic, antimony, bismuth, manganese, mercury and sulphur. The Erzgebirge is celebrated for its lace manufactures, embroideries, silk-weaving and toys. The climate in winter is inclement in the higher elevations, and, as the snow lies deep until the spring, the range is a winter sports centre. In summer the air is bracing, and many health resorts have sprung into existence, among which are Kipsdorf, Bärenfels and Oberwiesenthal. The district is well served by railway and road communications.

The Elstergebirge, a range some 16 m. in length, in which the Weisse Elster has its source, runs south-west from the Erzgebirge to the Fichtelgebirge and attains a height of 2,630 ft.

ERZINGAN or **ERZINJAN** (*Arsinga* of the middle ages), the chief town of a vilayet of the same name in Asiatic Turkey. Pop. (1927) 51,789. It is a place of some military importance, with large barracks and military factories. It is situated at an altitude of 3,900 ft., near the western end of a rich well-watered plain through which runs the Kara Su or western Euphrates. It is surrounded by orchards and gardens, and is about a mile from the right bank of the river, which here runs in two wide channels crossed by bridges. One wide street traverses the town from east to west, but the others are narrow, unpaved and dirty, except near the Government buildings and the large modern mosque of Hajji Izzet Pasha to the north. The principal barracks, military hospital and clothing factory are at Karateluk on the plain and along the foot-hills to the north 3 m. off. The principal industries are the manufacture of silk and cotton and of copper dishes and utensils. The plain, almost surrounded by lofty mountains, is highly productive with many villages on it and the border hills. Wheat, fruit, vines and cotton are largely grown, and cattle and sheep are bred. Water is everywhere abundant, and there are iron and hot sulphur springs. The battle in which the sultan of Rum (1243) was defeated by the Mongols took place on the plain, and the celebrated Armenian monastery of St. Gregory, "the Illuminator," lies on the hills 11 m. S.W. of the town.

Erzingan occupies the site of an early town in which was a temple of Anaitis. It was an important place in the 4th century when St. Gregory lived in it. The district passed from the Byzantines to the Seljuks after the defeat of Romanus, 1071, and from the latter to the Mongols in 1243. After having been held by Mongols, Tatars and Turkomans, it was added to the Osmanli empire by Mohammed II. in 1473. In 1784 the town was almost destroyed by an earthquake.

ESAR-HADDON, Assyrian king, son of Sennacherib; before his accession to the throne he had also borne another name, Assur-etil-ilani-yukin-abla. At the time of his father's murder (the 20th of Tebet, 681 B.C.) he was commanding the Assyrian army in a war against Ararat. Esar-Haddon returned to Nineveh, and on the 8th of Sivan was crowned king. A good general, Esar-haddon was also an able and conciliatory administrator. His first act was to crush a rebellion among the Chaldaeans in the south of Babylonia and then to restore Babylon, the sacred city of the West, which had been destroyed by his father. The walls and temple of Bel were rebuilt, its gods brought back, and after his right to rule had been solemnly acknowledged by the Babylonian priesthood Esar-haddon made Babylon his second capital. A year or two later Media was invaded and Median chiefs came to Nineveh to offer homage to their conqueror. He now turned to Palestine, where the rebellion of Abdi-milkutti of Zidon was suppressed, its leader beheaded, and a new Zidon built out of the ruins of the older city (676–675 B.C.). All Palestine now submitted to Assyria, and 12 Syrian and 10 Cyprian princes (including Manasseh of Judah) came to pay him homage and supply him with materials for his palace at Nineveh.

But a more formidable enemy had appeared on the Assyrian frontier (676 B.C.). The Cimmerii (*see* SCYTHIA) under Teuspa poured into Asia Minor; they were, however, overthrown in Cilicia, and the Cilician mountaineers who had joined them were severely punished. It was next necessary to secure the southern frontier of the empire. Esar-haddon accordingly marched into the heart of Arabia, to a distance of about 900 m., across a burning and waterless desert, and struck terror into the Arabian tribes. At last he was free to invade Egypt, and led the main body of the Assyrian troops into Egypt on the 5th of Adar, 673 B.C. The desert was crossed with the help of the Arabian sheikh. Egypt seems to have submitted to the invader and was divided into 20 satrapies. Another campaign, however, was needed before it could be finally subdued. In 670 B.C. Esar-haddon drove the Egyptian forces before him in 15 days (from the 3rd to the 18th of Tammuz) all the way from the frontier to Memphis, thrice defeating them with heavy loss and wounding Tirhaka himself. In 668 B.C. Egypt again revolted, and while on the march to reduce it Esar-haddon fell ill and died on the 10th of Marchesvan.

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ESAU, identified in Hebrew tradition with Edom, the eponymous ancestor of the Edomites, is the son of Isaac and Rebekah and elder twin brother of Jacob (Gen. xxv. 24–26). This narrative probably represents an earlier superiority of Edom over Israel, further attested by the view that Edom was a settled state before the Hebrew conquest of Canaan (Gen. xxxvi. 31 [P], Num. xx. 14 [E] etc.). The change in comparative status is reflected in two narratives of Genesis; in the one Esau sells his birthright to Jacob for a mess of red pottage (Gen. xxv. 21–34), whence the name Edom (=Red). According to the other, Jacob, in alliance with Rebekah, succeeded in cheating Esau out of the paternal blessing (Gen. xxvii.).

That Israel regarded Edom as living on a lower social order appears from Gen. xxv. 27, where Esau is a representative of the primitive "food-collector" or wandering hunter, Jacob a type of the "civilized" pastoral nomad. The greater fertility of Israelite territory is illustrated by the blessing of Jacob (Gen. xxvii. 26–29) and the corresponding curse of Esau (Gen. xxvii. 39–40).

ESBJERG, seaport, Denmark, on the west coast of Jutland. Its population grew from 13 in 1868 to 24,000 in 1928. The increase is due entirely to the construction of the harbour and railway in 1874. It is now an important commercial centre, with the only good harbour on the west coast of Jutland. It conducts an important passenger, mail and agricultural traffic with Harwich. There are stores for butter and eggs, export slaughteries and many factories. There is also a considerable fishing trade. The island of Fanoe, about 3 m. S.E., is a seaside resort.

ESCALANTE, a municipality (with administration centre and 11 *barrios* or districts) and port (sheltered by coral reefs) of the province of Negros Occidental, of the island of Negros, Philippine islands, on the north-east coast on Tañon strait, 329 m. from Manila. Pop. (1918), 28,934, of whom only 7 were whites. In 1918, it had 164 household industry establishments with output valued at 72,600 pesos. Of the 12 schools, 11 were public. The municipality was founded in 1860. The language is a dialect of Bisayan.

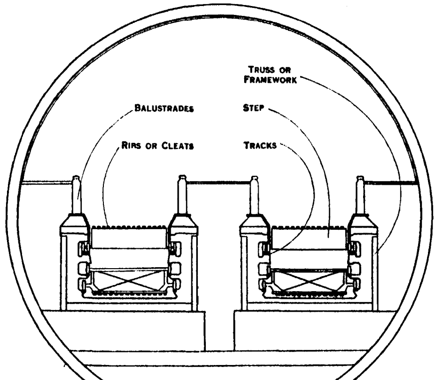
ESCALATORS. An escalator is a form of moving staircase in which motion in the plane of ascent is imparted to the stairs by mechanical means. Therefore a person standing on a step will be carried up or down according to the direction of motion. The early moving staircases were, in effect, inclined link belts forming inclined platforms without steps. As these are uncomfortable at any angle giving a reasonably high rate of ascent, moving staircases were later developed with steps, firstly by superimposing small articulated steps on the belts, and later by constructing unit steps running on tracks and attached to a chain; it was to these machines that the name "escalator" was given.

Four tracks are used, two being on each side of the step, and one of each pair for the back and the front. At the landings it is required that the steps form a level platform. This is done by arranging the supporting tracks so that they curve from the slope to the level in such a way that the horizontal distances between the tracks supporting the front and back of the step are always the same and equal to the distance between the wheels of the step running on these tracks; thus the top surface of each step is kept horizontal. In the early step machines the axes of wheels of each step lie in a horizontal plane and in later machines

in an inclined plane. The stairway runs between balustrades of wood or metal construction of form and shape varying according to local conditions. This balustrading commonly carries a flexible moving handrail, to assist the passenger in the ascent or descent. The tracks for the steps are carried in a truss or framework. The steps are attached to either one central or two side chains driven by sprocket wheels.

The earlier type step machines have a central chain driven at a point a little way down the slope and are provided with semi-circular tracks to transfer the chain and steps from the "go" to the "return" side. Some of the dependent weight of the chain and steps is relieved from the driving sprocket by introducing one or more sprockets, free to move and loaded by springs in the direction of the centre line of the machine and engaging the "go" and "return" sides of the chain, these sprockets being situated below the main driving sprocket and not supplied with any external power. In order to keep the chain and steps in contact with the curved track at the landing curves, the semi-circular tracks are loaded with weights. On the later machines the steps are arranged between two chains passing over sprockets at the ends of the machine. The upper sprocket runs in fixed bearings and is driven, while the lower runs free and a tension is kept on the main chains by a counterweight pulling the lower sprocket outwards, the bearings being movable. Safety devices are provided to deal with any irregular operation or breakage, such as broken chains, overspeed or reversal of the machine.

It is necessary to ensure that the user is transferred safely from the moving steps to the fixed landing. This is done on a step type machine with flat tread steps by arranging the steps to run flush with the landings and providing a diagonal barrier across the line of motion, thus ensuring that any person not stepping



TRANSVERSE SECTION OF TWO ESCALATORS, RUNNING 90 FT. PER MINUTE AT AN ANGLE OF 30°, CARRYING TWO PASSENGERS ON EACH STEP, TRANSPORTING 8,000 AN HOUR; MAKING THE OPERATING COSTS LOWER, THE CARRYING CAPACITY GREATER AND THE SERVICE QUICKER THAN WITH LIFTS

off sideways on to the landing is pushed off by contact with the barrier. An alternative construction which is more commonly used is to arrange ribs or cleats on the step tread at short distances apart and running from back to front of the steps. At the landings a metal comb is arranged with teeth projecting at a slight angle downwards towards the steps. The cleats on the steps move horizontally through the spaces between the teeth of the comb, and, since the plane of the top of the comb intersects the plane of the top of the cleats, the feet of any person not stepping off at the landing are slid gently up on to the stationary comb which joins the landing floor. This latter construction was also used on the earlier ramp type machines.

The usual linear speed, or speed of the steps up or down the incline for escalators, is 90–100ft. per min. corresponding, at the usual 30° angle of ascent, to a vertical speed of 45–50ft. per min., this representing a practicable operating speed both from the engineering and the passenger points of view. The limit of speed

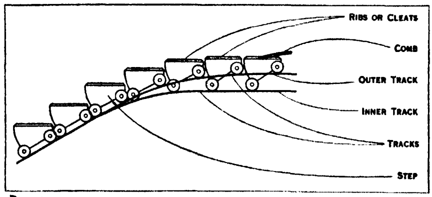


DIAGRAM OF ESCALATOR LANDING, SHOWING THE RELATION BETWEEN STEPS AND TRACKS AT LANDINGS AND THE METHOD OF CHANGING FROM STEPS TO FLAT PORTION, AND VICE VERSA

must depend on the landing arrangements and the necessity of catering for passengers of all ages and degrees of activity.

The escalator has an outstanding advantage over lifts or elevators in its continuity of action, and where vertical travel is associated with a displacement of the upper landing in relation to the lower, an escalator has the advantage of providing simultaneous movement in two dimensions; also the operating costs are lower. One escalator (one pair one up and one down) is equivalent in carrying capacity to several lifts, the equivalent number of lifts depending on size and speed.

The escalator has not yet been constructed for more than 60ft. vertical rise and this probably represents a practical operating limit. The lift is therefore a necessity for high rise services, unless two flights of escalators are used, with the consequent long time involved in the journey. Escalators are usually made of three sizes; *i.e.*, 2ft., 3ft. and 4ft., between balustrades. An escalator at any angle of 30° with the horizontal, running at 90ft. per min., carrying two passengers stationary on each step (4ft. wide), will transport 8,100 passengers per hour. If the passengers walk at the same time the capacity may be increased by 40%. Escalators are now in general use throughout the world in subways and elevated railways, industrial and factory buildings, restaurants, theatres and department stores. (W. S. G.-B.)

ESCANABA, a city of upper Michigan, U.S.A., on Little Bay de Noc, an inlet of Green bay (Lake Michigan); a port of entry and the county seat of Delta county. It is on Federal highways 2 and 41, and is served by the Chicago and Northwestern, the Escanaba and Lake Superior and the Soo Line railways, and by lake steamers in summer. The population was 13,103 in 1920 (22·5% foreign-born white) and was estimated locally at 15,000 in 1928. The city occupies a picturesque promontory 612ft. above sea-level. Its exhilarating climate and the attractions of the upper peninsula (varied and beautiful scenery, virgin forests and trout streams) make it a summer resort and a touring centre. It has 8m. of water front, and a natural deep-water harbour, open 8 months of the year, with four large, specially equipped docks for handling iron ore, of which over 6,000,000 tons are shipped annually. Escanaba is a division point of the Chicago and Northwestern railroad, which has large repair shops here. It is estimated that there are altogether 1,300 railroad employees in the city, and that the factories employ as many more. Among the important manufactures are lumber, maple flooring, veneers, charcoal, iron, chemicals, paper and cinder concrete blocks. There is a large tie-preserving plant. Escanaba was settled in 1863 and was chartered as a city in 1883. Since 1922 it has had a council-manager form of government.

ESCAPE, a verb meaning to get away from, especially from impending danger or harm, to avoid capture, to regain one's liberty after capture. As a substantive, "escape," in law, is the regaining of liberty by one in custody contrary to due process of

law (*see* RESCUE). "Escape" is used in botany of a cultivated plant found growing wild. The word is also used of a means of escape, *e.g.*, "fire-escape," and of a loss or leakage of gas, current of electricity or water.

ESCH A ALZ, a town of Luxembourg, on the river Alzette, near the frontier in the south-western corner of the country. It has important coal and iron mines and has light railway communications with the main lines serving Belgium, France and Germany. Pop. (1922), 21,208.

ESCHATOLOGY (the "doctrine of last things") is a theological term derived from the New Testament phrases "the last day" (ἐν τῇ ἐσχάτῃ ἡμέρᾳ John vi. 39) "the last times" (ἐπ' ἐσχάτων τῶν χρόνων I. Peter i. 20), "the last state" (τὰ ἔσχατα Matt. xii. 45) a conception taken over from ancient prophecy (Is. ii. 2; Mal. iv. 1). It was the common belief in the apostolic age that the second advent of Christ was near, and would give the divine completion to the world's history. The use of the term, however, has been extended so as to include all that is taught in the Scriptures about the future life of the individual as well as the final destiny of the world.

Eastern Religions.—There is a bewildering variety in the views of the future life and world held by different peoples. The future life may be conceived as simply a continuation of the present life in its essential features, although under conditions more or less favourable. It may also be thought of as retributive, as a reversal of present conditions so that the miserable are comforted, and the prosperous laid low, or as a reward or punishment for good or evil desert here. Personal identity may be absorbed, as in the transmigration of souls, or it may even be denied, while the good or bad result of one life is held to determine the weal or woe of another. The scene of the future life may be thought of on earth, in some distant part of it, or above the earth, in the sky, sun, moon or stars, or beneath the earth. The abodes of bliss and the places of torment may be distinguished, or one last dwelling-place may be affirmed for all the dead. Sometimes the good find their abiding home with the gods; sometimes a number of heavens of varying degrees of blessedness is recognized (*see* F. B. Jevons, *An Introduction to the History of Religion*, chs. xxi. and xxii., 1902; and J. A. MacCulloch's *Comparative Theology*, xiv., 1902).

Indian and Persian Contributions.—The Indian and the Persian contributions to eschatology deserve special mention. (1) A characteristic feature of Indian thought is the transmigration of the soul from one mode of life to another, the physical conditions of each being determined by the moral and religious character of the preceding. But deliverance from this cycle of existences, which is conceived as misery, is promised by means of speculation and asceticism. Denying the continuance of the soul, Buddhism affirmed a continuity of moral consequences (Karma), each successive life being determined by the total moral result of the preceding life. Its doctrine of salvation was a guide to, if not absolute non-existence, yet cessation of all consciousness of existence (Nirvana). Later Buddhism has, however, a doctrine of many heavens and hells. (2) In Zoroastrianism not only was continuance of life recognized, but a strict retribution was taught. Heaven and hell were very clearly distinguished, and each soul according to its works passed to the one or to the other. But this faith did not concern itself only with the future lot of the individual soul. It was also interested in the close of the world's history, and taught a decisive, final victory of Ormuzd over Ahriman, of the forces of good over the forces of evil. It is not at all improbable that Jewish eschatology in its later developments was powerfully influenced by the Persian faith.

Old Testament.—In the Old Testament we can trace the gradual development of an ever more definite doctrine of "the final condition of man and the world." This is regarded as the last stage in a moral process, a redemptive purpose of God. The eschatology of the Old Testament is thus closely connected with, but not limited by, Messianic hope, as there are eschatological teachings that are not Messianic. As the Old Testament revelation is concerned primarily with the elect nation, and only secondarily (in the later writings) with the individual persons composing it, the destiny of the nation stands in the foreground. The details of the development of the doctrine must be passed over, and its issue only be indicated. The contributions of the Old Testament to Christian eschatology embrace these features: "(1) the manifestation or advent of God; (2) the universal judgment; (3) behind the judgment the coming of the perfect kingdom of the Lord, when all Israel shall be saved and when the nations shall be partakers of their salvation; and (4) the finality and eternity of this condition, that which constitutes the blessedness of the saved people being the Presence of God in the midst of them—this last point corresponding to the Christian idea of heaven" (A. B. Davidson, in Hastings's *Bible Dictionary*, i. p. 738). This hope is for the people on this earth though transfigured.

To the individual it would seem at first only old age is promised (Is. lxv. 20; Zech. viii. 4), but the abolition of death itself is also declared (Is. xxv. 8). The resurrection which appears at first as a revival of the dead nation (Hos. vi. 2; Ez. xxxvii. 12–14), is afterwards promised for the pious individuals (Is. xxvi. 19), so that they too may share in the national restoration. Only in Daniel xii. 2 is taught a resurrection of the wicked "to shame and everlasting contempt" as well as of the righteous to "everlasting life." It was only at the Exile, when the nation ceased to be, that the worth of the individual came to be recognized, and the hopes given to the nation were claimed for the individual. Scholars, however, are not agreed how far any hope of individual immortality is found in the Old Testament. While some hold, others deny that the doctrine can be found in Ps. xvi. 9–11; and Ps. xvii. 15; but some such anticipation is more generally recognized in Job xix. 25–27; Ps. xlix. 14. 15 and Ps. lxxiii. 17–28. This belief in individual immortality is expressed poetically and obscurely; it is later than the eschatology of the people. It assumes the moral distinction of the righteous and the ungodly, and seeks a solution for the problem of the lack of harmony of present character and condition. Its deepest motive, however, is religious. The soul, once in fellowship with God, cannot even by death be separated from God. The individual hoped that he would live to share the nation's good, and thus the two streams of Old Testament eschatology at last flow together.

Apocryphal and Apocalyptic.—It is in the apocryphal and apocalyptic literature of Judaism that the fullest development of eschatology can be traced. Four words may serve to express the difference of the doctrine of these writings and the teaching of the Old Testament. Eschatology was *universalized* (God was recognized as the creator and moral governor of all the world), *individualized* (God's judgment was directed, not to nations in a future age, but to individuals in a future life), *transcendentalized* (the future age was more and more contrasted with the present, and the transition from the one to the other was not expected as the result of historical movements, but of miraculous divine acts), and *dogmatized* (the attempt was made to systematize in some measure the vague and varied prophetic anticipations). The details of this doctrinal movement may be studied in R. H. Charles, *A Critical History of the Doctrine of the Future Life in Israel, in Judaism, and in Christianity*, 1899.

New Testament.—The eschatology of the New Testament attaches itself not only to that of the Old Testament but also to that of contemporary Judaism, but it avoids the extravagances of the latter. Not at all systematic, it is occasional, practical, poetical, and dominantly evangelical, laying stress on the hope of the righteous rather than the doom of the wicked. The teaching of Jesus centres, according to the Synoptists, in the great idea of the "Kingdom of God," which is already present in the teacher Himself, but also future as regards its completion. In some parables a gradual realization of the kingdom is indicated (Matt. xiii.); in other utterances its consummation is connected with Christ's own return, His Parousia (Matt. xxiv. 3, 37, 39) the time of which, however, is unknown even to Himself (Mark xiii. 32). In this eschatological discourse (Matt. xxiv., xxv.) He speaks of the destruction of Jerusalem and of the end of the world as near, and seemingly as one. This is in accordance with the characteristic of prophecy, which sees in "timeless sequence" events which

are historically separated from one another. While the Return is represented in the Synoptists as an external event, it is conceived in the fourth gospel as an internal experience in the operation of the Spirit on the believer (John xiv. 16–21); nevertheless here also the Parousia in the Synoptic sense is looked for (John xxi. 22; *cf.* 1 John ii. 28). The object of the Second Coming is the execution of judgment by Christ (Matt. xxv. 31), both individual (xxii. 1–14) and universal (xiii. 36–42). This judgment presupposes the resurrection, belief in which was rejected by the Sadducees, but accepted by the Pharisees and the majority of the Jewish people, and confirmed by Christ according to the Fourth Gospel not only as an individual spiritual renovation (John v. 25, 26), but as a universal physical resuscitation (28 and 29), but whether Jesus Himself taught a resurrection of the wicked is doubtful. There is, however, a future punishment for the wicked in Gehenna (Matt. v. 29, 30; x. 28). On the *Intermediate State* Jesus does not speak clearly. But He uses the current terms Hades (Matt. xi. 23; xvi. 18; Luke xvi. 23), Paradise (Luke xxiii. 43) and Gehenna (Matt. xviii. 9) in the accepted meaning without any definite dogmatic import. When He speaks of death as "sleep" (Luke viii. 52; John xi. 11) it is to give men gentler and sweeter thoughts of it, not to inculcate the doctrine of an intermediate state as an unconscious condition. There are words which suggest rather the hope of an immediate entrance of the just into the Father's house and glory (John xiv. 2, 3, xvii. 24). He spoke frequently and distinctly both of the final reward for the righteous and final penalty for the wicked. Degrees of award are recognized (Luke xii. 47, 48). Two sayings are held to point to a terminable penalty (Matt. v. 25, 26, xii. 31, 32), but the one is so figurative and the other so obscure, that we are not warranted in drawing any such definite conclusion from either of them. The finality of destiny seems to be unmistakably expressed (Matt. vii. 23, x. 33, xiii. 30, xxv. 46, xxvi. 24; Mark ix. 43–48, viii. 36; Luke ix. 26; John iii. 16, viii. 21, 24). No second opportunity for deciding the issue of life or death is expressly recognized by Jesus even if such an expectation may be a legitimate inference from what He taught about the Father's love for the lost.

The apostolic eschatology presents resemblance amid difference. Jude (*v.* 6) as well as 2 Peter (ii. 4), refers to the judgment of the fallen angels. 2 Peter describes the place of their detention as Tartarus, and teaches that Christ's Parousia is to bring the whole present system of things to its conclusion, and the world itself to an end (iii. 10, 13). No certainty has been reached in the interpretation of the passages in 1 Peter iii. 18–22 and iv. 6; *cf.* Acts ii. 31, but they suggest to the Christian mind the expectation that the final destiny of no soul can be fixed until in some way or other, in this life or the next, the opportunity of decision for or against Christ has been given. The phrase "the times of restoration of all things" (iii. 21) is too vague in itself, and is too isolated in its context to warrant the dogmatic teaching of universalism. While John's Apocalypse is distinctly eschatological, the Epistles and the Gospel often give these conceptions an ethical and spiritual import, without, however, excluding the eschatological. Life is present while eternal (1 John v. 12, 13), but it is also future (ii. 25). There is expected a future manifestation of Christ as He is, and what the believer himself will be does not yet appear (iii. 2). The writer speaks of the last hour (ii. 18), the Antichrist that cometh (ii. 22, iv. 3), and the Christian's full reward (2 John *v.* 8) as well as the Parousia (1 John ii. 28). The Apocalypse reproduces much of the current Jewish eschatology. A millennial reign of Christ on earth is interposed between the first resurrection, confined to the saints and especially the martyrs, and the second resurrection for the rest of the dead. A final outburst of Satan's power is followed by his overthrow and the Last Judgment.

Although Paul sometimes describes the Kingdom of God as present (Rom. xiv. 17; 1 Cor. iv. 20; Col. i. 13), it is usually represented as future. The Parousia, if more prominent in his earlier writings, is not altogether absent from his later, although the expectation of personal survival does seem to grow less confident (*cf.* 1 Cor. xv. 51 and Phil. i. 20–24). The doctrines of the Resurrection, the Last Judgment, the Reward of the Righteous and the Punishment of the Wicked are not less distinctly expressed than in the other apostolic writings. Peculiar elements in Paul's eschatology are the doctrines of the Rapture of the Saints (1 Thess. iv. 17) and the Man of Sin (2 Thess. ii. 3–6), but these have affinities elsewhere. It is improbable that there is any reference to Christ's millennial reign in 1 Cor. xv. 22–24 or to purgatory in iii. 12–15, or to the descent into Hades in Rom. x. 7 and Eph. iv. 10. Universal restoration is inferred from 1 Cor. xv. 24–28; Phil. ii. 10–11; Eph. i. 9, 10; Col. i. 20. These passages inspire a hope, but do not sustain a certainty. Paul's shrinking from the disembodied state and longing to be clothed upon at death in 2 Cor. v. 1–8, cannot be regarded as a proof of an *interim* body prior to and preparatory for the resurrection body. Paul links the human resurrection with a universal renovation (Rom. viii. 19–23). His eschatology is not free of obscurities and ambiguities; and in the New Testament eschatology generally we are forced to recognize a mixture of inherited Jewish and original Christian elements (*see* ANTICHRIST).

During the first century of the existence of the Gentile Christian Church, "the hope of the approaching end of the world and the glorious kingdom of Christ" was dominant, although warnings had to be given against doubt and indifference. Redemption was thought of as still future, as the power of the devil had not been broken but rather increased by the First Advent, and the Second Advent was necessary to his complete overthrow. The expectations were often grossly materialistic as is evidenced by Papias's quotation as the words of the Lord of a group of sayings from the Apocalypse of Baruch, setting forth the amazing fruitfulness of the earth in the Messianic time.

The Gnostics and Montanism.—The Gnostics rejected this eschatology as in their view the enlightened spirit already possessed immortality. Marcion expected that the Church would be assailed by Antichrist; a visible return of Christ he did not teach, but he recognized that human history would issue in a separation of the good from the bad. Montanism sought to form a new Christian commonwealth which, separated from the world, should prepare itself for the descent of the Jerusalem from above, and its establishment in the spot which by the direction of the Spirit had been chosen in Phrygia. While Irenaeus held fast the traditional eschatological beliefs, yet his conception of the Christian salvation as a deification of man tended to weaken their hold on Christian thought. The Alogi in the 2nd century rejected the Apocalypse on account of its chiliasm, its teaching of a visible reign of Christ on earth for a thousand years. Montanism also brought these apocalyptic expectations into discredit in orthodox ecclesiastical circles.

The Fathers.—The Alexandrine theology strengthened this movement against chiliasm. Clement of Alexandria and Origen both developed peculiar views of their own which did not find general acceptance. In the 5th century there were rejected as heretical (1) "the doctrine of universalism, and the possibility of the redemption of the devil; (2) the doctrine of the complete annihilation of evil; (3) the conception of the penalties of hell as tortures of conscience; (4) the spiritualizing version of the resurrection of the body; (5) the idea of the continued creation of new worlds" (A. Harnack, *History of Dogma,* iii. p. 186).

A doctrine of the most perfect identity between the resurrection body and the material body soon established itself as alone orthodox. Augustine held fast to eternal punishment, but allowed the possibility of mitigations. Some believers, he taught, may pass through purgatorial fires; and this middle class may be helped by the sacraments and the alms of the living. This doctrine was sanctioned and developed by Gregory the Great. This view was inferred indirectly from Matt. xii. 31, and directly from 1 Cor. iii. 12–15. Afterwards purgatory took more and more the place of hell, and was subject to the control of the church. As regards the saints, different degrees of blessedness were recognized; they were supposed to wait in Hades for the return of Christ, but gradually the belief gained ground, especially in regard to the martyrs, that their souls at once entered Paradise. The primitive Christian eschatology was preserved in the West as

it was not in the East, and in times of exceptional distress the expectation of Antichrist emerged again and again. In the middle ages there was an extravagance of speculation on this subject, which may be seen in the last division of Aquinas's *Summa Theologiae.*

Protestant Theology.—While rejecting purgatory, Protestantism took over this eschatology. Souls passed at once to heaven or to hell; a doctrine even less adequate to the complex quality of human life. Luther himself looked for the passing away of the present evil world. Socinianism taught a new spiritual body, an intermediate state in which the soul is near non-existence, an annihilation of the wicked, as immortality is the gift of God. Swedenborg discards a physical resurrection, as at death the eyes of men are opened to the spiritual world in which we exist now, and they continue to live essentially as they lived here, until by their affinities they are drawn to heaven or hell. The doctrine of *eternal punishment* has been opposed on many grounds, such as the disproportion between the offence and the penalty, the moral and religious immaturity of the majority of men at death, the diminution of the happiness of heaven involved in the knowledge of the endless suffering of others (Schleiermacher), the defeat of the divine purpose of righteousness and grace that the continued antagonism of any of God's creatures would imply, the dissatisfaction which God as Father must feel until His whole family is restored. The contention should not be based on the meaning of the word "eternal" but on such broader considerations as have been indicated above. The doctrine of *conditional* immortality taught by Socinianism was accepted by Archbishop Whately, and has been most persistently advocated by Edward White, who "maintains that immortality is a truth, not of reason, but of revelation, a gift of God" bestowed only on believers in Christ; but he admits a continued probation after death for such as have not hardened their hearts by a rejection of Christ. This view is from the standpoint of science maintained by J. Y. Simpson in his book, *Man and the Attainment of Immortality,* 1922. The doctrine of *universal restoration* was maintained by Thomas Erskine of Linlathen on the ground of the Fatherhood of God, and Archdeacon Wilson anticipates such discipline after death as will restore all souls to God. The attitude of theologians generally regarding individual destiny is well expressed by Dr. James Orr, "The conclusion I arrive at is that we have not the elements of a complete solution, and we ought not to attempt it. What visions beyond there may be, what larger hopes, what ultimate harmonies, if such there are in store, will come in God's good time; it is not for us to anticipate them, or lift the veil where God has left it down" (*The Christian View of God and the World,* 1893, p. 397).

Recent Theological Thought.—Although in recent theological thought attention has been mainly directed to individual destiny, yet the other elements of Christian eschatology must not be altogether passed over. History has offered the authoritative commentary on the prophecy of the Parousia of Christ. The presence and power of His Spirit, the spread of His Gospel, the progress of His kingdom have been as much a fulfilment of the eschatological teaching of the New Testament as His life and work on earth were a fulfilment of Messianic prophecy, for fulfilment always transcends prophecy. Even if the common beliefs of the apostolic age have not modified the evangelists' reports of Jesus' teaching, it must be remembered that He used the common prophetic phraseology, the literal fulfilment of which is not to be looked for. Some parables (the leaven, the mustard seed) suggest a gradual progressive realization of His kingdom. The Fourth Gospel interprets both judgment and resurrection spiritually. Accordingly the general resurrection and the last judgment may be regarded as the temporal and local forms of thought to express the universal permanent truths that life survives death in the completeness of its necessary organs and essential functions, and that the character of that continued life is determined by personal choice of submission or antagonism to God's purpose of grace in Christ, the perfect realization of which is the Christian's hope for himself, mankind and the world.

Bibliography.—In addition to the works referred to above the following will be found useful: S. D. Salmond, *The Christian Doctrine of Immortality* (4th ed., 1901); L. N. Dahle, *Life after Death and the Future of the Kingdom of God* (Eng. tr. by J. Beveridge, 1895); J. A. Beet, *The Last Things* (new ed., 1905); W. G. T. Shedd, *Doctrine of Endless Punishment* (New York, 1886); F. W. Farrar, *The Eternal Hope* (1892); E. Petavel, *The Problem of Immortality* (Eng. tr. by F. A. Freer, 1892); E. White, *Life in Christ* (3rd ed., 1878); Macintyre, *The Other Side of Death* (1922); also the relevant sections in books on biblical and systematic theology. *See* also Immortality.

(A. E. G.)

ESCHEAT, in English law, the reversion of lands to the next lord on the failure of heirs of the tenant. This rule is explained by the conception of a freehold estate as an interest in lands held by the freeholder from some lord, the king being lord paramount. (*See* Estate.) As there are now but a very few freehold estates traceable to any mesne or intermediate lord, escheats, when they do occur, fall to the king as lord paramount. Besides escheat for defect of heirs, there was formerly also escheat *propter delictum tenentis,* or by the corruption of the blood of the tenant through attainder consequent on conviction and sentence for the offence of treason or felony. The real estate, therefore, escheated to the next heir, subject to the superior right of the Crown to the forfeiture of the lands—in the case of treason for ever, in the case of felony for a year and a day. All this was abolished by the Felony Act, 1870, which provided for the appointment of an administrator to the property of the convict. Escheat was also an incident of copyhold tenure. Trust estates were not subject to escheat until the Intestates' Estates Act, 1884. (*See* Eminent Domain.) In most of the British colonies escheat has been abolished, and in England this was effected by the Law of Property Act, 1922 (Copyholds), and the Administration of Estates Act, 1925.

In the United States, escheat, in the old English sense, existed in a few of the colonies before the Revolution; it has existed since only so far as regulated by statute. It now means the death of an owner of an estate intestate, that is, without a will or heirs at law, in which case it becomes the property of the state. Public administrators have been named in certain states to take charge of such estates and sell them for the benefit of the state.

ESCHENBURG, JOHANN JOACHIM (1743–1820), German critic and literary historian, was born at Hamburg on Dec. 7, 1743. He studied at Leipzig and Göttingen, and became professor and then director at the Collegium Carolinum in Brunswick. He published a series of German translations of the principal English writers on aesthetics, such as J. Brown, D. Webb, Charles Burney, Joseph Priestley and R. Hurd; and Germany owes also to him the first complete translation (in prose) of Shakespeare's plays (*William Shakespear's Schauspiele,* 13 vols., Zürich, 1775–82). This is virtually a revised edition of the incomplete translation published by Wieland between 1762 and 1766. Eschenburg died at Brunswick on Feb. 29, 1820.

ESCHENMAYER, ADAM KARL AUGUST VON (1768–1852), German philosopher and physicist, was born at Neuenburg, Württemberg, in July 1768. He took his M.D. at Tübingen, and practised at Sulz, and then at Kirchheim. In 1811 he became professor of philosophy and medicine at Tübingen and in 1818 professor of practical philosophy, but in 1836 he retired to Kirchheim, where he devoted himself to philosophical studies. Eschenmayer's views resemble those of Schelling, except in regard to the knowledge of the absolute. He believed that philosophy must be supplemented by "non-philosophy," a kind of mystical illumination by which we arrive at God, the absolute unity, and see Him as the originator of the finite world with its opposing factors. Eschenmayer's mystical tendency led to an interest in the phenomena of animal magnetism. He became a believer in demoniacal and spiritual possession; and his later writings are impregnated with the lower supernaturalism.

His principal works are—*Die Philosophie in ihrem Übergange zur Nichtphilosophie* (1803); *Versuch die scheinbare Magie des thierischen Magnetismus aus physiol. und psychischen Gesetzen zu erklären* (1816); *System der Moralphilosophie* (1818); *Psychologie in drei Theilen, als empirische, reine, angewandte* (1817); *Religionsphilosophie* (3 vols., 1818–24); *Grundriss der Naturphilosophie* (1832); *Die Hegel'sche Religions philosophie verglichen mit dem christl. Princip* (1834); *Der Ischariotismus un-*

serer Tage (1835) (against Strauss's *Life of Jesus*); *Konflikt zwischen Himmel und Hölle* (1837); *Grundzüge der christl. Philosophie* (1840); and *Betrachtungen über den physischen Weltbau* (1852).

ESCHSCHOLTZ, JOHANN FRIEDRICH (1793–1831), Russian traveller and naturalist, was born in Nov. 1793, in Dorpat, where he died in May 1831. He was naturalist and physician to Otto von Kotzebue's exploring expedition during 1815–18, and then became professor of anatomy (1819) and director of the zoological museum in Dorpat. He published the *System der Akalephen* (1829), and the *Zoologischer Atlas* (1829–33). The botanical genus *Eschscholtzia,* which comprises the California poppies, was named by Chamisso in his honour.

ESCHWEGE, a town of Germany, in the Prussian province of Hesse-Nassau, on the Werra, 28 m. S.E. of Cassel. Pop. (1925) 12,748. In the 13th and 14th centuries it belonged alternately to Thuringia and Hesse, but passed definitely to the latter at the beginning of the 15th century. It consists of the old town on the left, the new town on the right bank of the Werra, and Brückenhausen on a small island connected with the old and new towns by bridges. Its chief industries are leather-making, metal-founding, yarn-spinning, cotton- and wool-weaving, the manufacture of cigars, machines, barrels, cork and soap-boiling. It has two ancient buildings, the Nikolai-turm, built in 1455, and the old castle.

ESCHWEILER, a town of Germany, in the Prussian Rhine province, on the Inde, and the Cologne-Herbesthal railway, about 8 m. E.N.E. from Aix-la-Chapelle. Pop. (1925) 26,023. The manufacture of iron, steel and zinc goods is carried on; other industries include tanning, distilling and brewing. In the neighbourhood there are valuable coal mines.

See Koch, *Geschichte der Stadt Eschweiler* (Frankfort, 1890).

ESCOBAR Y MENDOZA, ANTONIO (1589–1669), Spanish churchman, was born at Valladolid, and at the age of fifteen became a Jesuit. He soon became a famous preacher, and his facility was so great that for fifty years he preached daily. His best known works are *Summula casuum conscientiae* (1627); *Liber theologiae moralis* (1644), and *Universae theologiae moralis problemata* (1652–66). The first contains the famous maxim that purity of intention may be a justification of actions which are contrary to the moral code and to human laws. Its doctrines were criticized in the fifth and sixth of Pascal's *Provincial Letters* and were ridiculed in witty verses by Molière, Boileau and La Fontaine. Escobar also wrote Biblical commentaries and Latin verses in praise of Ignatius Loyola.(1613) and of the Virgin (1618). He died at Valladolid on July 4, 1669.

ESCOIQUIZ, JUAN (1762–1820), Spanish ecclesiastic, politician and writer, was born in Navarre in 1762. He entered the church, was a prebendary of Saragossa, and acted as tutor to Prince Ferdinand (Ferdinand VII.). He was a busy and pushing member of the literary clique which looked up to Godoy as its patron. But as Ferdinand grew up, and after his marriage with a Neapolitan princess, Escoiquiz became the centre of a court opposition to Godoy and to his policy of alliance with France. He was exiled from the court, but, nevertheless, contrived to take part in the conspiracy of the Escorial in October 1807. He was imprisoned and sent for trial with other conspirators. But as they had appealed to Napoleon, who would not suffer his name to be mentioned, the government had to allow the matter to be hushed up, and the prisoners were acquitted. After the outbreak at Aranjuez (March 17, 1808), in which he had a share, he became one of the most trusted advisers of Ferdinand. The new king's decision to go to meet Napoleon at Bayonne was largely inspired by him. His *Idea sencilla de las razones que motivaron el viaje del Rey Fernando VII. a Bayona* (1814) is a valuable historical document, and contains a singularly vivid account of an interview with Napoleon. When the Spanish royal family was imprisoned by Napoleon, Escoiquiz remained with Ferdinand at Valençay. When Ferdinand was released in 1814 he came back to Madrid, but after a very brief period of office in 1815 he was sent as a prisoner to Murcia. Though he was afterwards recalled, he was again exiled to Ronda, where he died on Nov. 27, 1820.

ESCOMBE, HARRY (1838–1899), South African statesman, a member of a Somersetshire family, was born at Notting Hill, London, on July 25, 1838, and educated at St. Paul's school. He emigrated, in 1859, to the Cape. He practised as an attorney in Natal, and in 1872 was elected to the legislative council. In 1880 he secured the appointment of a harbour board for Natal, and was himself made chairman. The transformation of the port of Durban into a harbour available for ocean liners was due to his energy. In 1888–89 he defended Dinizulu and other Zulu chiefs against a charge of high treason. On the grant of responsible government in 1893, he served as attorney general under Sir J. Robinson in the first ministry, and was prime minister of Natal in 1897 for a few months. In Oct. 1899 he prepared measures of defence against the invasion by the Boers. He died on Dec. 27, 1899.

The *Speeches of the late Right Hon. Harry Escombe* (Maritzburg, 1903), ed. J. T. Henderson, contains brief biographical notes by Sir John Robinson and the editor.

ESCORIAL or **ESCURIAL,** in Spain, is one of the most remarkable buildings in Europe, comprising a convent, a church, a palace and a mausoleum. It is situated in wild and barren country 3,432 ft. above the sea, on the south-western slopes of the Sierra de Guadarrama, within the borders of the province of Madrid and the kingdom of New Castile. By the Madrid-Avila railway it is 31 m. N.W. of Madrid.

According to the usual tradition, the Escorial owes its existence to a vow made by Philip II. of Spain (1556–98), shortly after the battle of St. Quentin, in which his forces succeeded in routing the army of France. The day of the victory (Aug. 10, 1557) was sacred to St. Laurence, and the building was dedicated to that saint, and received the title of *El real monasterio de San Lorenzo del Escorial.* The last distinctive epithet was derived from the little hamlet in the vicinity which furnished shelter, not only to the workmen, but to the monks of St. Jerome, who were afterwards to be in possession of the monastery; and the hamlet is generally supposed to derive its name from the *scoriae* or dross of certain old iron mines. The work was entrusted to Juan Bautista de Toledo, and the first stone was laid in April 1563. On the death of Toledo in 1567 a worthy successor was found in Juan Herrera. On Sept. 13, 1584, the last stone of the masonry was laid.

The ground plan of the building is estimated to occupy an area of 396,782 sq.ft. There are seven towers, 15 gateways and, according to Los Santos, no fewer than 12,000 windows and doors. The church is the finest portion of the whole Escorial and ranks as one of the great Renaissance churches of Europe. It is about 340 ft. from east to west by 200 from north to south, and thus occupies an area of about 70,000 sq.ft. The dome is 60 ft. in diameter, and its height at the centre is about 320 ft. Directly under the altar is situated the pantheon or royal mausoleum, a richly decorated octagonal chamber. The library, situated above the principal portico, was at one time one of the richest in Europe, comprising the king's own collection, the spoils of the emperor of Morocco, Muley Zidan (1603–1628) and various contributions from convents, churches, cities and private libraries. Among its curiosities still extant are two New Testament Codices of the 10th century and two of the 11th; various works by Alphonso the Wise (1252–84), a Virgil of the 14th century and a Koran of the 15th.

Of the artistic treasures with which the Escorial was gradually enriched, it is sufficient to mention the frescoes of Pellegrino Tibaldi, Luis de Carbajal, Bartolommeo Carducci or Carducho and Luca Giordano, the crucifix of Cellini and the pictures of Titian, Tintoretto, El Greco and Velasquez. After the conflagration of 1671, only the church, a part of the palace, and two towers escaped uninjured. In 1808 the whole building was exposed to the ravages of the French soldiers. In 1872, the college and seminary, a part of the palace and the upper library were devastated by fire; but the damage was subsequently repaired. In 1885 the conventual buildings were occupied by Augustinian monks.

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fundacion del Escorial y su fabrica, in the *Coleccion de documentos inéditos para la historia de España,* vol. vii.; J. de Herrera, *Sumario y breve declaracion de los diseños y estampas de la fab. de S. Lorencio el Real del Escurial* (Madrid, 1589); José de Sigüenza, *Historia de la orden de San Geronimo,* etc. (Madrid, 1595–1605).

ESCOVEDO, JUAN DE (d. 1578), Spanish politician, secretary of Don John of Austria, began life in the household of Ruy Gomez de Silva, prince of Eboli. When Don John of Austria, after the battle of Lepanto in 1571, began to launch on a policy of self-seeking adventure, Escovedo was appointed as his secretary with the intention that he should act as a check on these follies. He began to disobey orders from Madrid and became entangled in intrigues to manage or even to coerce the king. In July 1577, and contrary to the king's orders, he came to Spain from Flanders, where Don John was then governor. The king gave orders to Antonio Perez that he was to be put out of the way. After two clumsy attempts had been made to poison him at Perez's table, he was killed by bravos on the night of Easter Monday, March 31, 1578.

See Gaspar Muro, *La Princesse d'Eboli* (Paris, 1878); and W. H. Prescott, *Reign of Philip II.* (1855–59).

ESCROW, a written agreement entered into by three parties, the obligor, the obligee, and the depositary, for the transfer or conveyance of certain property. The sealed agreement of the obligor (generally accompanied by the deed, bond or chattel to be conveyed) made contingent upon some future happening, or upon the performance of some act by the obligee, is delivered to the depositary and held by him pending the occurrence of that event or the performance of the required act by the obligee. When the event has taken place or the obligee has performed the specified act, the depositary delivers to him the agreement and the deposit which he has held, and the transaction is complete. The depositary or custodian is allowed no discretion but must follow strictly the terms of the agreement as it concerns the other two parties.

ESCUDO, the monetary unit of Portugal. Prior to the revolution, the monetary unit was the milreis, equivalent nominally to 108 cents, but as Portugal has never adopted the full gold standard, the milreis fluctuated widely in value.

The result of the revolution was to change the name of the unit from "milreis" to "escudo," and during and since the World War, it has lost most of its value. In 1920 it was worth 10.49 cents, and by 1924 it had fallen to 2.8 cents. By the end of 1927 it had improved to about five cents in value.

Notes of the Portuguese Bank are in circulation. In 1913, 87,000,000 escudos were outstanding, but by the end of 1926 the volume had risen to 1,836 millions. Against these the bank held reserves in gold and "foreign assets" amounting to 58 millions of escudos. These are presumably valued at the par of exchange of 108 cents, and if they were revalued at the rate then current of five cents, they would stand at 1,250 millions. In reality, therefore, the note issue has ample backing, but a revaluation of the escudo is dependent upon the maintenance of stable financial and political conditions.

ESCUINTLA, a city of Guatemala, Central America, 47m. W. of Guatemala City on the main line of the International railways of Central America. Pop. about 13,000. Escuintla is a commercial centre of some importance, as it lies at the western foot of the cordillera, and has tributary to it a considerable area of sugar, cacao and coffee country. Hot springs located near Escuintla are frequented during the season, from February to April.

ESCUTCHEON, a heraldic term for a shield with armorial bearings displayed (*see* HERALDRY). The word is also applied to the ornamented plates from the centre of which door-rings, knockers, etc., are suspended, or which protect the wood of the key-hole from the wear of the key.

ESENIN, SERGIUS (1895–1925), Russian poet, was born Oct. 4, 1895, in Constantinovo, since his death officially renamed Esenino, in the Ryazan province. A peasant by birth, he lived in his native village until he was 17 when he moved to Moscow. His first poems (1915) met with immediate success. In 1919 he founded the Imagist group. Esenin travelled in Persia and also visited America and France. He was married first to the American dancer, Isadora Duncan, from whom he soon parted, and secondly to a grand-daughter of Count Leo Tolstoy. He died by his own hand on Dec. 28, 1925. Although he was a staunch supporter of the Soviets, his meditative and purely lyrical talent was tragically out of touch with the matter-of-fact post-Revolutionary Russia.

Esenin has been considered the finest Russian poet of his generation and second only to Blok. His poetry reflects the mysticism of the old Russian peasantry with its ikons and its folklore, as in "Radunitza" (Day of the Dead), "Goluben" (Blueness); in "Inonia" he depicts a religious Utopia and proclaims the advent of a "peasant Christ." All his poems reflect the same love for peasant Russia, its fields, thatched cottages, its trees and animals. He called himself "the last peasant poet" and deplored the invasion of the land by the town—"the iron guest." His town and tavern poems ("Moscow of the Taverns," "The Confessions of a Hooligan," etc.) describing the evil victory of the town and its allurements, are of a tragic and captivating sincerity. His poetic style is highly imaginative and his simple, transparent verse follows the classic Pushkin tradition.

See English translations in *The Chapbook,* No. 31 (Nov. 1922) and *The Bermondsey Book* (March 1926); articles by Trotsky, *Pravda* No. 15 (1926) and Z. Vengerova, *The Bermondsey Book* (March 1926).

ESHER, REGINALD BALIOL BRETT, 2ND VISCOUNT (1852–), British politician and writer, eldest son of the 1st Viscount Esher, was born in London, June 30, 1852, and educated at Eton and Trinity college, Cambridge. He entered politics, becoming private secretary to the Marquess of Hartington in 1878, and from 1880 to 1885 was Liberal member for Penryn and Falmouth. From 1895 to 1902 he was secretary to the Office of Works. He succeeded his father in 1899 and in 1901 was appointed deputy constable and lieutenant-governor of Windsor Castle. In 1902 he was appointed one of the commissioners who enquired into the conduct of the South African War. In 1904 he was chairman of the War Office reconstitution committee, and in 1905 became a permanent member of the committee of imperial defence. He was chairman of the Territorial Force Association of the county of London 1909–13, and president, 1912–21. Lord Esher was selected by King Edward VII. as one of the editors of the *Letters of Queen Victoria,* which appeared in 1907, and he produced *The Girlhood of Queen Victoria* (1912). His other works include *The Influence of King Edward* (1915), *The Tragedy of Kitchener* (1921), *Ionicus* (1923) and *Cloud-capt Towers* (1927).

ESHER, WILLIAM BALIOL BRETT, 1ST VISCOUNT (1817–1899), English lawyer and master of the rolls, was born at Chelsea, London, on Aug. 13, 1817. He was educated at Westminster and at Caius college, Cambridge. Called to the bar in 1840, he went the northern circuit, and became a Q.C. in 1861. On the death of Richard Cobden he unsuccessfully contested Rochdale as a Conservative, but in 1866 was returned for Helston. Brett rapidly made his mark in the House, and in 1868 he was appointed solicitor-general. On behalf of the crown he prosecuted the Fenians charged with having caused the Clerkenwell explosion. In parliament he took a leading part in the promotion of bills connected with the administration of law and justice. He was (August 1868) appointed a justice in the court of common pleas. Some of his sentences in this capacity excited much criticism, notably so in the case of the gas stokers' strike, when he sentenced the defendants to imprisonment for twelve months, with hard labour, which was afterwards reduced by the home secretary to four months. On the reconstitution of the court of appeal in 1876, Brett was elevated to the rank of a lord justice. After holding this position for seven years, he succeeded Sir George Jessel as master of the rolls in 1883. In 1885 he was raised to the House of Lords as Baron Esher. The Solicitors Act of 1888, which increased the powers of the Incorporated Law Society, owed much to his influence. He retired from the bench at the close of 1897, and a viscounty was conferred upon him on his retirement. He died in London on May 24, 1899.

ESHER, a township in the Chertsey parliamentary division of Surrey, England, on the Portsmouth road, 14½ m. S.W. of London

on the Southern railway. It is pleasantly situated on rising ground above the river Mole, 3 m. from its junction with the Thames. Of the ancient mansion of Esher place, founded by William of Waynflete, bishop of Winchester (*c.* 1450), in which Cardinal Wolsey resided for some weeks in 1529, the gatehouse remains. The modern mansion was erected in 1803. To the south is Claremont, built by the great Lord Clive (1769) on the site of a mansion of Sir John Vanbrugh. In 1816 it was presented to Princess Charlotte, on her marriage to Prince Leopold, afterwards king of the Belgians. She died here in 1817, and on the death of her husband in 1865 the property reverted to the Crown. Louis Philippe, ex-king of the French, resided here from 1848 until his death in 1850, and later the duke of Albany. In 1882 Claremont became the private property of Queen Victoria. Christ Church, Esher, contains some interesting memorials. The township lies within the urban district of Esher and The Dittons, which includes the favourite riverside resort of Thames Ditton and the Sandown Park racecourse. The whole district is largely residential and the ancient commons, including Ditton Marsh and Littleworth, are of wide extent. Pop. of urban district (1921) 14,309.

ESKER, a name for long and often winding ridges of gravel and sand in regions of former glaciation, notably in Ireland, Sweden (where they are called åsar), and in the state of Maine, U.S.A. Their origin has given rise to much controversy, but they are generally considered to represent the material formerly filling the channels of streams under, within, or even upon the ice. This material is left behind as the ice melts. (*See* also GLACIAL PERIOD.) (R. H. RA.)

ESKILSTUNA, a town of Sweden in the district (*län*) of Södermanland on the Hjelmar river, which unites lakes Hjelmar and Mälar, 65 m. W. of Stockholm by rail. Pop. (1928), 30,622. It is mentioned in the 13th century, and is said to derive its name from Eskil, an English missionary martyred on the spot. It rose into importance in the reign of Charles X., who bestowed on it considerable privileges, and gave the first impulse to its manufacturing activity. It is the chief seat in Sweden of the iron and steel industries, its cutlery being especially noted, while damascened work is a specialty. There is a technical school for metal industries. There are, in the town or its neighbourhood, great engineering works.

ESKIMO LANGUAGE. This language is spoken with only a few varieties of dialect from Greenland along the arctic coasts of Canada to the Bering straits (Eskimo settlements on the Asiatic side) and along the southern coasts of Alaska, on the south coast near to Mt. Elias. On the Aleutian islands Eskimo influence is found. The Chukchee on the easternmost peninsula of Siberia are in touch with the Eskimo, and have some features in common. The Eskimo dialects have been regarded as akin to the Ural-Altaic family.

Phonetics. System of consonants of the central west Greenland dialects

	lip	point of tongue (blade)	back	uvula	
tenues (stops)	p	t	k	ᴋ	voiceless
fricatives (open)	ʋ	j l	g	ʀ	voiced
aspirates	ɸ	ꞅ s λ	χ	ꞅ	voiceless
nasals	m	n	ŋ	ɴ	voiced

The consonants have a four-fold division and an abundance of fricatives and uvulars, the latter articulated in the inmost parts of the mouth. Before a uvular consonant the vowels *e*, *o*, and *a* become *uvularized* (retracted towards the uvula), *e.g.*, in *er*ᴋ*e*ᴋ, a nit; *orsso*ᴋ, blubber; ᴋ*a*ᴋᴋ*a*ᴋ, hill. This gives the speech a guttural sound. Otherwise their speech is melodious and expressive. There is no system of pitch in the words to differentiate the meanings. The stress accent is dependent on the weight of the syllable. Since both consonants and vowels occur, now short, now long, and the meaning of the word is strictly dependent on these differences, the rhythm of speech is very irregular, somewhat like that of a drum, especially noticeable in recitation or lofty style.

In the early literary language the peculiar sounds and accents were incompletely reflected. The orthography was firstly coined by Hans Egede and his son Paul in their Greenland translations of the Bible and the linguistic pioneer works of Paul Egede (*Dictionarum*, 1750, *Grammatica Groenl.*, 1760). In modern Greenland orthography, reformed by the missionary Samuel Kleinschmidt (*Grammatik der grönländischen Sprache mit theilweisem Einschluss des Labrador Dialects*, Berlin, 1851), the four uvulars are rendered as ᴋ, r, rr, rng, and the aspirated fricatives as vf (gf), ss (gss), dl (tdl), gg, rr. g (*iga*, kettle) is pronounced as in North German *Regen*, gg as ch in *ich*, j always as y in *yes;* in North and East Greenland dialects g is replaced by ng (*iŋa*, kettle), and dl in East Greenl. by t.

The main Greenland dialects centre around Godthaab in West Greenland and Angmagssalik (pronounced Ammassalik) on the east coast. In the Central Eskimo dialects west of Davis strait the Greenl. s and ss (*issé*, eye; *isse*, frost) correspond to j and tj (Labrador *ijé; itje*), and west of Hudson Bay the Greenl. initial s (*siko*, ice) is replaced by h (*hiko*). The dialects of western Alaska differ fundamentally from those of Greenland.

Grammatical Structure.—The language is polysynthetic. The grammar is extremely rich in flexional forms, the conjugation of a common verb being served by about 350 suffixes, equivalent to personal pronouns and verb endings. For the declension of a noun there are 150 suffixes (for dual and plural, local cases, and possessive flexion). The demonstrative pronouns have a separate flexion. The derivative endings effective in the vocabulary and the construction of sentences or sentence-like words amount to at least 250. Notwithstanding all these constructive peculiarities, the grammatical and synthetic system is remarkably concise and, in its own way, logical.

The plural ending is *t* (or *it*), both in nouns and verbs. Besides, there is a dual in k. There is no article and no gender, nor any separate auxiliaries or copulas except such as are expressed by means of suffixes. The possessive relation is nearly always emphasized, if the nature of the noun involves possession. There is a large system of possessive suffixes in singular, dual, and plural, which take the place of possessive pronouns; and the same endings appear in part also in the flexion of the verb.

Possessive suffixes of nouns recognizable in verb endings:

igdlu-a his hut (*igdlo*)	ᴋ*ajâ* his kayak
igdlu-ga my hut	ᴋ*aja-ra* my kayak
igdlo-rse your hut	ᴋ*aja-rse* your kayak
igdlo hut; *igdlut* huts	ᴋ*aja*ᴋ kayak

takuvâ (*-aa*) he saw it
takuva-ra I saw it
takuva-rse you saw it
*takuvo*ᴋ he sees (saw)

The possessive flexion embraces a double set of suffixes, transitive and intransitive, agreeing with the fact that the noun has two basal cases of function in the sentence, the Absolutive case ending in k, ᴋ, t, or a vowel, and the Relative in p, the latter also having the function of the genitive. The Absolutive is used if the noun is the subject of an intransitive verb (ᴋ*aja*ᴋ *tikipo*ᴋ, a kayak has arrived), or object of a transitive verb (*kajak takuvara*, I saw a kayak). The Relative has the function of the subject of a transitive verb, *e.g.*, *puissip* ᴋ*aja*ᴋ *takuvâ*, the seal (*puisse*) saw the kayak. There are separate series of possessive suffixes for each of these functions of the noun.

The verb has an indicative and interrogative and a great number of subordinate moods (contemporative participle; causal proposition, etc.). There are four degrees of conjugation and besides a special negative conjugation common to all verbs (*-ngila* does not, *e.g.*, *takûngilara*, I did not see him). The numeral system is quinary, based on 1 to 5, though with special terms of 6, 10, 11 and 16, and it amounts to 21. They count by

means of their fingers and toes, 20 being "a man brought to an end."

Mentality.—The vocabulary is rich in expressions referring to hunting life and animals, technical terms of weapons and utensils in all their details and uses, terms of all sorts of empiric notions, and terms referring to the mind and senses, *e.g.*, special word stems meaning to die from thirst, hunger, cold or longing. A peculiar category of basal stems expresses incapability, *e.g.*, stems meaning not to know, not to be able to, to have no proof, not to regard, etc., whereas the corresponding stems to know, prove, regard, do not exist. "I know" is expressed by "I do not ignore," even "to be good" has no positive stem, but is produced by negation of being bad or evil (*ajorpoK*, is bad—*ajúngilaK*, is good). They have words for stones of many kinds, iron, copper, but none for metal; for the various colours, but not for colour; for numbers, but none for number; for Eskimo (*inuk*, in plur. *inuit*) and for some few neighbouring peoples in Canada, but none for man (humanity).

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ESKIMOS. The name Eskimo is said to have come from Indian neighbours to the south, and to signify people who eat their food raw. This name seizes upon one of the striking cultural differences between the Eskimos and at least the most northerly Athabascans of Canada. The Slaveys and Dog-Ribs, for instance, were horrified even at seeing white men eating their ordinary underdone roasts; they would naturally be still more revolted with the Eskimo habit of eating not only underdone meats but also completely raw flesh on occasion.

According to the view of the greater number of leading anthropologists, the Eskimos are merely one kind of North American Indian, both in blood and language. A few authorities state that they are lighter in complexion than most other Indians, but the majority opinion holds them to be average North American natives in eyes, complexion and hair. In head-form different groups range between average cephalic indices of 74 and 82. In stature they are not a particularly small people, the men averaging 1,647 mm. in east Greenland, 1,648 mm. around Coronation Gulf, 1,689 mm. at the Mackenzie mouth, and 1,682 mm. on the Noatak River in western Alaska. In the districts of southwest Greenland and Labrador there is so much white blood that neither the original stature of the people nor any other physical characteristic can be determined.

It seems likely that some two thousand years ago, or less, the ancestors of the present Eskimos were forest dwellers north of Lake Superior. Then, apparently, they moved north till they struck the Canadian Arctic coast somewhere between Coronation Gulf and Boothia Peninsula, splitting there into two main streams, one flowing northeast across the islands and then southeast into Greenland, the other west along the north coast of America and around the west and south coasts of Alaska as far as Prince William Sound. A few hundred, apparently in fairly recent times, crossed over to Siberia and occupied the immediate corner around and a little beyond East Cape. The Labrador Eskimos crossed Belle Isle straits and penetrated some distance south into Newfoundland, but it is not clear whether these were forays or permanent settlements.

About half the Canadian arctic islands are either occupied now by Eskimos or visited by them occasionally. Other islands, such as Melville, were occupied some centuries ago, perhaps only for a short period. Prince Patrick Island has not yet been so fully explored that we know whether it ever was occupied, and the same is true of the Ringnes Islands. But Brock, Borden, Lougheed and Meighen Islands were sufficiently examined by the Stefansson Expedition of 1913–18 to make it seem probable that they were never occupied and perhaps never even visited by Eskimos, whether in ancient or modern times.

In 1928 the total Eskimo population was estimated at 30,000. Of this number about half have more or less white blood. Out of nearly 15,000 Eskimos in Greenland, perhaps 10,000 come under this head, and some are practically white. The like is true of southern Labrador, where people classified as Eskimos speak no language but English. There has also been some blood mixture on the west coast of Hudson Bay and in Baffin Island; but from King William Island west to and including Victoria Island there has been no European intermarriage in historic times, and it is one of the disputed questions whether the so-called "Blond" Eskimos of Coronation Gulf and southwest Victoria Island have European blood (in that case derived from the Norse colony which occupied Greenland in the Middle Ages), or whether the few "blond" individuals in this district are pure North American Indians who came by their lighter complexions "naturally." There is an uninhabited stretch of about 200 miles from Coronation Gulf to Cape Bathurst. Thence westward slight recent admixture with Europeans begins, and increases along the south-west Alaskan coast and south to the limit of Eskimo occupation.

ESKIMO FATHER COUNTING TO HIS SON ON HIS FINGERS, FINGER AND TOE ENUMERATION BEING THE ONLY METHOD OF COUNTING KNOWN TO ESKIMOS. THE FIGURE 20 MEANS "A MAN COUNTED TO THE END"

It is difficult to estimate what the population may have been before the white man came. Contagious diseases, introduced by Europeans, notably measles, have wrought great havoc among the Canadian and Alaskan Eskimos. In certain western districts a single epidemic about a quarter of a century ago is known to have killed from 25% to 75% in different places. Judging from Richardson's account, there must have been more than a thousand Eskimos in the Mackenzie delta in 1848, and perhaps twice that number. But in 1906 Stefansson found these represented by less than thirty descendants. Fully half of that reduction appeared to be accounted for by two epidemics within the memory of people who were still living in 1906, and the preceding reduction was doubtless due to epidemics then forgotten, perhaps one or more of the smallpox plagues that have swept aboriginal Canada. Similar reductions in numbers seem likely for all sections except Greenland. Even there epidemics doubtless took toll formerly, but a strict quarantine maintained by the Danes has enabled the population to increase considerably during the last half century. Perhaps 100,000 may be a reasonable minimum estimate for Eskimo numbers before white contact began to injure as well as benefit the natives.

It seems probable that the various epidemics have now killed off most of the susceptibles (except between King William and Victoria islands), leaving only the immunes and the descendants of immunes, so that the Eskimo population generally is probably now at about its lowest numerical ebb. It seems likely, therefore, from all accounts, that the Eskimos are destined to disappear not by actually dying out but by merging into the white population, with whom they readily intermarry. A strong social prejudice against such marriages is found only in large towns, like Nome, Alaska. In places where the Eskimos markedly outnumber the whites there is no such prejudice.

A description of the living habits of the Eskimos at once brief and clear is impossible, for they live under many environments, both natural and social. In southwest Greenland, for instance, they have been in touch with Europeans for nine hundred years. But on the south shore of Dolphin and Union Straits and elsewhere they had never seen Europeans, either so far as we or they know, until the Second Stefansson Expedition in 1910, and there were even small numbers farther east and south who had never met Europeans until the Rasmussen Expedition in 1923. These

same Eskimos had naturally never seen a book, or words either written or printed; but the Eskimos of south-west Greenland have been publishing every year since 1861 an annual in their own language, edited and printed by themselves, exclusively from Eskimo contributors, both writers and artists. Some Eskimos in Greenland live more than 600 miles north of the arctic circle, but others in Labrador live more than 600 miles south of the circle. Many Eskimos have never seen a tree but others visit forested country either occasionally or frequently, and some live perpetually or temporarily in or near a forest. In Hudson Bay they have had the current firearms of Europe in every decade since before the American Revolution, but in Coronation Gulf all of them were still hunting with bows and copper-tipped or stone-tipped arrows in 1910. Some have lived for decades almost entirely on food which they buy with wages, others buy no food even now and live exclusively by hunting or fishing. Some Eskimos depend mainly on seal, some eat that meat rarely, and a few have never tasted it. Whales, even bowhead running towards 80 feet in length, were captured in some districts of Alaska and Canada as far east as Coronation Gulf, and again around Baffin island and other eastern districts. In most other parts the larger whales were not captured, and consequently not eaten, except when they happened to drift ashore dead. The smaller whales, such as the beluga, were more widely hunted. The walrus is important food in certain easterly and westerly districts, but not in the central section from Point Barrow to Hudson Bay. Some Eskimos live mainly by caribou hunting and others have never seen a caribou; some live mainly by fishing while others rarely taste fish.

Even such common statements as "Eskimos live in snow houses" are, in that simple form, more entertaining than instructive, for over half the Eskimos in the world have never seen a snow house, and only about one-quarter are in the habit of using them as the common dwellings of winter. Snow houses are wholly absent from Alaska. In the Mackenzie delta they were used only in emergencies. From there eastward to the Atlantic, however, they are the usual winter dwelling except in parts of Labrador. Of nearly 15,000 Eskimos in Greenland to-day, less than 500 have ever seen a snow house. The only Greenlandic snow-house users are the small group around Cape York, and even they more commonly dwell in houses of earth raftered with slabs of stone or with the bones of large animals.

The Eskimos speak one language from easternmost Greenland to farthest Alaska as do also a few hundred people in Siberia on the other side of Bering Straits. It is of the type called polysynthetic. In order to get along reasonably well an Eskimo must have at the tip of his tongue a vocabulary of more than 10,000 words, much larger than the active vocabulary of an average business man who speaks English. Moreover these Eskimo words are far more highly inflected than those of any of the well-known European languages, for a single noun can be spoken or written in several hundred different forms, each having a precise meaning different from that of any other. The forms of the verbs are even more numerous. The Eskimo language is, therefore, one of the most difficult in the world to learn, with the result that almost no traders or explorers have even tried to learn it. Consequently there has grown up, in intercourse between Eskimos and whites, a jargon similar to the pidgin English used in China, with a vocabulary of from 300 to 600 uninflected words, most of them derived from Eskimo but some derived from English, Danish, Spanish, Hawaiian and other languages. It is this jargon which is usually referred to by travellers as "the Eskimo language." (*See* ESKIMO LANGUAGE.)

Roughly speaking, the Eskimos are, in social organization, communistic anarchists, with the modification that usually raw materials are common property but made articles are privately owned. In the Mackenzie district, for instance (before European influence became strong), a pile of fish caught by a man belonged to him only in a modified sense. Large animals were divided among the people present at the kill, but smaller animals would be taken home by the one who caught them. However, when these were cut up the hunter's wife would either give pieces of raw meat to all who wanted them, or only to families that had none of their own. In some cases she would send away no meat but would shout an invitation to all within hearing to come and share the meal after she had cooked it. Really personal articles, such as a woman's sewing gear, could be sold by her without asking her husband's consent, although she usually asked his advice. He could similarly sell his private hunting gear, but seldom did so without previous discussion with his wife. A thing of recognized common property, such as a dog, could never be sold "legally" except by both man and wife. If it did happen that a husband sold a dog without consulting his wife, the community thought it reprehensible. A house belonged to the family that built it as long as they occupied it, and, if they wanted to retain ownership when they moved away, they could do so, but only for a short time by leaving a substantial part of their property behind. This was seldom done, however, for when a man moved away he usually intended to be gone at least a year and in that case was perfectly willing that anyone else should move in. The first comer did move in, and if by some accident the builder's family returned they would no more think of ousting the new occupant than we would think of driving away a camper who had pitched his tent on public land where our tent had stood the week before.

A statement about the Eskimo religion can scarcely be brief and clear without being misleading. It is not far wrong, however, to say that the idea of worship as Christians understand it is rudimentary or absent. In the Mackenzie district, for instance, Stefansson found no trace of any idea like that of a god or a goddess, although it has been found by Boas, Rasmussen and others farther east, possibly because it is 900 years since the Greenland Eskimos first came in contact with the Christian Norse colony. There have been several centuries of Christian contact, too, around Davis Straits and Hudson Bay, whereas the same contact is less than a century old at the Mackenzie mouth, and really less than half that, so far as effective cultural relations are concerned.

Judging from the Mackenzie view, the Eskimos formerly thought of every stick and stone as well as every cloud and beast and bird as having a life or a soul. To their mind nothing in Nature ever happens; it is always done by or through some spirit. These are not worshipped, or influenced by anything like prayer, but are controlled by charms and magic formulae. A spirit, according to that view, is neither good nor bad, but merely does the good or evil bidding of him who controls it. This controller is always some human being, most likely a shaman; but it may be anyone who has a charm or knows a magic formula.

Like more highly civilized people, the Eskimos are, of course, confused in their religious thinking. Different answers and confused answers come from the most thoughtful and best-informed members of the same community. As a general rule the Mackenzie Eskimos do not think that bad weather or a famine is caused by any spirit acting for itself, though it may be caused by a spirit acting for a shaman. But they agree that famines sometimes come without the intervention of a malevolent human being. As nearly as we can express it, they seem to think that these famines come automatically as the result of the breaking of some tabu—not that this breaking offends any spirit but merely that the famine just comes when a tabu has been broken. Such a famine or other unfavourable condition can be changed by discovering who has broken a tabu and getting that person to confess. This confession need not be accompanied by any penitence or effort at restitution. Just as the mere breaking of a tabu brings on trouble so does the mere confession stop it.

There is an almost infinite variety of tabus among the Eskimos. Every act of human life can be subject to tabu. Still the most numerous and complicated are the ones which relate to food. In northern Alaska, for instance, the number of tabus applying to mountain sheep alone is no doubt much greater than the entire number of tabus mentioned in the Bible as applying in one way or another to every variety of food and drink used by the Jews.

Public opinion is the only controlling influence over those Eskimos who have been little influenced by other North American Indians or by whites. The force of this public opinion is to us incomprehensibly strong. It appears unthinkable to an ordinary

Eskimo to go against it. There are no chiefs, soldiers, police or prisons, and there are practically only two punishments; the disapproval of the community, and death. When an individual becomes intolerable there are informal discussions about him that go on for months and perhaps for years. There is such secrecy about these that it is seldom that even a man's own mother tells him about it. In case of eventual unanimity, the theoretically right thing is that the obnoxious person shall be killed by his nearest of kin. This is to prevent blood feud, for the highest duty of revenge lies upon the nearest relative. If the nearest acts as executioner, there is no one to take revenge upon.

In cases where a man is killed before the community arrives at unanimity of opinion there is usually a blood feud. Such feuds end usually by the family that is for the moment one ahead in the retaliation game suddenly moving bag and baggage to a distant community. Even so, there have been instances of revivals of feuds after as much as twenty years. An exceptional making-up of all blood feuds occurred in the Mackenzie district following the dreadful measles epidemic of 1900 which destroyed most of the community. The survivors agreed that now they were so few they must bury all differences along with their dead.

Monogamy is the common relation of the Eskimos, but polygamy and polyandry are either of them socially permissible, and both occur. In the Mackenzie district a second wife is usually taken by a man on the suggestion of the first wife who points out either that her health is not good enough or that the family and household are now too large for her to manage without assistance. The husband, however, selects the second wife. She nevertheless usually gets along very well with the chief wife, being in some measure a form of favoured servant.

There are no other servants in an Eskimo household, excepting that anyone who chooses to adhere to the family and who is admitted into it naturally does his or her share of the work. Voluntary adherents who are blind, crippled or ill, are taken in as readily as those who are well (at least that is the theory) and are expected to do no work, or only what their infirmity permits. The head of a family is proud of the number of voluntary adherents that gather to him, for it is a sign that he is looked upon as a resourceful man and a good provider. He is even more proud of the dependents who cannot work, for their number shows that he has a superabundance of resources, since he can care for them. The leading man of the Mackenzie community in 1906, for instance, had a family of twenty-seven, nineteen of whom were voluntary adherents, three of these helpless. This man was called a chief by the white traders, but neither he nor anyone else in that community had any such powers as chiefship implies. He had a great deal of influence but no authority.

While yet unchanged by civilization, the Eskimos seem to have been everywhere the healthiest and happiest people in the world. Disagreeing on many things, most travellers have agreed on this, especially regarding their happiness. By the common testimony of observers, they laugh as much in a month as ordinary civilized people do in a year, and they have all the other signs of contentment and well-being. There has been no agreement in explaining this, however. Some think it is a racial trait, some believe it to be due to the stimulating climate or to the outdoor life, and some think it is caused by the stimulating nature of the food. In certain Eskimo districts, such as western Alaska, vegetables were eaten to a considerable extent even before white men appeared, but there are many districts, such as Coronation Gulf, where nothing but flesh food is eaten even to-day. It required about twenty years at the mouth of the Mackenzie, from the time whaling ships began to winter there, before the Eskimos could be induced to eat any considerable proportion of white man's food, even where it was urged upon them. It will probably be twenty years (from 1910, when the first trader came there) before any considerable amount of vegetables begins to be eaten in Coronation Gulf.

The Eskimos are themselves well satisfied with their flesh foods and their clothes of hide and fur. They are equally satisfied with their country and climate. No "primitive" people is so difficult to induce to visit foreign lands, or so uniformly eager to get back after a season spent away. They are commonly looked upon by the world as an unfortunate people, but seem congenitally unable to grasp that point of view themselves.

Bibliography.—For Greenland: *See* the works of H. Rink, K. Rasmussen and W. Thalbitzer, and many articles in the great Danish annual *Meddelelser om Groenland* (some of these in English, or in Danish with French summaries). For Baffin island: *See* the writings of Franz Boas in the *Bulletin* of the American Museum of Natural History and his *The Central Eskimo,* Bureau of American Ethnology (1888). For Labrador: L. M. Turner, *Ethnology of the Ungava District,* Bureau of American Ethnology (1894); E. W. Hawkes, "The Labrador Eskimo," *Memoir 91* of the Geological Survey of Canada (1916). For the mainland and islands from Hudson Bay to Coronation Gulf: K. Rasmussen, *Across Arctic America* (1927), a greatly abridged translation from the Danish; *see* also the various reports of Rasmussen's Fifth Thule Expedition. For the Copper Eskimos (mainland and islands around Coronation Gulf): V. Stefansson, *My Life With the Eskimo* (1913), *Anthropological Papers of the American Museum of Natural History* (1914), *The Friendly Arctic* (1921). D. Jenness, *The Life of the Copper Eskimos* and several articles in *Report of the Canadian Arctic Expedition of 1913–18* (Ottawa, 1922 *seq.*); K. Rasmussen, *op. cit.* For Mackenzie river: V. Stefansson, *op. cit.* and *Hunters of the Great North* (1922). For northern Alaska: J. Murdoch, *Ethnological Results of the Point Barrow Expedition,* Bureau of American Ethnology (1892); V. Stefansson, *op. cit.* North-western Alaska: E. W. Nelson, *The Eskimo About Bering Strait,* Bureau of American Ethnology (1899). (V. S.)

ESKI-SHEHR, a town of Asia Minor, the capital of the vilayet of the same name. It is a station on the Haidar Pasha-Angora railway, 194½ m. from the former and 164 m. from Angora, and the junction for Konia; and is situated on the right bank of the Pursak Su (*Tembris*), a tributary of the Sakaria. Pop. (1927) 81,556. Eski-Shehr, *i.e.*, "the old town," lies about a mile from the ruins of the ancient Phyrgian Dorylaeum. The latter is mentioned in connection with the wars of Lysimachus and Antigonus (about 302 B.C.), and frequently figures in Byzantine history as an imperial residence and military rendezvous. It was the scene of the defeat of the Turks under Kilij-Arslan by the crusaders in 1097, and fell finally to the Turks of Konia in 1176. The town is divided by a small stream into a commercial quarter on low ground, in which are the bazaars, khans and the hot sulphur springs (122° F) which are mentioned as early as the 3rd century by Athenaeus; and a residential quarter on the higher ground. The town is noted for its good climate, the Pursak Su for the abundance of its fish. About 18 m. to the E. are extensive deposits of meerschaum.

ESMARCH, JOHANNES FRIEDRICH AUGUST VON (1823–1908), German surgeon, was born at Tönning, in Schleswig-Holstein, on Jan. 9, 1823, and died at Kiel on Feb. 23, 1908. He studied at Kiel and Göttingen, and in 1846 became B. R. K. von Langenbeck's assistant at the Kiel surgical hospital and in 1857 head of the general hospital and professor at the university. His attention had been directed to the subject of military surgery in the Schleswig-Holstein wars of 1848 and 1864, in which he had served in the field hospitals, and when the Franco-German War broke out in 1870 he was appointed surgeon-general to the army, and afterwards consulting surgeon at the great military hospital near Berlin. Esmarch was one of the greatest authorities on hospital management and military surgery. His *Handbuch der kriegschirurgischen Technik* (1877) is illustrated by admirable diagrams, showing the different methods of bandaging and dressing, as well as the surgical operations as they occur on the battlefield. Esmarch himself invented an apparatus, which bears his name, for keeping a limb nearly bloodless during amputation. No part of Esmarch's work is more widely known than that which deals with "First Aid," his *First Aid on the Battlefield* and *First Aid to the Injured* being popular manuals on the subject.

See H. Rohlfs, *Geschichte der deutschen Medizin* (Leipzig, 1885, vol. iv.).

ESMERALDAN, an independent linguistic stock of South American Indians, whose name is derived from the province of Esmeraldas in Ecuador. The Esmeraldan tribes occupied the coast region extending from the Bahia de Caraques northward to the mouth of the Esmeraldas river. They are now practically extinct. According to the early accounts these tribes artificially deformed the head. The men wore a short poncho-like shirt to the waist, the women an apron. Nose, ears and lips were pierced and gold, emerald and turquoise ornaments were worn in them.

The teeth were also inlaid with gold. The Esmeraldan tribes were sedentary, agricultural folk, raising also considerable cotton, which they wove into excellent cloth. Pottery was made, and they used both dug-out canoes and log rafts in coastwise trade. Their houses had reed walls, thatched roofs, and were grouped in large villages. They had special religious structures, in which were images. Child sacrifice was in use, the bodies being afterward flayed, the skin stuffed with straw and set up in their temples. The archaeological remains in this area, of which brief preliminary reports only have been made, suggest strongly an early cultural association of some sort with Central America.

See M. H. Saville, *Antiquities of Manabi* (Contributions to South American Archaeology, vols. I., II., Mus. Amer. Indian, New York City) R. Vernau and P. Rivet *Ethnographie ancienne de l'Equateur* (1912).

ESNA, a town of Upper Egypt on the west bank of the Nile, 484 m. S.S.E. of Cairo by rail, the railway station being on the opposite side of the river. Pop. 16,000, mostly Copts. Esna, one of the healthiest towns in Egypt, is noted for its manufactures of pottery and its large grain and live stock markets. There is considerable traffic with the oasis of Kharga, which lies almost due west of the town. Nearly in the centre of the town is the Ptolemaic and Roman temple of the ram-headed Khnūm, almost buried in rubbish and houses. The interior of the pronaos contains the latest known hieroglyphic inscription, dating from the reign of Decius (A.D. 249–251). In the neighbourhood are remains of Coptic buildings, including a subterranean church in the desert half a mile beyond the limits of cultivation. The name Esna is from the Coptic *Sne*. By the Greeks the place was called Latopolis, from the worship here of the latus fish. In the persecutions under Diocletian A.D. 303, the Christians of Esna, a numerous body, suffered severely.

ESOTERIC, having an inner or secret meaning. This term, and its correlative "exoteric," were first applied in the ancient Greek mysteries to those who were initiated (ἔσω, within) and to those who were not (ἔξω, outside), respectively. It was then transferred to a supposed distinction drawn by certain philosophers between the teaching given to the whole circle of their pupils and that containing a higher and secret philosophy which was reserved for a select number of specially advanced or privileged disciples. This distinction was ascribed by Lucian (*Vit. Auct.* 26) to Aristotle (*q.v.*), who, however, uses ἐξωτερικοὶ λόγοι (*Nic. Ethics*) merely of "popular treatises." It was probably adopted by the Pythagoreans and was also attributed to Plato. In the sense of mystic it is used of a secret doctrine of theosophy, supposed to have been traditional among certain disciples of Buddhism.

ESPAGNOLS SUR MER, LES, the name given to the naval victory of King Edward III. of England on Aug. 29, 1350, over a Spanish fleet commanded by Don Carlos de la Cerda, a Castilian freebooter, who had recently captured several English ships and murdered their crews. The English fleet assembled at Winchelsea early in August, King Edward commanding in chief in the cog. "Thomas"; the prince of Wales, Henry earl of Lancaster, Lord Scrope of Bolton and other members of the court also commanded ships. Their object was to cut off de la Cerda on his return from Sluys, where he had gone to collect merchandise. On the afternoon of Aug. 29 he appeared, running down the Channel with the north-east wind, with about 40 sail in all. Edward commanded about 50 ships, but they were inferior in build and size to the Spaniards who could fling missiles on them from their upper-works and tops. In addition, de la Cerda carried a strong force of Spanish cross-bowmen and Flemish mercenaries. He could easily have avoided action, as the English were close inshore when first sighted, but he had no wish to do so, and steered straight for them as they ran out from Winchelsea. King Edward's "Thomas" was severely injured on colliding with the first enemy, but he was able to grapple another and board and capture her just as the "Thomas" was about to sink.

The Spanish fire was very galling and did great damage, the prince of Wales being hard pressed till relieved by Henry of Lancaster, when the prince also boarded a Spaniard as his own ship was sinking. The ship carrying the king's household, commanded by Robert de Namur, was grappled by an enemy which began to tow her away. She would undoubtedly have been captured had not Hannekin, a squire of the commander's, boarded the Spaniard and cut her halliards and several shrouds and stays with his sword, thus bringing down her mainsail, so that she was brought to a standstill and captured instead. By night time the English had had the best of the action, the number of ships they captured varying in different accounts from 14 to 26. They suffered heavily, however, in casualties and had at least two ships sunk.

See Sir N. H. Nicolas, *A History of the British Navy* (1847).

ESPALIER, a lattice-work or row of stalks, originally shoulder high, on which fruit trees, shrubs and flowers, particularly roses and creepers, are trained. Espaliers are usually made of larch or other wood, iron and metal rails being too great conductors of heat and cold. The advantage of this method of training is that the fruit, etc., is more easily got at, and while protected from wind is freely exposed to sun and air, and not so open to extreme changes of temperature as when trained on a wall. (*See* HORTICULTURE.)

ESPARTERO, BALDOMERO (1792–1879), duke of Vitoria, duke of Morella, prince of Vergara, Count Luchana, knight of the Toison d'Or, etc., Spanish soldier and statesman, was born at Granatulu, a town of the province of Ciudad Real, on Feb. 27, 1792. He was the son of a carter, who wanted to make him a priest, but the lad at 15 enlisted in a battalion of students to fight against the armies of Napoleon I. In 1815 he went to America as a captain under General Morillo, who had been made commander-in-chief to quell the risings of the colonies on the Spanish Main. For eight years Espartero distinguished himself in the struggle against the colonists. He was several times wounded, and was made major and colonel on the battlefields of Cochabamba and Sapachni. He had to surrender to Sucre at the final battle of Ayacucho, which put an end to Castilian rule. He returned to Spain, and, like most of his companions in arms, remained under a cloud for some time.

Espartero became in 1832, on the death of King Ferdinand VII., one of the most ardent defenders of the rights of the daughter, Isabella II. The Government sent him to the front, directly the Carlist War broke out, as commandant of the province of Biscay, where he severely defeated the Carlists in many encounters. At times he showed qualities as a *guerrillero* quite equal to those of the Carlists, like Zumalacarregui and Cabrera, by his daring marches and surprises. Twice he obliged the Carlists to raise the siege of Bilbao before he was appointed commander-in-chief of the northern army on Sept. 17, 1836, when the tide of war seemed to be setting in favour of the pretender in the Basque provinces and Navarre, though Don Carlos had lost his ablest lieutenant, the Basque Zumalacarregui. In Nov. 1836 he again forced the Carlists to raise the siege of Bilbao. His troops included the British legion under Sir de Lacy Evans. This success turned the tide of war against Don Carlos, who vainly attempted a raid towards Madrid. Espartero was soon at his heels, and obliged him to hurry northwards, after several defeats. In 1839 Espartero carefully opened up negotiations with Maroto and the principal Carlist chiefs of the Basque provinces. These ended in their accepting his terms under the famous convention of Vergara. Espartero was styled "El pacificador de España," was made a grandee of the first class, and received two dukedoms.

During the last three years of the war Espartero, who had been elected a deputy, exercised from his distant headquarters such influence over Madrid politics that he twice hastened the fall of the cabinet, and obtained office for his own friends. At the close of the war the queen regent and her ministers attempted to elbow out Espartero and his followers, but a *pronunciamiento* ensued in Madrid and other large towns made the marshal prime minister. He soon became virtually a dictator, as Queen Christina resigned and left the kingdom very soon afterwards. The Cortes elected Espartero regent by 179 votes to 103 in favour of Arguelles, who was appointed guardian of the young queen. For two years Espartero ruled Spain in accordance with his Radical

and conciliatory dispositions, giving special attention to the reorganization of the administration, taxation and finances, declaring all the estates of the church, congregations and religious orders to be national property, and suppressing the *diezma*, or tenths. He suppressed the Republican risings with as much severity as he did the military *pronunciamientos* of Generals Concha and Diego de Leon. The latter was shot in Madrid.

Espartero crushed with much energy a revolutionary rising in Barcelona, but on his return to Madrid was so coldly welcomed that he perceived that his prestige was on the wane. The advanced Progressists coalesced with the partisans of the ex-regent Christina to promote *pronunciamientos* in Barcelona and many cities. The rebels declared Queen Isabel of age, and, led by General Narvaez, marched upon Madrid. Espartero embarked at Cadiz on July 30, 1843, for England, and lived quietly apart from politics until 1848, when a royal decree restored to him all his honours and his seat in the senate. He retired to his house in Logroño, which he left six years later, in 1854, when called upon by the queen to take the lead of the powerful Liberal and Progressist movement which prevailed for two years. The old marshal vainly endeavoured to keep his own Progressists within bounds in the Cortes of 1854–56, and in the great towns, but their excessive demands for reforms and liberties played into the hands of a clerical and reactionary court and of the equally retrograde governing classes. The growing ambition of General O'Donnell constantly clashed with the views of Espartero, until the latter, in sheer disgust, resigned his premiership and left for Logroño. O'Donnell's *pronunciamiento* in 1856 put an end to the Cortes, and the militia was disarmed, after a sharp struggle in the streets of the capital.

After 1856 Espartero resolutely declined to identify himself with active politics, and steadily refused office. King Amadeus made him prince of Vergara. The Restoration raised a statue to him near the gate of the Retiro Park in Madrid. Spaniards of all shades, except Carlists and Ultramontanes, paid homage to his memory when he died at his Logroño residence on Jan. 8, 1879. His tastes were singularly modest, his manners rather reserved, but always kind and considerate for humble folk. He was a typical Spanish soldier-politician, though he had more of the better traits of the soldier than of the arts of the statesman. His military instincts did not always make it easy for him to accommodate himself to courtiers and professional politicians.

See Florez, E., *Historia de su vida militar y politica* (1844–45); Mariano, *La Regencia de D. Baldomero Espartero* (1870); Pirala, A., *Historia de la guerra civil, con la regencia de Espartero* (1889).

ESPARTO or **SPANISH GRASS** (*Stipa tenacissima*), a grass resembling the ornamental feather-grass of gardens. It is indigenous to south Spain and north Africa (where it is known as Halfa or Alfa), and is especially abundant in the sterile and rugged parts of Murcia and Valencia, and in Algeria, flourishing best in sandy, ferruginous soils, in dry, sunny situations on the sea coast. It attains a height of 3 or 4 feet. The stems are cylindrical, and clothed with short hair, and grow in clusters of from 2 to 10ft. in circumference; when young they serve as food for cattle, but after a few years acquire great toughness. The leaves vary from 6in. to 3ft. in length, and are grey-green in colour; on account of their tenacity of fibre and flexibility they have for centuries been employed for making ropes, sandals, baskets, mats and other articles. Ships' cables of esparto, being light, float on water, and have long been in use in the Spanish navy.

Esparto leaves contain 56% by weight of fibre, or about 10% more than straw, and hence have come into requisition for the manufacture of paper. For this purpose they were first utilized by the French, and in 1857 were introduced into Great Britain. For paper-making the leaves should be gathered before they are quite matured; if, however, they are obtained too young, they furnish a paper having a semi-transparent appearance. The leaves are gathered by hand, and from 2 to 3cwt. may be collected in a day by a single labourer. They are generally obtained during the dry summer months, as at other times their adherence to the stems is so firm as often to cause the uprooting of the plants in the attempt to remove them. Esparto may be raised from seed, but cannot be harvested for twelve or fifteen years after sowing.

Another grass, *Lygeum Spartum*, with stiff rush-like leaves, growing in rocky soil on the high plains of the Mediterranean countries, especially Spain and Algeria, is also a source of esparto.

For the processes of the paper manufacturer esparto is used dry, and without cutting; roots and flowers and stray weeds are removed, and the material is then boiled with caustic soda, washed and bleached.

ESPERANCE, a small seaport on a natural harbour (Esperance Bay) on the south coast of W. Australia, 275 m. N.E. from Albany. Some importance attaches to it because of the large areas of wheat lands which are being opened up in the hinterland. The railway from Esperance to Salmon Gums is being extended to Norseman and Esperance will then tap the Norseman-Kalgoorlie gold-field area also.

ESPERANTO: *see* UNIVERSAL LANGUAGE.

ESPINEL, VICENTE MARTÍNEZ (1551–1624), Spanish poet and novelist. Expelled from the University of Salamanca in 1572, he served as a soldier in Flanders, returning to Spain in 1584 or thereabouts. He took orders in 1587, and four years later became chaplain at Ronda, absented himself from his living, and was deprived of his cure; but his musical skill obtained for him the post of choirmaster at Plasencia. His *Diversas Rimas* (1591) are undeniably good examples of technical accomplishment and caustic wit. Espinel, however, survives as the author of a clever picaresque novel entitled *Relaciones de la vida del Escudero Marcos de Obregón* (1618), from which Le Sage has not scrupled to borrow many of the incidents and characters in *Gil Blas*. Espinel also revived the *décima* known as *espinela*, a stanza of ten octosyllabic lines.

ESPIONAGE. The word "espionage" and its equivalents in most European languages are derived from a Germanic root which appears in the word *spähen*. The essential feature of espionage is its clandestine character. Espionage as practised between States may, therefore, be defined as "the attempt to obtain by clandestine means, for communication to a foreign government, information concerning another government which is likely to be injurious to that government."

The clandestine character of espionage lays it open to objection from the moral point of view; and espionage is, in fact, often practised by persons of undesirable character. As Montesquieu says, "Spying might perhaps be tolerable if it were done by men of honour; but the infamy which inevitably attaches to the agent is a criterion of the infamy of the practice." Individuals have taken the view that by practising espionage they were performing a necessary service to their own country. More generally, however, spies are recruited from among persons of doubtful character who are ready to undertake anything in order to earn money rapidly. The dangerous nature of the work has, moreover, a certain attraction for the adventurous.

Private Espionage.—Where the object is to obtain information on the conduct of an individual, or the progress of a business transaction, information may be obtained through conversation in ordinary social intercourse. Technical matters are dealt with by "information agencies" or private detectives. Private espionage also has recourse to even baser methods, such as the utilization of gossip collected from neighbours or from the doorkeepers of blocks of flats. In countries under an autocratic government, such as tsarist or Bolshevik Russia, and Fascist Italy, the political police authorities can obtain considerable assistance from doorkeepers; and the latter can, in periods of crisis, give important aid to the authorities (*e.g.*, at the time of the Commune of 1871).

Internal Political Espionage.—All governments employ spies, informers and secret agents, to keep them informed of the activities, views and relations of their opponents, or in some cases simply to acquaint them with the state of public opinion. The *sbirri* employed by the Venetian Republic are closely paralleled by the secret police of the French Revolution, the Holy Alliance and the tsarist régime. Agents of this kind penetrated into all strata of society, gained the confidence of conspirators, sometimes acted as *agents-provocateurs*, and sent in reports which varied in value according to the intelligence and character of the agent. They were, and still are, of considerable assistance to their gov-

ernments, so long, at any rate, as different departments do not each employ their own agents who work against one another, as happened in France under the First Empire. "Secret funds" are generally created for the organization of this kind of espionage and for the payment of secret agents. The funds are usually at the disposal of the heads of the government departments responsible for home affairs, foreign affairs, and the army and navy. In most modern countries their administration is not controlled by parliament.

In prisons and convict settlements the authorities employ spies known as "stool-pigeons" to discover plots for escape, to obtain confessions from prisoners, and in general to assist in ensuring punishment for all offences. The ex-convict Vidocq, when he became head of the Paris Sûreté in 1832, specialized in the employment of prison spies.

In political espionage, the spy very frequently acts as *agent-provocateur,* particularly during periods of crisis such as civil wars, revolutions and religious persecutions. Skilful use of espionage was made in England by Burleigh and Walsingham in Elizabeth's reign, and in France under Louis XIII. and Louis XV., by the Lieutenants of Police d'Argenson, Berryer and Sartines. Louvois set spies to watch over the conduct of his officers—a practice which has often recurred.

Fouché, who was minister of police from 1799 to 1802 and from 1804 to 1810, may be regarded as the real creator of political espionage, which he used to foil the numerous plots concocted by Jacobins, royalists, *émigrés* and *Chouans* during the Consulate and the Empire. In Russia, the famous Okhrana, or defensive police, was founded in 1881 to combat terrorism. It has been proved that Azeff, who was a member of the Central Committee of the People's Party, Pope Gapone, who played an important part in the revolution of 1905, and Malinowski, one of the deputies in the Duma, were all agents of the Okhrana. The Okhrana was responsible for the assassination of the Grand Duke Sergius, and of the ministers Plehve and Stolypin. Its activities reached their height in the period 1906–17. The famous Cheka, or "extraordinary commission for the repression of the counter-revolution and of speculation," continued the methods of the Okhrana and applied them to the opponents of the Bolsheviks. Since 1925 the Cheka has been replaced by the G.P.U.

Political espionage is sometimes practised in the international sphere. The Holy Alliance covered Europe with a network of spies. It had informers, *agent-provocateurs* and spies among the various groups of political *émigrés* in Paris and London. Heinrich Heine, Mürger, Princess Lieven and the Countess Kalergis are stated to have sent information to the Cabinets of Vienna and St. Petersburg (Leningrad). Similarly, international espionage has been used to combat the activities of anarchists.

Diplomatic Espionage in Peace-time.—The duties of diplomatic agents in peace-time include, not only the carrying out of negotiations and the protection of nationals of their country resident abroad, but also observation of what goes on in the countries to which they are sent. They are required to obtain accurate information on current events and on all matters which, directly or indirectly, affect the interests of the country they represent, even if such matters would normally appear to fall outside their sphere of action.

Modern diplomacy originated in the Italian cities of the middle ages; and the early Italian ambassadors, particularly the Venetians, were exceedingly able spies. Modern ambassadors have a technical staff of military, naval, aeronautical, commercial and legal attachés, whose duty it is to collect accurate information on various branches of national activity in foreign countries. It is thus possible to say that "an ambassador is often nothing more than an honourable spy acting under the protection of the law of nations."

So long as a diplomatic agent maintains a correct attitude, and does not use unfair means such as bribing officials, or stealing documents, his activities are quite distinct from those which come under the definition of espionage. It has, however, often happened that diplomatic agents, such as ambassadors, consuls and attachés have failed to observe a correct attitude. Two examples will suffice. In 1811, Col. Czernicheff, Russian attaché in Paris, with the complicity of an employee of the ministry of war, named Michel, obtained access to certain documents and figures. He was suspected and watched, but made his escape. Michel was shot. The second instance is the incident of the German and Italian military attachés in the Dreyfus affair. (*See* DREYFUS and ANTI-SEMITISM.)

Military Espionage or Espionage Proper.—Military espionage differs to some extent in the methods which it employs, according to whether a state of war or of peace prevails. In modern times it is, therefore, usual to set up two central departments to organize the collection of information and to supervise the agents employed; a police department (such as the Okhrana, the *Sûreté Générale,* etc.) and a military department (Intelligence Service, *Bureau d'Etat Major,* etc.). The two, of course, maintain the necessary liaison with one another. It may happen at certain times, as in France after the Dreyfus affair, that the functions of the military intelligence department are, to some extent, handed over to the police authorities. On the other hand it is inevitable that in time of war the military department which acts in liaison with the police authorities should be predominant.

Acts of espionage are recorded in the Bible and by classical authors such as Xenophon and Caesar. Organized espionage did not however exist until the 17th century under Cromwell in England and Richelieu in France. Richelieu had a complete system of espionage, the head of which was Père Joseph, *l'éminence grise.* It was mainly diplomatic in character; military espionage was until much later left in the hands of the military authorities. Frederick the Great made great use of spies. It was he who said "Marshal de Soubise is always followed by a hundred cooks; I am always preceded by a hundred spies." Napoleon's spy service was as efficient as his police service. In peace time the marshals who were in command of the forces stationed near the frontiers employed spies paid out of the secret funds. In war time the spy service was placed under the control of Gen. Savary. One of his most famous agents was Schülmeister, who played an important part in the campaign of 1805. He acted for both sides, conveying information both to Mack and to Savary. By supplying false intelligence, he fostered the irresolution and inertia of the Austrian general, who finally capitulated at Ulm.

In Germany the development of the espionage system dates from the middle of the 19th century. The secret police of the kingdom of Prussia was made into an independent, modern and specialized organization with a chief of its own, and had to keep watch over the internal and external safety of the country. Under the direction of Stieber the German espionage organization prepared the way for the campaigns which preceded the establishment of German unity: the Bohemian campaign of 1866 and the Franco-Prussian war of 1870–71. Stieber himself, disguised in various ways, visited Bohemia and facilitated the triumphal march of the Prussian forces to Sadowa. The preparations for the French campaign were made on a still more extensive and systematic scale. It was estimated that there were about 30,000 German spies in France in 1870. There was a complete system of local agents, travelling supervisors and regional commissioners. When the army was mobilized, Stieber was appointed head of the military intelligence. His duties included keeping watch over the army headquarters and over the personal safety of important personages, the supervision of correspondence, and above all the collection of information on the movements and strength of the enemy forces, and the state of public opinion and the available resources in the districts through which the German army passed. Zerniki, Stieber's lieutenant, made the preparations for the king of Prussia's entry into Versailles, and organized a system of espionage in that town. It has been proved that what took place in Paris during the siege was accurately known to the German staff; references to this state of affairs may be found in Alphonse Daudet's *Contes du Lundi.*

The Japanese made equally careful preparations for their campaign in Manchuria in 1904–05. Thus, although the Japanese army was relatively ill provided with cavalry, it was always well informed of the movements of the Russians, while its own changes

of position were masked by a screen of Chinese spies who were accepted by the Russians as inhabitants of the country.

Germany took as careful precautions for the World War of 1914–18 as for that of 1870. Espionage was facilitated by the large number of German nationals who were settled in foreign countries, and by the wide extension of German trade. The eastern departments of France in particular were riddled with German agents—agricultural workers, domestic servants, hairdressers, commercial travellers, German teachers, etc., many of whom gave themselves out as Belgians, Swiss or Luxembourgeois. The number of espionage and treason cases tried during the war shows how widespread was the German espionage system. The most famous trial was that of the woman spy Mata-Hari, a native of the Dutch East Indies, who was shot at Vincennes. The Governments of various countries found it necessary to put up posters in public places drawing attention to the necessity of discretion in conversation. "Be silent, be on your guard, enemy ears are listening" said the French posters. A part somewhat similar to that of the military intelligence departments was played by the inhabitants in the occupied areas, who endeavoured to help their own government and embarrass the armies of occupation. A number of French, Belgian and British of both sexes paid with their lives for acts of patriotic espionage. Two conspicuous instances are Nurse Cavell, who was shot by the Germans for having assisted escaped allied prisoners and helped them to make their way to neutral countries, and Louise de Bettignies, a Frenchwoman who was sentenced on similar grounds and died in prison.

Neutral countries, particularly those adjoining the belligerent countries, were important centres of espionage: witness Italy up to 1915, Greece, the Netherlands, the United States and Argentina. Nor did espionage end with the war, and there are many facts to prove that it still goes on, even between countries which are in close alliance with each other.

Methods of espionage vary with the object in view. Two things have to be done: information has to be obtained, and it then has to be communicated to the authority which requires it. In obtaining information, spies either act for themselves or bribe other persons who have access to the information which they require. In this, money and women's wiles both play an important part, as is shown by all the spy trials which have taken place at various times. In communicating the information received, when this cannot be done by word of mouth, all possible means are used, from ciphers and codes to the various signals employed in war time. In this matter great inventiveness has been shown by spies, their employers, and counter-espionage agents.

Many methods are employed to combat espionage. They may be classified as follows:

(1) Violent reactions of public opinion. The crowd suddenly turns on the spy or suspected spy, and there is a spontaneous outbreak of lynching. Incidents of this kind often occur during times of war or revolution, and spy-mania leads to terrible scenes of brutality and to gross miscarriages of justice.

(2) Technical protection in the form of counter-espionage. This exists in private as well as in diplomatic and military espionage. Its object is to discover and foil the ruses of the other side, and to neutralize its successes. The military and police departments responsible for espionage also carry out counter-espionage, and it sometimes happens that the same agents are employed for both purposes, and are thus in the pay of both sides.

(3) Diplomatic action to combat diplomatic espionage. A government which discovers that the diplomatic agents of a foreign Power have been guilty of incorrect behaviour towards it can demand their recall, although the agents in question are protected by diplomatic immunity. This may result in the breaking off of diplomatic relations, as occurred in Great Britain as a result of the activities of the agents of Soviet Russia which led to the police raid on Arcos ltd. in 1927.

(4) Penal measures against military espionage. The authorities responsible for action of this kind and also the severity of the penalties differ according as the countries concerned may be at peace or at war. Even in peace time heavy penalties of fine and imprisonment are imposed for espionage. Cases are tried by the ordinary courts, in camera if necessary. In war time, spies are court-martialled; and death becomes the normal penalty. Attempts have been made at several international conferences to arrive at uniform rules for the repression of espionage, *e.g.*, the Brussels Conference of 1874, and the Hague Conference which adopted the Convention of 1907. These conferences defined the distinctive character of espionage as residing in its clandestine nature, settled questions relating to guides, aeronauts, and the inhabitants of districts occupied by an invader, and dealt with the trial of spies. Unfortunately, not all countries have accepted the rules laid down, or have observed them in time of war.

(5) It may be hoped that the League of Nations may render mutual espionage less and less necessary since, with a view to preparing the way for a future limitation of armaments, it has undertaken the publication of extremely detailed annual statistics of the military and naval strength of the various states which are members of the league.

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ESPIRITO SANTO, a maritime State of Brazil, bounded north by Bahia, east by the Atlantic ocean, south by Rio de Janeiro, and west by Minas Geraes. Pop. (1920) 457,328. Area, 17,248 sq.m. With the exception of Sergipe it is the smallest of the Brazilian States. The western border of the State is traversed by low ranges of mountains forming a northward continuation of the Serra do Mar. The eastern part of the State belongs to the coastal plain, in great part low and swampy, with large areas of sand barrens, and broken by isolated groups and ranges of hills. With the exception of these sandy plains the country is heavily forested, even the mountain sides being covered with vegetation to their summits. The northern and southern parts are fertile, but the central districts generally are comparatively poor. The inland valleys and slopes are very fertile and heavily forested, and much of the Brazilian export of rosewood and other cabinet woods is drawn from this State. There is only one good bay on the coast, that of Espirito Santo, on which the port of Victoria is situated. The river-mouths are obstructed by sand bars and admit small vessels only. The principal rivers of the State are the Mucury, which rises in Minas Geraes and forms the boundary line with Bahia, the Itaunas, São Domingos, São Matheus, Doce, Timbuhy, Santa Maria, Jucú, Benevente, Itapemirim, and Itabapoana, the last forming the boundary line with Rio de Janeiro. The Doce, São Matheus, and Itapemirim rise in Minas Geraes and flow entirely across the State. The lower courses of these rivers are generally navigable, that of the Rio Doce for a distance of 90 miles. The climate of the coastal zone and deeper valleys is hot, humid and unhealthy, malarial fevers being prevalent. In the higher country the temperature is lower and the climate is healthy. Espirito Santo is almost exclusively agricultural, sugar-cane, coffee, rice, cotton, tobacco, mandioca and tropical fruits being the principal products. Agriculture is in a very backward condition, however, and the State is classed as one of the poorest and most unprogressive in the republic. The rivers and shallow coast waters are well stocked with fish, but there are no fishing industries worthy of mention. There are three railway lines in operation in the State—one running from Victoria to Cachoeira do Itapemirim (50 m.), and thence inland to Manhuassu and Carangola, another line, reaching Santo Eduardo in Rio de Janeiro (58 m.), where connection is made with the Leopoldina system running into the national capital, and a third railway running north-westerly from Victoria to Diamantina, Minas Geraes, about 450 miles. The chief cities and towns of the State, with their populations in 1920, are Victoria (municipality, 21,866); São Matheus (municipality, 14,497), on a river of the same name 16 m. from the sea; Serra (municipality, 6,777); Guarapary (municipality), a small port

(10,904); south by west of the capital; Conceicão da Barra (municipality, 5,514); the port of São Matheus (12,000); and Cachoeira do Itapemirim (46,102), an important commercial centre in the south.

Espirito Santo formed part of one of the original captaincies which were given to Vasco Fernandes Coutinho by the Portuguese Crown. The first settlement (1535) was at the entrance to the bay of Espirito Santo, and its name was afterwards given to the bay and captaincy. It once included the municipality of Campos, now belonging to the State of Rio de Janeiro.

The islands of Trinidad and Martim Vaz, which lie about 715 m. E. of Victoria, belong politically to this State. They are uninhabited, but considerable importance is attached to the island of Trinidad because Great Britain has twice attempted to take possession of it. It rises 1,200 ft. above sea-level and is about 6 m. in circumference, but it has no value other than that of an ocean cable station. An excellent description of this singular island is to be found in E. F. Knight, *Cruise of the "Alerte"* (1895).

ESPOZ Y MINA, FRANCISCO (1781–1836), Spanish guerrillero leader and general, born at Ydozin, Navarre, June 17, 1781. He enlisted in Doyle's regiment in 1808, passed to the guerrilla band commanded by his nephew Xavier Mina, was made commander of the guerrilleros of Navarre (April 1, 1810), and commander-in-chief in Upper Aragon and on the left bank of the Ebro (Sept. 7, 1812). A successful strategist and excellent organizer, he compelled the French authorities to allow him to levy customs dues on all goods imported into Spain, except contraband of war, which he would not allow to pass without fighting. With the money thus obtained he paid a regular salary to his bands whom he had brought to a respectable state of efficiency in 1812. Espoz y Mina served with distinction under the duke of Wellington (1813–14). After the restoration of Ferdinand he fell into disfavour; involved in the Liberal Party plot at Pamplona (Sept. 25–26), he went into exile, and at the revolution of 1820 served the Liberal Party in Galicia, Leon and Catalonia. In 1823 he fled to England, took part in an unsuccessful rising against Ferdinand in 1830; recalled to Spain under the regent Christina, he was given the command against the Carlists in 1835. He resigned in April of the same year for reasons of health; his later command in Catalonia was only memorable for the part he took in forcing the regent to grant a constitution (Aug. 1836). He died at Barcelona on Dec. 24, 1836.

See F. Espoz y Mina, *Memorias* (Madrid, 1851–52); *A Short Extract from the Life of General Mina* (Eng. and Span. text, London, 1825).

ESPRONCEDA, JOSÉ DE (1808–1842), Spanish poet, was born at or near Almendralejo de los Barros. In his 14th year he joined a secret society and, sentenced to five years' seclusion in the Franciscan convent at Guadalajara, began an epic poem entitled *El Pelayo.* He escaped to Portugal and thence to England, where he found the famous Teresa whom he had met at Lisbon. In 1830 he eloped with her to Paris, took part in the July revolution, and soon after joined the raid of Chapalangarra on Navarre. In 1833, at the amnesty, he obtained a commission in the queen's guards; but this he soon forfeited by a political song. Banished to Cuéllar, he wrote a poor novel entitled *Sancho Saldaña ó el Castellano de Cuéllar* (1834). He took an active part in the revolutionary risings of 1835 and 1836; in 1840 he was appointed secretary of legation at The Hague; and in 1842 he was elected deputy for Almería; but death cut short his parliamentary career. His poems (1840) at once gained for him a reputation which still continues undiminished. The influence of Byron pervades Espronceda's life and work. It is present in an ambitious variant on the Don Juan legend, *El Estudiante de Salamanca,* Elvira's letter being obviously modelled on Julia's letter in *Don Juan;* the *Canción del Pirata* is suggested by *The Corsair;* and the Byronic inspiration is not wanting even in the noble fragment entitled *El Diablo Mundo,* based on the story of Faust. But in *El Mendigo,* in *El Reo de Muerte,* in *El Verdugo,* and in the sombre vehement lines, *A Jarifa en una orgía,* Espronceda proves himself one of the most potent and original lyrical poets produced by Spain during the 19th century.

See E. Rodríguez Solís, *Espronceda; su tiempo, su vida, y sus obras* (1883); J. Cascales Muñoz, *D. José de Espronceda* (1914).

ESQUIMAULT. A naval and military station situated on the south of Vancouver island, British Columbia, and connected by an electric railway to Victoria and Nanaimo. It has an excellent harbour, navy yard, meteorological station and barracks for naval and military purposes, all of which have been handed over to the Canadian Government by the British Admiralty. A large salmon cannery and a ship-yard provide the principal industrial interest. Pop. 5,100.

ESQUIRE, originally the attendant on a knight, whose helm, shield and lance he carried at the tournament or on the field of battle. The esquire ranked immediately below the knight bachelor, and his office was regarded as the apprentice stage of knighthood. The title was regarded as one of function, not of birth, and was not hereditary. In time, however, its original significance was lost sight of, and it came to be a title of honour, implying a rank between that of knight and valet or gentleman, as it technically still remains. Thus in the later middle ages esquire (*armiger*) was the customary description of holders of knight's fees who had not taken up their knighthood, whence the surviving custom of entitling the principal landowner in a parish "the squire" (*see* SQUIRE). Camden, at the close of the 16th century, distinguished four classes entitled to bear the style: (1) The eldest sons of knights, and their eldest sons, in perpetual succession; (2) the eldest sons of the younger sons of peers, and their eldest sons, in like perpetual succession; (3) esquires created by royal letters patent or other investiture, and their eldest sons; (4) esquires by office; *e.g.,* justices of the peace and others who bear any office of trust under the Crown. To these the writer in the 3rd edition of the *Encyclopædia Britannica* (1797) added Irish peers and the eldest sons of British peers, who, though they bear courtesy titles, have in law only the right to be styled esquires. Officers of the king's courts, and of the royal household, counsellors at law and justices of the peace he described as esquires only "by reputation"; and justices of the peace have the title only as long as they are in commission; while certain heads of great landed families are styled "esquires" by prescription.

It is clear, however, that the title of esquire was very loosely used at a much earlier date. On this point Selden is somewhat scornfully explicit. "To whomsoever, either by blood, place in the State or other eminency, we conceive some higher attribute should be given, than that sole Title of Gentleman, knowing yet that he hath no other honorary title legally fixed upon him, we usually style him an *Esquire,* in such passages as require legally that his degree or state be mentioned; as especially in Indictments and Actions whereupon he may be outlawed. Those of other nations who are Barons or great Lords in their own Countries, and no knights, are in legal proceedings stiled with us, Esquires only. Some of our greatest Heralds have their divisions of Esquires applied to this day. I leave them as I see them, where they may easily be found." Coke, too, says that every one is entitled to be termed esquire who has the legal right to call himself a gentleman (2. *Institutes,* 688).

At the present time the following classes are recognized as esquires on occasions of ceremony or for legal purposes: (1) All sons of peers and lords of parliament during their fathers' lives, and the younger sons of such peers, etc., after their fathers' deaths; the eldest sons of peers' younger sons, and their eldest sons for ever. (2) Noblemen of all other nations. (3) The eldest sons of baronets and knights. (4) Persons bearing arms and the title of esquire by letters patent. (5) Esquires of the Bath and their eldest sons. (6) Barristers-at-law. (7) Justices of the peace and mayors while in commission or office. (8) The holders of any superior office under the Crown. (9) Persons styled esquires by the sovereign in their patents, commissions or appointments. (10) Attorneys in colonies where the functions of counsel and attorney are united (in England solicitors are "gentlemen," not "esquires").

In practice, however, the title of esquire, now to all intents and purposes meaningless, is given to any one who "can bear the port, charge and countenance of a gentleman." The word has followed the same course as that of "gentleman" (*q.v.*), and for very simi-

lar reasons. It is still not customary in Great Britain to address, *e.g.*, a well-to-do person engaged in trade as esquire at his shop; it would be offensive not to do so at his private residence. In America, on the other hand, the use of the word "esquire" is practically obsolete, "Mr." ("Mister" or "Master," at one time the title special to a "gentleman") being the general form of address.

See Selden, *Titles of Honor* (1672); Camden, *Britannia* (ed. 1594); Coke, *Institutes; Enc. of the Laws of England, s.v.* "Esquire"; Du Cange, *Glossarium, s.v.* "Scutarius," "Scutifer" and "Armiger" (ed. 1886). (W. A. P.)

ESQUIROL, JEAN ÉTIENNE DOMINIQUE (1772–1840), French alienist, was born at Toulouse on Feb. 3, 1772. In 1794 he became a pupil at the military hospital of Narbonne, and subsequently studied in Paris at the Salpêtrière under P. Pinel, whose assistant he became. In 1811 he was chosen physician to the Salpêtrière, and in 1817 he began a course of lectures on the treatment of the insane, which led to the appointment of a commission to inquire into the subject. The asylums of Rouen, Nantes and Montpellier were built in accordance with his plans. In 1823 he became inspector-general of the university of Paris for the faculties of medicine and in 1826 chief physician of the asylum at Charenton. He died in Paris on Dec. 13, 1840. Esquirol's principal work is *Des maladies mentales, considérées sous les rapports médicaux, hygiéniques, et médico-légaux* (1838), which provides the first rational, scientific treatment of the subject. He first sketched out the main forms of insanity, and was the founder of a great school of French alienists who developed the work he had begun. See INSANITY.

ESQUIROS, HENRI FRANÇOIS ALPHONSE (1812–1876), French writer, born in Paris on May 23, 1812, was fined and imprisoned for his *L'Évangile du peuple* (1840). He was elected in 1850 as a Social Democrat to the legislative assembly, but was exiled in 1851 for his opposition to the Empire. Returning to France in 1869 he was again a member of the legislative assembly, and in 1876 was elected to the senate. He died at Versailles on May 12, 1876. Among his numerous works on social subjects may be noted: *Histoire des Montagnards* (2 vols., 1847); *Paris, ou les sciences, les institutions et les moeurs au XIX^e siècle* (2 vols., 1847), and *Histoire des martyrs de la liberté* (1851).

ESS, JOHANN HEINRICH VAN (1772–1847), German Catholic theologian, was born at Warburg, Westphalia, on Feb. 15, 1772. He became a Benedictine, and served as a priest at Schwalenberg from 1799 to 1812, after which, until 1822, he was professor of theology and joint-director of the teachers' seminary at Marburg. He died at Affolderbach in the Odenwald on Oct. 13, 1847.

His publications include a German trans. of the New Testament (1807); *Auszüge aus den heiligen Vätern u. anderen Lehrern der kath. Kirke über das nothwendige u. nützliche Bibellesen* (1808); *Gedanken über Bibel u. Bibellehre* (1816); *Was war die Bibel den ersten Christen* (1816); a German trans. of the Old Testament (1822–36); an edition of the Vulgate (1822–24) and of the Septuagint (1824).

ESSAD (*c.* 1875–1920), Turkish pasha and Albanian leader, sprang from the rich Albanian family of the Toptani, and was born at Elbasan. He entered the political service of the Sultan 'Abdul Hamid, and when the Turkish Revolution broke out joined the new movement and was deputy for Albania in the first Turkish Parliament. His influence over the somewhat uncertain Albanian population, and the desire of the Constantinople Government not to have so exceedingly cunning and skilful a man for their enemy, led to his being given, in 1912, the high command at Scutari, then under siege by the Montenegrins, though he knew almost nothing of military matters. But the town commandant Hasan Riza was the soul of the defence of Scutari; and, in order to have a free hand for his own secret dealings with the Montenegrins, Essad had him assassinated on Jan. 13, 1913. On April 25 Essad took the lead in the unreal and theatrical ceremony of handing over the fortress to Montenegro, but when the princedom of Albania was constituted after the Balkan War, Essad became Minister of War and also Minister of the Interior to William of Wied, and brought his policy into close touch with that of Italy. During the World War he was president of the Albanian delegation in Paris, but appeared at frequent intervals at Salonika and on the Albanian front as a guerrilla leader. He succeeded in bringing about the overthrow, by a so-called National Assembly in Cusonio, of the "Provisional Government of Durazzo," which was under Italian influence, and this National Assembly purposed to proclaim Essad King of Albania. But on June 13, 1920, he was killed in front of the Hotel Continental in Paris by Aveni Rustam, an Albanian.

ESSARTAGE: *see* AGRICULTURE, PRIMITIVE.

ESSAY, ESSAYIST. As a form of literature, the essay is a composition of moderate length, usually in prose, which deals in an easy, cursory way with a subject, and, in strictness, with that subject only as it affects the writer. Dr. Johnson, himself an eminent essayist, defines an essay as "an irregular, undigested piece"; the irregularity may perhaps be admitted, but want of thought, that is to say, lack of proper mental digestion, is clearly not characteristic of a fine example. It should, on the contrary, always be the brief and light result of experience and profound meditation, while "undigested" is the last epithet to be applied to the essays of Montaigne, Addison or Lamb. Bacon said that the Epistles of Seneca were "essays," but this can hardly be allowed. Bacon himself goes on to admit that "the word is late, though the thing is ancient." The word, in fact, was invented for this species of writing by Montaigne, who merely meant that these were experiments in a new kind of literature. This original meaning, namely that these pieces were attempts or endeavours, feeling their way towards the expression of what would need a far wider space to exhaust, was lost in England in the course of the 18th century.

Montaigne, in inventing the essay, had probably little suspicion of the far-reaching importance of what he had created. In his dejected moments, he turned to rail at what he had written, and to call his essays "inepties" and "sottises." But in his own heart he must have been perfectly aware that he had devised a new thing; that he had invented a way of communicating himself to the world as a type of human nature. It is not often that we can date with any approach to accuracy the arrival of a new class of literature into the world, but it was in the month of March 1571 that the essay was invented. Montaigne (*q.v.*) wrote slowly, not systematically; it took nine years to finish the two first books of the essays. The earliest imprint saw the light in 1580, at Bordeaux, and the Paris edition of 1588, which is the fifth, contains the final text of the great author. These dates are not negligible in the briefest history of the essay, for they are those of its revelation to the world of readers. It was in the delightful chapters of his new, strange book that Montaigne introduced the fashion of writing briefly, irregularly, with constant digressions and interruptions, about the world as it appears to the individual who writes.

It has always been admitted that Montaigne's genius has an affinity with the English. He was early read in England, and certainly by Bacon, whose is the second great name connected with this form of literature. It was in 1597, only five years after the death of Montaigne, that Bacon published in a small octavo the first ten of his essays. These he increased to 38 in 1612 and to 58 in 1625. It is possible that when he wrote them he was not yet familiar with the style of his predecessor, which was first made popular in England, in 1603, when Florio published his translation of the *Essais*. In the later editions Bacon greatly expanded his theme, but he never reached, or but seldom, the freedom and ease, the seeming formlessness held in by an invisible chain, which are the glory of Montaigne, and distinguish the typical essayist. It would seem that at first, in England, as in France, no lesser writer was willing to adopt a title which belonged to so great a presence as that of Bacon or Montaigne. The one exception was Sir William Cornwallis (d. 1631), who published essays in 1600 and 1617, of slight merit, but popular in their day. No other English essayist of any importance appeared until the Restoration, when Abraham Cowley wrote eleven "Several Discourses by way of Essays," which did not see the light until 1668. Cowley's essay "Of Myself" is a model of what these little compositions should be. The name of Bacon inspires awe, but it is really not he, but Cowley, who is the father of the English essay.

When we reach the 18th century, we find the essay suddenly be-

come a dominant force in English literature. It made its appearance almost as a new thing, and in combination with the earliest development of journalism. On April 12, 1700, appeared the first number of a penny newspaper, entitled the *Tatler*, a main feature of which was to amuse and instruct fashionable readers by a series of short papers dealing with the manifold occurrences of life. But it was not until Steele, the founder of the *Tatler*, was joined by Addison that the 18th century essay really started upon its course. It displayed at first, and indeed it long retained, a mixture of the manner of Montaigne with that of La Bruyère combining the form of the pure essay with that of the character study, as modelled on Theophrastus. Addison's early *Tatler* portraits, in particular such as those of "Tom Folio" and "Ned Softly," are hardly essays. But Steele's "Recollections of Childhood" is, and here we may observe the type on which Goldsmith, Lamb and R. L. Stevenson afterwards worked. In Jan. 1711, the *Tatler* came to an end, and was almost immediately followed by the *Spectator*, and in 1713 by the *Guardian*. Later in the century, after the publication of other less successful experiments, appeared Fielding's essays in the *Covent Garden Journal* (1752) and Johnson's in the *Rambler* (1750), the *Adventurer* (1752) and the *Idler* (1759). There followed a great number of polite journals, in which the essay was treated as "the bow of Ulysses in which it was the fashion for men of rank and genius to try their strength." Goldsmith reached a higher level than the Chesterfields and Bonnell Thorntons had dreamed of, in the delicious sections of his *Citizen of the World* (1760). After Goldsmith, the 18th century essay declined into tamer hands, and passed into final feebleness with the pedantic Richard Cumberland and the sentimental Henry Mackenzie. The *corpus* of 18th century essayists is extremely voluminous, and their reprinted works fill some 50 volumes.

A great revival of the essay took place during the first quarter of the 19th century, and foremost in the history of this movement must always be placed the name of Charles Lamb. He perceived that the real business of the essay, as Montaigne had conceived it, was to be largely personal. The *Essays of Elia* began to appear in the *London Magazine* for Aug., 1820, and proceeded at fairly regular intervals until Dec., 1822; early in 1823 the first series of them were collected in a volume. The peculiarity of Lamb's style as an essayist was that he threw off the Addisonian and still more the Johnsonian tradition, and boldly went back to the rich verbiage and brilliant imagery of the 17th century for his inspiration. He succeeded, moreover, in reaching a poignant note of personal feeling, such as none of his predecessors had ever aimed at; the essays called "Dream Children" and "Blakesmoor" are examples of this. Leigh Hunt, clearing away all the didactic and pompous elements which had overgrown the essay, restored it to its old *Spectator* grace, and was the most easy nondescript writer of his generation in periodicals such as the *Indicator* (1819) and the *Companion* (1828). The sermons, letters and pamphlets of Sydney Smith were really essays of an extended order. In Hazlitt and Francis Jeffrey we see the form and method of the essay beginning to be applied to literary criticism. The writings of De Quincey are almost exclusively essays. His biographical and critical essays are interesting, but they are far from being trustworthy models in form or substance. In a sketch, however rapid, of the essay in the 19th century, prominence must be given to the name of Macaulay. His earliest essay, that on Milton, appeared in the *Edinburgh Review* in 1825, very shortly after the revelation of Lamb's genius in "Elia." No two products cast in the same mould could, however, be more unlike in substance. In the hands of Macaulay the essay ceases to be a confession or an autobiography; it is strictly impersonal, it is literary, historical or controversial, vigorous, trenchant and full of party prejudice. The periodical publication of Macaulay's Essays in the *Edinburgh Review* went on until 1844.

In later times the essay in England has been cultivated both on the personal and on the impersonal model. The essays of R. L. Stevenson are of the same class as those of Montaigne and Lamb, and he approached far more closely than any of his contemporaries to their high level of excellence. In America in the meanwhile the essay had been written with genius by Thoreau in *Walden;* and Emerson's *Essays,* though not in the tradition of Montaigne and Lamb, were rich in lofty thought and utterance. The critical essay belongs, perhaps, to the sphere of criticism rather than of the essay, but a form so delightfully used by Matthew Arnold, Augustine Birrell and Edmund Gosse cannot be left unmentioned. Alice Meynell's *Essays* is perhaps the most beautiful book of essays ever written by a woman. During the 20th century the essay has been reborn as a playful kind of literature, and Max Beerbohm, Hilaire Belloc, G. K. Chesterton and E. V. Lucas are among those who have excelled in the art.

Although invented by a great French writer the essay was very late in making itself at home in France. The so-called *Essais* of Leibnitz, Nicole, Yves Marie André and so many others were really treatises. Voltaire's famous *Essai sur les moeurs des nations* is an elaborate historical disquisition in nearly 200 chapters. Later, the voluminous essays of Joseph de Maistre and of Lamennais were not essays at all in the literary sense. On the other hand, the admirable *Causeries du lundi* of Sainte-Beuve (1804–69) are literary essays in the fullness of the term, and have been the forerunners of much brilliant essay-writing in France. Among those who have specially distinguished themselves as French essayists may be mentioned Théophile Gautier, Paul de Saint-Victor, Anatole France, Jules Lemaître, Ferdinand Brunetière and Émile Faguet. All these are literary critics, and it is in the form of the analysis of manifestations of intellectual energy that the essay has been most successfully illustrated in France. All the countries of Europe, since the middle of the 19th century, have adopted this form of writing; such monographs or reviews, however, are not perfectly identical with the essay as it was conceived by Addison and Lamb. This last, it may be supposed, is a definitely English thing, and this view is confirmed by the fact that in several European languages the word "essayist" has been adopted.

See Hugh Walker, *The English Essay and Essayists* (1915); J. B. Priestley, *Essayists Past and Present* (1925).

ESSEN, a manufacturing town of Germany, in the Prussian Rhine province, 22 m. N.E. from Düsseldorf on the main line of railway to Berlin. Pop. (1925) 468,966. Essen was originally the seat of a Benedictine nunnery, and was formed into a town about the middle of the 10th century by the abbess Hedwig. The abbess of the nunnery governed the town until 1803, when it was secularized and incorporated with Prussia. In 1807 it came into the possession of the grand dukes of Berg, but was transferred to Prussia in 1814. In 1920 the Communists held, for a time, the factories, which were only retaken after heavy fighting. Occupied by the French after the Armistice, Essen was evacuated by them on Aug. 1, 1925.

Railways radiate from it to all the principal towns of the Westphalian iron and coal fields. The minster, dating from the 10th century, with fine pictures, relics and wall frescoes, is noteworthy and is very similar to the Pfalz-Kapelle (*capella in palatio*) at Aix-la-Chapelle. The town originally owed its prosperity to the large iron and coal fields underlying the basin in which it is situated. Chief among its industrial establishments are the famous iron and steel works of Krupp (*q.v.*), and the whole of Essen may be said to depend for its livelihood upon this firm, which now produces locomotives, agricultural machinery, etc., and was employing in 1925 some 35,000 workers. There are also manufactories of woollen goods and cigars, dyeworks and breweries.

ESSENES. (1) *Meaning.*—The Essenes, who included the Therapeutae and Hemerobaptists, were a body of pre-Christian Jews who lived a monastic life: whether they are to be regarded as a distinct sect is a matter of controversy. But there is general agreement that from the Maccabaean age and onward, if not earlier, there were individuals and brotherhoods known as Essenes and distinguished by characteristics such as the community of property, the practice of charity and the pursuit of virtue.

(2) *Sources.*—The sources of information about the Essenes are direct and indirect. To the former category belong Philo, Josephus and Pliny, who may be considered as of primary importance. Other writers of this category who speak of the Essenes as a whole, *e.g.*, Epiphanius, Hippolytus, Porphyry and Eusebius are secondary. The first-named seems to identify Essenes and Elkesaites, the accounts of the two next are based on Josephus

and the last cites Philo. Of the three none is entitled to the rank of an independent witness. Indirect information is occupied by the Rabbinical writings and the epithet indirect is employed because no connected account, such as is found in Philo, Josephus or Pliny occurs in Talmud or Midrash, but much valuable knowledge about individual Essenes is contained in these sources. Their purpose is not to provide a picture of a sect, favourable or unfavourable according to the predilections of the author. The mention of a given custom or a specific act is due to considerations of history or of *halakhah* (Canon Law): the circumstance that the actor or the followers of the custom may be identified as Essenes is a matter of modern interest but had little or no meaning to the authority by whom it happened to be recorded.

(3) *Names.*—Greek writers refer to the Essenes by names of which the most common are 'Εσσηνοί and 'Εσσαῖοι. The derivations are disputed. The English *Essene* comes, through the Latin, from 'Εσσηνοί. This form is unknown to Philo who invariably uses the alternative. Josephus uses both names, the former more frequently. Other writers who generally or exclusively prefer 'Εσσηνοί or *Esseni* are Solinus, Pliny, Synesius and Hippolytus, while Hegesippus and Porphyry favour 'Εσσαῖοι. Epiphanius has forms peculiar to himself; these are most probably corruptions or local variants. To what Hebrew or Aramaic equivalents may 'Εσσηνοί, 'Εσσαῖοι be referred? The problem is not easy to answer. Various solutions have been suggested but even after the Greek terms have been explained satisfactorily, there still remain the Rabbinic names, of a totally different style, which were applied to men who lived by a rule to all intent Essene and which must therefore be deemed to be as accurate designations of Essenes as those preserved in the Greek and Latin writings.

Philo equates 'Εσσαῖοι with ὅσιος: this is mere allegory and can hardly have been intended as etymology. The following derivations are suggested. From the Hebrew:—*Ḥashshā'im* (the silent ones): *'Asah* (he acted) and *'Anshē Ma'aseh* (men of action): *Ḥāzah* (he saw visions) and *Sāḥah* (he bathed). The first is the most probable: apart from other considerations no suitable adjectival forms exist from the verbs in the perfect tense given above. From the Aramaic:—*Ḥasē, Ḥāsen* with stat. emphat. *Ḥasāya* (pious), *'Asā* (he healed), 'Εσσηνοί may come from *Çenū'im* (chaste).

The Talmudic names are *Ḥaṣidim* (or *Zeqēnim*) *Ha-rishōnim* (the ancient Saints or elders); *Neqiyyē Had Da'ath* (the pure-minded); *Çenū'im* (the chaste); *Ḥashsha'im* (the silent ones); *Wattiqim* (men of exactitude): *Banna'im* (builders), etc.

(4) *Description.*—Philo (*Quod omnis probus liber*, secs. 12, 13), after describing the Persian Magi and the Indian Gymnosophists, reminds his readers that similar examples of virtuous people can be adduced from Judaism. He instances the Essenes, who lived in Palestine and Syria and who numbered about 4,000. He speaks again of the Essenes in his lost *Apology for the Jews*, which is preserved by Eusebius (*Prep. Evang.*, viii. 11). The Essenes were Communists: they supported themselves by manual labour (generally by agriculture, never by making weapons of war), the proceeds of which replenished the common fund. They were devoted to study, prayer, and acts of benevolence, especially towards the aged and sick. Some approved of conjugal intercourse under restricted conditions, *i.e.*, until children had been born; others abstained from marriage altogether. They recruited their ranks by adopting children who were young enough to imbibe their teaching or by accepting proselytes of a mature age who had reached a period when the allurements of the world would have lost their attraction. They condemned slavery in principle and practice: the younger ministered to the elder and the natural respect due to seniority and learning replaced the artificial claims of rank. They chose their rulers, maintained special codes, possessed their own secrets, traditionally preserved and imparted, in which angelology figured prominently. They had no single city of their own, however, but tended to congregate as a result of their mode of life and to concentrate in certain districts, notably on the western shore of the Dead sea. As a body they preferred the country to the city, yet we find individuals among them not infrequently taking part in political life. They despised pleasure and luxury, regarding anointing oil as particularly hateful and defiling. They wore simple white garments and did not own a change of clothes. They bathed in cold water, ate but a single dish and worked till sundown. They prayed before sunrise and at their meals grace was said by a priest. Their conduct was orderly and their conversation restrained.

In all their enterprises the leaders directed the procedure, and named the persons called upon to officiate; only in deeds of mercy and charity could the individual act independently. They objected to oaths, but an oath once taken was never capable of being annulled. Herein lay the chief disciplinary power of their officers, for since they observed strict purity in their food and refrained from eating anything which others had prepared, anyone excommunicated could soon be starved into obedience; cases of expulsion seem to have been almost unknown and instances of disobedience seem to have been rare. A novitiate of three years, divisible into two stages of increasing asceticism, was demanded of the postulant for admission. Josephus, who states that he underwent this probationary period but then resigned, must therefore be trusted in his accounts of the external life and tenets of the Essenes, but he cannot be regarded as having possessed an inner knowledge of their secrets, which the Essenes revealed only to those who joined their order. The oath exacted from the initiate, before he was allowed to share the common meal, is given by Josephus: "to be pious to the Deity, to practice justice towards men; never to injure anyone, either of his own accord or under compulsion: always to hate the wicked and side with the just: ever to show faithfulness to all mankind and to be true to those in authority, for all power comes from God: never when in office, to force his personal views or authority or to assume a special dress or luxury: to love truth and hate falsehood: to keep his hands pure of theft and his soul from unrighteous gain: not to have any secret from his brethren and never to betray one of theirs, even at the cost of his life: to pass on the traditions he himself had received: never to be a brigand: to safeguard the sacred books and to preserve with care the names of the angels that had been taught to him."

Sabbath observance was very strict: non-statutory sacrifices were avoided: in the society there were four grades, based on learning and seniority. They lived long, as a result of their simple habits and diet and neither bribery nor torture could make them false to their principles. Pliny (*Hist. Nat.* v. 17) describes the customs of the Essenes and terms them "a race by themselves, more remarkable than any other in the wide world." Philo, deeming one proof alone sufficient to establish his definition of the Essenes as "champions of virtue" says: "From time to time their country has been seized by many rulers . . . some more ferocious than wild beasts, surpassing every form of savagery, massacring hordes of their subjects, severing them limb from limb while alive. Yet none of these bloodthirsty tyrants has ever been able to lay a single charge at the door of an Essene." Josephus stresses the belief of the Essenes in the Resurrection and states that their doctrines were borrowed by the Pythagoreans and Stoics: he considers that the Essenes are the oldest of ascetics and that it was from Egypt that their doctrines spread abroad. He mentions also their addiction to prophecy and the foretelling of events.

(5) *History and Tenets.*—The chief problems concerning the Essenes are the following: Were they a distinct sect? what was their origin? how and why did they arise and disappear? The circumstance that the Essenes are known by a variety of designations, all of which are epithets describing their aims or beliefs, and none of which incorporates the name of a founder or the place where he lived, goes to prove that the Essenes were not a distinct, well-defined body to be segregated from the general mass of Jews. That they were a separate sect used to be the accepted view. It was held that foreign influences, Persian or Buddhist or Pythagorean or Syrian, were responsible for the Essenes and that their characteristic beliefs and practices were derived from some non-Jewish source. The four theories enumerated above had, each one, their distinguished advocates. The preponderating mass of Jewish material which forms the foundation of Essenism, must not be overlooked. The opposite view, that of Kohler, is, in the main, true: he regards the Essenes as "a branch of the Pharisees

who conformed to the most rigid rules of levitical purity while aspiring to the highest degree of holiness." Perhaps the extent to which non-Jewish thought is mirrored in Essenism is slightly greater than Kohler is disposed to concede, but Kohler is undoubtedly correct in his main thesis that the Essenes were essentially Jewish in origin, that they belonged to the Pharisees, and that they did not, on the whole, constitute a sect.

VARIETIES OF ESSENISM

That the term Essenism was a general one, and applicable to a variety of forms of belief is clear. Thus while the Essenes as a whole belonged to Palestine and Syria, the Therapeutae (θερα πευταί lit. "attendants" or "physicians": hence "worshippers of God") were to be found in Egypt, on the shores of Lake Mareotis, by Alexandria. Philo, who is the sole authority for their existence and who speaks of them in *De Vita Contemplativa*, distinguishes the contemplative Therapeutae from the remaining Essenes who lived a more practical life. Philo cannot account for the origin of the name Therapeutae and this circumstance tends to show the antiquity of these ascetics. The Alexandrian community lived in mean and scattered houses, near enough to afford mutual protection when necessary, but not too close to disturb the solitude which was so greatly prized. Each house contained a chamber called σεμνεῖον or μοναστήριον devoted to prayer and meditation (*cf.* Matt. vi. 6). During the week the Therapeutae lived apart and meditated in solitude, but on Sabbath they prayed and they ate in common. Their so-called feasts (where no flesh was served and only cold water was drunk) especially that held on the eve of Pentecost, were famous and formed a contrast to Greek revels. At these feasts the philosophical discourse was the chief feature. This was followed by hymns and by the *pervigilium*, celebrated with antiphonal and joint singing and with choral dancing in imitation of Moses and Miriam at the Red sea. In view of the habits of the Therapeutae, the existence of pre-Christian monasticism cannot be denied. Already in Philo's days the Therapeutae were considered to be ancient. Strabo, who was born in 63 B.C. and who visited Egypt before 25 B.C., speaks of buildings at Heliopolis which the priests had taken over from the former guilds of philosophers and scientists. He states that these learned men were consulted by Plato and Eudoxus but that the σύστημα and the ἄσκησις were extinct. Philo, describing the Therapeutae, makes use of these same technical terms. The Stoic philosopher Chaeremon, a contemporary of Strabo, records the σύστημα and ἄσκησις so that the line of continuity was not necessarily broken. Porphyry (*De Abstinentia*, iv. 6) preserves Chaeremon's account which resembles Philo's description of the Therapeutae, even including details such as their posture, gait and habit of eating hyssop with their bread. Incidentally it may be remarked that F. C. Conybeare has vindicated the genuineness of Philo's account against P. Lucius's endeavour to impugn its authenticity. Eusebius, struck by the resemblance of the Therapeutae to Christian monks, claimed them to be Christians converted by Mark. He was followed by various patristic writers and mainly on this account Lucius maintained that Philo's book *De Vita Contemplativa* was a later Christian forgery, intended to procure the sanction of Philo's name for the rising monasticism of the Church. It is, however, now generally acknowledged that Conybeare is correct and the Therapeutae are held to have been a variety of the Essenes, distinguished by a love of contemplative devotion.

Another division is that of the Hemerobaptists or *Tobele-Shaharith*, whose daily ablutions were a matter of ritual—John the Baptist may have belonged to them. Epiphanius (*Panarion*, I, 17) mentions them as the fourth heresy among the Jews, and classes them doctrinally with the Pharisees but, like the Sadducees, they are said to have denied the resurrection of the dead. Both Hegesippus and Justin Martyr speak of the Hemerobaptists.

Common to all the above mentioned varieties of the Essenes is the circumstance that each is described as forming a homogeneous body, ruled by officers acting in accordance with traditional laws and possessing initiatory oaths and ceremonies incumbent on the neophyte. The Greek sources make it clear that they are speaking of sects. On the other hand the Rabbinic writings speak of individuals or informal groups, lacking altogether the cohesion and permanence which the Greek imply. Probably both are correct, for allowance must be made for the fact that the Greek accounts are connected descriptions, possibly coloured by the desire to heighten parallels to other bodies, while in Rabbinic sources only incidental references occur and the comprehensive designation Essene is probably never met with. Little is said of the Essenes that does not fall within pharisaic category. Among the Pharisees were plenty of men who, singly, or collectively, lived the Essene life. (Büchlers *Types of Palestinian Piety* contains plenty of illustrations.) But they were not recluses. They were men of action who brought religion into life. Menahem, an Essene, predicted Herod's rise to power. Judas the Essene foretold the death of Antigonus. John the Essene was a general in the Roman War.

Probably the Essenes and Pharisees sprang from the pre-Maccabaean *Ḥasidim*. In later times we hear of the *Ḥasīdim ha-Rishōnim*, brotherhoods (*Ḥabūroth*) of pious men who waited in meditation before statutory services began "in order to attune their minds to their Father in Heaven" and who met also for common meals; of the *Neqiyyē had-Da'ath*, probably a more informal body of "pure-minded ones" who paid special reverence to the scroll of the law; of the *Çenū'im* or "chaste ones" among the priesthood and the *'Anāwim or* "humble ones," both elderly men who possessed and transmitted the secret of the divine name of 42 letters and who, copying Moses and Israel before Sinai, refrained from sexual intercourse in the hope of meriting a further revelation: of the *Ḥash-shā-'im*, or "reticent ones" to whom secret scrolls were entrusted: to the *Wattiqim*, or "men of exactitude" who so arranged their morning prayers that they finished the recital of the *Shema'* at the time of the sun's first brilliance, and of other groups.

In view of the foregoing it is hard to believe that the Essenes remained pent within a watertight compartment and that they are strictly to be differentiated from the mass of primitive Judaism, all the more as no comprehensive Hebrew name for them can be produced to justify such an assumption. An anonymous corporation can scarcely be conceived: supporters and opponents alike, would have felt the necessity for precision: an appellation or a taunt-word that would be indisputably applicable must inevitably have won popularity, just as the terms "Society of Friends" or "Quakers" unambiguously designate a definite religious body, and just as no doubt is entertained as to those to whom the term Pharisee refers. No such categorical epithet in Hebrew is known for the Essenes. The term Pharisee sufficed to cover all their subdivisions. For it cannot be argued that the Essene tenets lie far off the beaten track of Judaism. Abstinence is possibly the only exception and too much must not be made of the Greek writers' emphasis on this element. Nor is it unknown in the Talmud. Private fasts and asceticism are mentioned on many occasions. That they are deprecated is another matter. Judaism possesses enough official disciplinary abstinence to render it desirable to check the common impulse towards optional asceticism. But the desire of the individual to add to the statutory prescriptions was Jewish as well as Essene because it was natural in saints: it is found at all times and deprecated at all times by those who guide the common worshippers and who wisely strive to guard them against excess. Essene tenets can certainly not be detached. It is only by carefully gathering all instances of individual holiness and by segregating them as unusual in Judaism that the Essenes can be isolated. Having abstracted all the sweetness, the remaining drab gloom and ugliness is said to represent normal Judaism: this forms an agreeable foil to the Gospels. Not infrequently the motive for exalting the Essenes has been the desire to decry the spiritual outlook of Jesus' contemporaries.

DRAWN FROM ALL CLASSES

Moreover, the Essenes were drawn from all classes, they had their priests, which merely means that their ranks included pious *Cohanim*. In the same way their insistence on the immutable nature of oaths recalls the Sadducees and their objection to annulling vows. The often misunderstood "Corban" episode of the Gospels would show that Jesus followed the Pharisee view, for it

was they who insisted on dissolving, wherever possible, rash vows adversely affecting parents while the Essenes or Sadducees stood for the letter of the bond. The gospel writer has confused the controversialists and made Jesus appear to be blaming the Pharisees for the very principle on which they and he were in agreement against the Sadducees. If, therefore, Essenes included priests, Pharisees and Sadducees, they cannot have formed a definitely separate body. The term Essene can denote nothing more than "pious," in the vaguest sense of the word, allowing for all manner of divergencies according to the personal tastes of individuals and groups.

When we read that the Essenes accompanied the reading of the Law by expository homilies, we cannot doubt but that the reference is to Haggadic Midrash of which their secret books may well have consisted. Their angelology is not necessarily more foreign than much similar material contained in the *Haggadah* and which later developed into *Qabbalah*. Perhaps it is begging the question to take a Jewish origin and Jewish angelology for granted. Be this as it may, the presence of angelology among Essene beliefs is no argument for the foreign origin of general Essenism, just as little would it be logical to argue that Judaism as a whole is foreign because Judaism contains angelology which is foreign.

What is perhaps the most conclusive argument against the isolation of the Essenes is their imperceptible disappearance. The Sadducees vanished silently after A.D. 70 because the *raison d'être* of the priests disappeared with the Temple. But no such reason can explain why no more is heard of the Essenes, either in Judaism or in Christianity. They seem to have faded from history. The answer is that they assimilated their environment, they did not succumb to it. They imposed their mark on their contemporaries so impressively that they conquered. The communistic groups and the ascetic practices were a means to an end: the practice of virtue and the cult of saintliness, being part of the teaching of Judaism as of Christianity, ceased to be the distinctive mark of the Essene. When paganism lapsed, Essenism had achieved its purpose. The Essene, or his convert, became the good Christian or the good Jew. That a number of men of extraordinary piety should have influenced their generation and gradually raised the general level to their own height need excite no wonder. That the first men in the world to condemn the institution of slavery should have carried the teachers and saints of their age with them and should have merged and become lost as virtue spread and morality prevailed is no more surprising than that the groups which constituted the apostolic Church and which exhibited considerable varieties of outlook should have blended imperceptibly and with a gradual loss of individuality into the harmonious background of universal Christianity.

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(H. M. J. L.)

ESSENTIAL OILS. The terms *essential, ethereal* or *volatile oils* are applied to volatile odoriferous bodies of an oily character, obtained almost exclusively from vegetable sources. They must be distinguished from the two other great groups of naturally occurring substances with which they share the general name "oil," or for none but rather superficial reasons. Its minerals differ from them in consisting of hydro-carbons (compounds of carbon and hydrogen without oxygen; *see* PETROLEUM); the animal or vegetable oils, on the other hand, are oxygen-containing substances consisting mainly of esters (*q.v.*) belonging to the class of glycerides (*q.v.*), that is, compounds of glycerine (*q.v.*) or fatty acids (*q.v.*); they are discussed in the article OILS, FATS AND WAXES, and the more important of them in individual articles.

Occurrence.—The essential oils of plants are present, as a rule, in very small amounts; in cloves there is as much as 16–18% of oil, but rose petals yield as little as 0·2% of the essential oil, while from jasmine blossoms only $\frac{1}{10}$ of this quantity can be obtained. The oils may be found in special cells, glands or ducts, in one particular organ, or distributed over many parts of the plant, such as leaves, bark, roots, flowers or fruits. From the work of Charabot and others it appears that the oils are actually formed in the green (chlorophyll-bearing) parts of the plant, possibly as a result of pathological processes or as by-products of plant metabolism. As the plant matures the oils are transported to other tissues, in particular the flowering shoots, where secondary changes (oxidation, esterification, etc.) in the constitution of the oils may occur. In the case of the plants (lavender, peppermint, etc.) studied by Charabot, the oil content reached a maximum immediately before fertilisation of the flowers. At this stage there was notable consumption, or loss, of oil, the proportion of which further decreased as the fruits ripened. The quantity and composition of the essential oils of plants may vary with the conditions of cultivation, *e.g.*, light, climate, soil, altitude, etc., as is instanced by the different ester content of oils from lavender grown in England and the south of France.

Occasionally the odoriferous ethereal oils are not present as such in the living plant, but occur as scentless compounds of sugars termed *glucosides, e.g.*, amygdalin in bitter almonds, gaultherin in wintergreen, sinigrin of mustard seeds. When the tissues are macerated the ferment action of the enzymes present in the plant decomposes the glucosides, liberating the characteristically odorous ethereal oil.

Function.—The function of the oils in the plant is uncertain; they may be merely excretory by-products (*e.g.*, resins, oil of turpentine), or secretions for specific purposes, for example, to attract insects to the flowers: the high consumption of essential oil during the period of fecundation points to a possible nutritive value.

The animal secretions musk, ambergris, civet and castor, are considered in the separate articles under these headings and under PERFUMERY. The crude secretions are used in perfumery and no essential oils are separated. It is doubtful whether the odour of these bodies is due to volatile oils; recently, however, certain characteristic aromatic ketones have been isolated.

Physical Properties.—The volatile oils are mostly insoluble in water, but freely soluble in alcohol, ether, fatty and mineral oils. As a rule they are not oleaginous to the touch and leave no permanent grease-spot. They are usually liquid at ordinary temperatures; some, on standing, deposit solid matter (*stearoptenes*) which crystallise from the liquid remainder (*elaeoptene*), *e.g.*, oil of camphor, rose oil. In specific gravity the ethereal oils range from 0·85 to 1·142; they possess a high refractive power and the majority rotate the plane of polarised light.

The natural volatile oils consist usually of mixtures of several chemical individuals; the properties of the various components are in accordance with their chemical constitution, which determines the means to be employed for their identification and estimation.

The present state of our knowledge does not permit of strict correlation of odour and chemical constitution. The hydrocarbons have, on the whole, no pronounced odour; scent appears with the introduction of oxygen, nitrogen or sulphur in certain groups such as hydroxyl (OH), aldehyde (—CHO), nitrile (—CN), isothiocyanate (—SCN), etc., to the molecule, but particular groupings cannot be associated with particular types of odour. Different groups may have practically equal effects, for instance, benzaldehyde C_6H_5CHO and nitrobenzene $C_6H_5NO_2$ have almost identical odours. In the case of the synthetic musks, symmetrical arrangement in the benzene nucleus of the three nitro- (or substituted nitro- groups) seems to be essential to the production of odour.

Constitution.—The components of the ethereal oils are, as a rule, compounds of hydrogen, carbon and oxygen only; hydrocarbons occur to a considerable extent in some oils, *e.g.*, pinene in oil of turpentine; nitrogen and sulphur compounds are also found (*see* below). The constituents of the volatile oils may be classed in the following groups according to their chemical nature:—

(1) *Hydrocarbons, e.g.*, styrolene in storax; the terpenes (*q.v.*), *e.g.*, pinene in oil of turpentine, limonene in lemon and orange-peel oils. (2) *Alcohols* (*a*) straight chain, *e.g.*, linaloöl from oils of lavender, neroli and linaloe, geraniol in rose otto, palmarosa and citronella oils: (*b*) terpene alcohols, *e.g.*, borneol in Borneo camphor; terpineol in oils of linaloe, cajeput, etc., also artificially prepared from oil of turpentine for lilac odours: (*c*) phenols, *e.g.*, menthol

in oil of peppermint; thymol in thyme oil; eugenol in oil of cloves. (3) *Esters, e.g.*, isoamyl acetate, synthetic for pear flavour; methyl salicylate in oil of wintergreen, and synthesised from salicylic acid; geranyl acetate in oils of palmarosa, lemongrass, pettitgrain, etc., and synthesised from geraniol for rose and orange flower odours. The *acids* occasionally occur in the free state in natural oils, but have the greatest importance in combination as esters. (4) *Aldehydes, e.g.*, citral in lemongrass and lemon oils; citronellal from oil of lemon; benzaldehyde in oil of bitter almonds, laurel oil; vanillin in vanilla, gumbenzoin, etc., and artificially prepared from eugenol or guaicol; heliotropin (piperonal) in oil of spiraea, synthesised from safrole for heliotrope odour. (5) *Ketones, e.g.*, menthone in oil of peppermint; camphor in oil of camphor, ionone synthesised from citral for violet odours. (6) *Oxides and lactones, e.g.*, safrole from oils of sassafras and camphor; coumarin in tonka bean, woodruff, synthesised from salicylic aldehyde for "new mown hay" odours; eucalyptol (cineol) in oil of eucalyptus. (7) *Nitrogen* and *sulphur compounds, e.g.*, prussic (hydrocyanic) acid in oil of bitter almonds, laurel oil; nitrobenzene ("oil of mirbane") synthesised from benzene for almond odour; trinitrobutylxylene (Baur's xylene musk) synthesised from xylene for substitute musk: allylisothiocyanate in oil of mustard. Many other compounds exist and most are to be found in a variety of natural oils; only the principal sources can be quoted here.

Preparation.—Essential oils are obtained from plants by the following methods:—

(1) *Steam distillation*, the most important method, is applicable to the widest range of substances, *e.g.*, peppermint, camphor, cloves, etc.; it is especially favoured for the production of the more stable oils, such as oils of cedar, cloves, etc. (2) *Expression*, by hand (*"écuelle"* and *"éponge"*) or by machinery, used almost entirely for the production of oils contained in the rinds of fruits such as lemon, bergamot, etc. (*See* LEMON.) (3) *Extraction* by (*a*) volatile solvents such as petroleum ether, alcohol, etc. (a practice which has increased greatly of recent years); (*b*) by cold neutral fats (*"enfleurage"*) or (*c*) by hot oils or fats (*"maceration"*). Descriptions of these processes are given in the article PERFUMERY.

Terpeneless oils are prepared from several natural oils, *e.g.*, oil of lemon, by removal of the terpene hydrocarbons present by fractional distillation. These hydrocarbons have no odour value, and, on account of their liability to atmospheric oxidation, impair the keeping properties of the oil; further they diminish the solubility in dilute alcohol.

Synthetic Oils.—The so-called synthetic oils may be grouped into two classes: (1) *Isolates* or artificial oils, consisting of chemical individuals isolated in a more or less pure condition from a natural essential oil, *e.g.*, menthol, cineol, isolated by freezing from oils of peppermint and eucalyptus respectively; (2) oils synthesised by chemical means from such isolates (*e.g.*, piperonal from safrole of sassafras oil) or from other raw materials such as coal-tar derivatives (*e.g.*, methyl salicylate from salicylic acid). The synthetic essences may be identical with the odorous bodies present in a natural oil, for example, vanillin, synthesised from eugenol of oil of cloves, or from coal-tar guaiacol, and coumarin produced from salicylic aldehyde; many, however, are bodies which do not occur naturally in the plants. Such are ionone, derived from citral isolated from oil of lemongrass, which is the basis of all violet scents, and perhaps the most important of all the synthetic perfumes; nitrobenzene which although chemically distinct from the benzaldehyde of almond oil, nevertheless possesses a coarse almond odour, and the exceedingly interesting synthetic musks. These latter are structurally very different from the ketones isolated from natural musk which, however, they closely resemble in odour and fixative properties. (Further examples of synthetic perfumes are quoted in the article PERFUMERY.)

Applications.—Essential oils find an extensive range of uses, of which the principal are the various applications in perfumery (*q.v.*), for perfumes, toilet preparations, soaps, etc. Important also are the uses in connection with foods. The value of flavouring herbs, condiments, etc., is largely due to the ethereal oils contained in them, while the delicate aroma of tea, coffee, wine, etc., depends on the presence of minute quantities of the same bodies. Consequently essential oils, and in particular the terpeneless oils, are employed in the flavouring of aerated beverages, etc.; the synthetic fruit essences are largely used in confectionery.

Many of the volatile oils find extensive use in medicine, either on account of their disinfectant properties, *e.g.*, thymol, eucalyptol, borneol (the principal constituent of Borneo camphor, which, mentioned by Rhazes as early as A.D. 923, was used as a prophylactic for the plague in the Middle Ages), or for their analgesic value, *e.g.*, camphor, oil of wintergreen (treatment of rheumatism).

In the arts, oil of turpentine is used on the largest scale in the manufacture of paints and varnishes and as a source of artificial camphor. Oils of lavender and spike are used as paint vehicles, more especially for the painting of pottery and glass.

Production.—The cultivation of plants for ethereal oil production has become a large industry; the most important producing area for natural floral products is the Alpes Maritimes district in the south of France, but the industry is now extending to Germany and Italy and the countries bordering on the Mediterranean, such as Bulgaria, which has long been the centre for rose oil production. The increased consumption of synthetic perfumes has in many cases stimulated the agricultural side of the trade; enormous quantities of sassafras and lemongrass are now cultivated solely for the recovery of the respective isolates safrole and citral. Lavender and peppermint oils of English origin rank as the best qualities; Japan has practically a monopoly of menthol production, while from the Far East come also the spice oils, or their raw materials, such as cinnamon and cloves, with eucalyptus, camphor, etc. America imports the bulk of the essential oils required; her production, however, of peppermint, lemon and orange oils is rapidly increasing. Attempts are being made to develop the cultivation of essential oils of orange and lemon in Africa and Australia respectively. *See* also PERFUMES, TERPENES, LEMON, EUCALYPTUS, MUSK, etc.

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ESSENTUKI, a town in the Terek county of the North Caucasian Area, U.S.S.R., in lat. 44° 2′ N., long. 42° 48′ E. It is 11 miles west by rail from Pyatigorsk, altitude 2,096 feet. In the last thirty years the population has increased from 9,974 to 23,218 (in 1926) and the town now has an electric station, and a factory for obtaining oil from sunflower seeds. Its alkaline and sulphur-alkaline mineral waters, similar to those of Ems, Selters and Vichy, are much visited in summer. The climate shows great variations in temperature.

ESSEQUIBO or **ESSEQUEBO,** one of the three counties of British Guiana, taking its name from the river Essequibo. (*See* GUIANA.)

ESSEX, EARLS OF. The first earl of Essex was probably Geoffrey de Mandeville (*q.v.*), who became earl about 1139, the earldom being subsequently held by his two sons, Geoffrey and William, until the death of the latter in 1189. In 1199 Geoffrey Fitzpeter or Fitzpiers (d. 1213), who was related to the Mandevilles through his wife Beatrice, became earl of Essex, and on the death of Geoffrey's son William in 1227 the earldom reverted for the second time to the Crown. Then the title to the earldom passed by marriage to the Bohuns, earls of Hereford, and before 1239 Humphrey de Bohun (d. 1275) had been recognized as earl of Essex. With the earldom of Hereford the earldom of Essex became extinct in 1373; afterwards it was held by Thomas of Woodstock, duke of Gloucester, a son of Edward III. and the husband of Eleanor de Bohun; and from Gloucester it passed to the Bourchiers, Henry Bourchier (d. 1483), who secured the earldom in 1461, being one of Gloucester's grandsons. The second and last

Bourchier earl was Henry's grandson Henry, who died early in 1540. A few weeks before his execution in 1540 Thomas Cromwell (*q.v.*) was created earl of Essex; then in 1543 William Parr, afterwards marquess of Northampton, obtained the earldom by right of his wife Anne, a daughter of the last Bourchier earl. Northampton lost the earldom when he was attainted in 1553; and afterwards it passed to the famous family of Devereux, Walter Devereux, who was created earl of Essex in 1572, being related to the Bourchiers. Robert, the third and last Devereux earl, died in 1646. In 1661 Arthur Capel was created earl of Essex, and the earldom is still held by his descendants.

ESSEX, ARTHUR CAPEL, 1st Earl of (1632–1683), English statesman, son of Arthur, 1st Baron Capel of Hadham (*c.* 1641), executed in 1649, and of Elizabeth, daughter and heir of Sir Charles Morrison of Cashiobury in Hertfordshire, was baptized on Jan. 28, 1632. In June 1648, then a sickly boy of 16, he was taken by Fairfax's soldiers from Hadham to Colchester, which his father was defending, and carried every day round the works with the hope of inducing Lord Capel to surrender the place. At the restoration he was created Viscount Malden and earl of Essex (April 20, 1661).

He early showed himself antagonistic to the court, to Roman Catholicism, and to the extension of the royal prerogative, and was coupled by Charles II. with Holles as "stiff and sullen men," who would not yield against their convictions to his solicitations. Nevertheless he was sent on an embassy to Denmark in 1669, and in 1672 became lord lieutenant of Ireland. During the five years of his rule in Ireland he took great pains to understand the Irish situation, the purity of his administration brought him into conflict with many interested persons, accustomed to corrupt methods, and he was recalled in 1677. On the fall of Danby in 1679 he became a commissioner of the treasury, and in the next year a member of the council. He was a supporter of the policy of Halifax, and in spite of his strong Protestant views, gained the king's confidence.

Subsequently his political attitude underwent a change, the exact cause of which is not clear—probably a growing conviction of the dangers threatened by a Roman Catholic sovereign of the character of James. He now, in 1680, joined Shaftesbury's party and supported the Exclusion bill, and on its rejection by the Lords carried a motion for an association to execute the scheme of expedients promoted by Halifax. On Jan. 25, 1681, at the head of fifteen peers he presented a petition to the king requesting the abandonment of the session of parliament at Oxford. He was a jealous prosecutor of the Roman Catholics in the popish plot, and voted for Stafford's attainder, on the other hand interceding for Archbishop Plunket, implicated in the pretended Irish plot. But he declined participation in Shaftesbury's design to seize the Tower in 1682, and on Shaftesbury's consequent departure from England became the leader of Monmouth's faction, in which were now included Lord Russell, Algernon Sidney, and Lord Howard of Escrick. Essex took no part in the wilder schemes of the party, but after the discovery of the Rye House Plot in June 1683, and the capture of the leaders, he was arrested at Cashiobury and imprisoned in the Tower. On July 30, he was discovered in his chamber with his throat cut. Evidence points clearly if not conclusively to suicide, his motive being possibly to prevent an attainder and preserve his estate for his family.

Essex was a statesman of strong and sincere patriotism, just and unselfish, conscientious and laborious in the fulfilment of public duties, blameless in his official and private life. Evelyn describes him as "a sober, wise, judicious and pondering person, not illiterate beyond the rule of most noblemen in this age, very well versed in English history and affairs, industrious, frugal, methodical and every way accomplished"; and declares he was much deplored, few believing he had ever harboured any seditious designs. He married Lady Elizabeth Percy, daughter of Algernon, 10th earl of Northumberland, by whom, besides a daughter, he had an only son Algernon (1670–1710), who succeeded him as 2nd earl of Essex.

Bibliography.—*See* the Lives in the *Dict. of Nat. Biography* and in *Biographia Britannica* (Kippis), with authorities there collected; Essex's Irish correspondence is in the *Stow Collection* in the British Museum, Nos. 200–217, and selections have been published in *Letters written by Arthur Capel, Earl of Essex* (1770) and in the *Essex Papers* (Camden Society, 1890), to which can now be added the *Calendars of State Papers, Domestic,* which contain a large number of his letters and which strongly support the opinion of his contemporaries concerning his unselfish patriotism and industry; *see* also *Somers Tracts* (1813), x., and for other pamphlets relating to his death the catalogue of the British Museum.

ESSEX, ROBERT DEVEREUX, 2nd[1] Earl of (1566–1601), son of the 1st Devereux earl, was born at Netherwood, Herefordshire, on Nov. 19, 1566. He was educated at Trinity college, Cambridge, and in 1585 accompanied his stepfather, the earl of Leicester, to Holland, where he distinguished himself at the battle of Zutphen. He now took his place at court, where he was in high favour with Elizabeth, and in consequence on bad terms with Raleigh. In 1587 he was appointed master of the horse, and in the following year was made general of the horse and installed knight of the Garter. On the death of Leicester he succeeded him as chief favourite of the queen. Elizabeth was approaching 60; Essex was scarcely 21. Though well aware of the advantages of his position, and somewhat vain of the queen's favour, his constant attendance on her at court was intolerable, and in 1589, without her consent, he joined the expédition of Drake and Sir John Norris against Spain. In June, however, he was compelled to obey a letter enjoining him at his "uttermost peril" to return immediately. In 1590 Essex married the widow of Sir Philip Sidney, but in dread of the queen kept the marriage secret. When it was avowed, the queen was excessively angry, but, on the understanding that the lady should "live retired in her mother's house," was mollified.

In 1591 Essex was appointed to the command of a force auxiliary to one formerly sent to assist Henry IV. of France against the Spaniards; after a fruitless campaign he was recalled from the command in Jan. 1592. For some years after this most of his time was spent at court, where he held a position of unexampled influence, both on account of the favour of the queen and from his own personal popularity. In 1596 he was appointed with Lord Howard of Effingham, Raleigh and Lord Thomas Howard, to the command of the successful expedition against Cadiz. Shortly after this the queen's feelings towards him seem to have changed, and an open rupture was only prevented by the influence of Francis Bacon, at that time Essex's most intimate friend. In 1597 he was appointed master of the ordnance, and in 1598 commander of an expedition against Spain, known as the Islands or Azores Voyage. As the Plate fleet escaped him he failed of his main purpose; and when on his return the queen met him with the usual reproaches, he retired to his home at Wanstead. Elizabeth conferred on Lord Howard of Effingham the earldom of Nottingham for services at Cadiz, the main merit of which was justly claimed by Essex, but she sought to console Essex by making him earl marshal of England. Nevertheless the quarrel remained unhealed. In a discussion on the appointment of a lord deputy to Ireland, Essex, on account of some taunting words of Elizabeth, turned his back upon her, and when she, unable to control her indignation, slapped him on the face, he left her swearing that such an insult he would not have endured even from Henry VIII.

In Aug. 1598, Essex succeeded Burghley as chancellor of Cambridge, and in the following year, while Ulster was in rebellion under the earl of Tyrone, was made lieutenant and governor-general of Ireland. His campaign was unsuccessful, and by opposing the commands of the queen and the council, agreeing with Tyrone on a truce in September, and suddenly leaving the post of duty with the object of privately vindicating himself before the queen, he laid himself open to serious charges. He was brought in June 1600 before a specially constituted court, deprived of his offices, and ordered to live a prisoner in his own house during the queen's pleasure. Chiefly through the intercession of Bacon his liberty was soon restored to him, but he was ordered not to return to court. When he was refused the renewal of his patent for sweet wines, he paraded (Feb. 7, 1601) the streets of

[1]*i.e.,* in the Devereux line.

London with 300 retainers, and shouted, "For the queen! a plot is laid for my life!" These proceedings awakened no response from the citizens, and Essex returned to Essex House, where after defending himself for a short time he surrendered. After a trial—in which Bacon, who prosecuted, delivered a speech against his quondam friend and benefactor, he was condemned to death, and notwithstanding many alterations in Elizabeth's mood, the sentence was carried out on Feb. 25, 1601.

Essex, who was lacking in the qualities necessary for a statesman or general, owed his position to his personal charm. He was brave, chivalrous, impulsive, imperious sometimes with his equals, but generous to all his dependants and incapable of secret malice. He was also a patron of literature and the drama, and himself a poet.

See W. B. Devereux, *Lives of the Earls of Essex* (1853); E. A. Abbott, *Bacon and Essex* (1877) and L. A. Cadwallader, *Career of the Earl of Essex* (1923); also the article BACON, FRANCIS, and authorities there, and general bibliography in *Camb. Mod. Hist.* (vol. 3, 1904); Lyton Strachey, *Elizabeth and Essex* (1928).

ESSEX, ROBERT DEVEREUX, 3RD[1] EARL OF (1591–1646), son of the preceding, was born in 1591. He was educated at Eton and at Merton college, Oxford. Shortly after the arrival of James I. in London, Essex (whose title was restored, and the attainder on his father removed, in 1604) was placed in the household of the prince of Wales to share his studies and amusements. At 15 he married Frances Howard, daughter of the earl of Suffolk; during his absence abroad (1607–09) she fell in love with Robert Carr (afterwards earl of Somerset), and on her charging her husband with physical incapacity, the marriage was annulled in 1613. A second marriage with Elizabeth, daughter of Sir William Paulet, also ended unhappily. From 1620 to 1623 he served in the wars of the Palatinate, and in 1625 he was vice-admiral of a fleet which made an unsuccessful attempt to capture Cadiz. In 1639 he was lieutenant-general of the army sent by Charles against the Scottish Covenanters, in what is known as the first Bishops' War, but there was no fighting. The outbreak of the Civil War in 1642, found him in command of the parliamentary army. At the battle of Edgehill he remained master of the field, and in 1643 he captured Reading, and relieved Gloucester; but in the campaign of the following year, on account of disease, financial disorders and his own lack of initiative, nearly his whole army fell into the hands of Charles. In 1645, on the passing of the self-denying ordinance, providing that no member of parliament should hold a public office, he resigned his commission; but his annuity of £10,000 was continued to him for life. He died on Sept. 14, 1646, his line becoming extinct.

See Robert Codrington, M.A., "Life of Robert Earl of Essex," printed in *Hart. Misc.;* Clarendon's *History of the Rebellion;* and Hon. W. B. Devereux, *Lives of the Earls of Essex* (1853).

ESSEX, WALTER DEVEREUX, 1ST[1] EARL OF (1541–1576), the eldest son of Sir Richard Devereux, was born in 1541. His grandfather was the 2nd Baron Ferrers, who was created Viscount Hereford in 1550 and by his mother was a nephew of Henry Bourchier, a former earl of Essex. Walter Devereux succeeded as 2nd Viscount Hereford in 1558, and in 1561 or 1562 married Lettice, daughter of Sir Francis Knollys. In 1569 he served as high marshal of the field, under the earl of Warwick and Lord Clinton, in the suppression of the northern insurrection. For his services he in 1572 received the Garter and was created earl of Essex, the title which formerly belonged to the Bourchier family. He offered on certain conditions to subdue and colonize, at his own expense, a portion of the Irish province of Ulster, at that time completely under the dominion of the rebel O'Neills, under Sir Brian MacPhelim and Tirlogh Luineach, with the Scots under their leader Sorley Boy MacDonnell. He set sail for Ireland in July 1573, but a storm dispersed his fleet, and his forces did not assemble till late in the autumn. His troops were diminished in winter quarters at Belfast to little more than 200 men. Intrigues of various sorts, and fighting of a guerrilla type followed, and Essex had difficulties both with the deputy Fitzwilliam and with the queen. His offensive movements in Ulster took the form of raids and brutal massacres among the O'Neills; in Oct. 1574 he treacherously captured MacPhelim at a conference in Belfast, and after slaughtering his attendants had him and his wife and brother executed at Dublin. Elizabeth, instigated apparently by Leicester, suddenly commanded him to "break off his enterprise"; but, as she left him a certain discretionary power, he took advantage of it to defeat Tirlogh Luineach, chastise Antrim, and massacre several hundreds of Sorley Boy's following, chiefly women and children, discovered hiding in the caves at Rathlin. He returned to England in the end of 1575. Elizabeth then made him earl marshal of Ireland, but he died of dysentery three weeks after his arrival in Dublin in the autumn of 1576. After his death Leicester married his widow. The massacres of the O'Neills and of the Scots of Rathlin leave a dark stain on the reputation of Essex.

[1] *i.e.*, in the Devereux line.

See Sidney Lee's article in the *Dict. Nat. Biog.; Lives of the Devereux Earls of Essex,* by Hon. Walter B. Devereux (1853); Froude's *History of England,* vol. x.; J. S. Brewer, *Athenaeum* (1870), part i. pp. 261, 326.

ESSEX, an eastern county of England, bounded north by Cambridgeshire and Suffolk, east by the North Sea, south by the Thames, dividing it from Kent, west by the administrative counties of London, Middlesex and Hertfordshire. Its area is 1,530 square miles. Its configuration is sufficiently indicated by the direction of its rivers. Except that in the northwest the county includes the heads of a few valleys draining northward to the Cam and so to the Great Ouse, all the streams run southward and eastward, either into the Thames, or into the North Sea by way of the broad, shallow estuaries which ramify through the flat coast lands. The highest ground lies consequently in the north-west, between the Cam basin and the rivers of the county. The Lea (which with its headwaters the Stort forms a great part of the western boundary), the Roding and several smaller streams flow southward to the Thames. Canvey island, just before Southend is reached, is typical of many of the marsh islands along the coast. Following the coast northward from Shoeburyness at the Thames mouth, the other chief rivers may be specified according to their estuaries. The Roach ramifies among several islands of which Foulness is the largest, while its main branch joins the estuary of the Crouch. Next follows the Blackwater, which receives the Chelmer, the Brain and other streams. Following the numerous creeks and islets, with the large island of Mersea, the Colne estuary is reached. The Colne and Blackwater may be said to form one large estuary, as they enter the sea by a well-marked common mouth, 5 m. in width, between Sales Point and Colne Point. There is a great irregular inlet (Hamford Water) receiving no large stream, west of the Naze promontory, and then the Stour, forming the boundary with Suffolk on the north, joins its estuary to that of the Orwell near the sea.

There are several popular seaside places along the Essex coast, of which Southend-on-Sea (with Leigh and Westcliff) above the mouth of the Thames, Clacton-on-Sea, Frinton-on-Sea, Walton-on-the-Naze, and Dovercourt adjoining Harwich are the chief. These and other stations on the estuaries, such as Burnham-on-Crouch, are also in favour with yachtsmen. The sea has at some points seriously encroached upon the land within historic times. The low soft cliffs at various points are liable to give way against the waves; in other parts dykes and embankments are necessary to prevent inundation. Inland the county is pleasantly undulating and for the most part well wooded. It was formerly, indeed, almost wholly forested, the ancient Waltham forest stretching from Colchester to the confines of London. Of this a fragment is preserved in Epping forest (*see* EPPING) between the Lea and the Roding. On the east of the Roding Hainault forest is traceable, but was disafforested in 1851. The oak is the principal tree; a noteworthy example was that of Fairlop in Hainault, which measured 45 ft. in girth, but was blown down in 1820.

Geology.—The geological structure of the county is very simple: the greater part is occupied by the London clay with underlying Reading beds and Thanet sands, with here and there small patches of Bagshot gravels on elevated tracts, as at High Beech, Langdon hill, Brentwood and Rayleigh; and occasionally the same beds are represented by the large boulder-like Sarsen

stones on the lower ground. In the north, the chalk, which underlies the Tertiary strata over the whole county, appears at the surface and forms the downs about Saffron Walden, Birdbrook and Great Yeldham; it is brought up again by a small disturbance at Grays Thurrock where it is quarried on a large scale for lime, cement and whiting. Small patches of Pleistocene Red Crag rest upon the Eocene strata at Beaumont and Oakley, and are very well exposed at Walton-on-the-Naze where they are very fossiliferous. Most of the county is covered by a superficial deposit of glacial drifts, sands, gravel and in places boulder clay, as at Epping, Dunmow and Hornchurch where the drift lies beneath the Thames gravel. An interesting feature in relation to the glacial drift is a deep trough in the Cam valley revealed by borings to be no less than 340 ft. deep at Newport; this ancient valley is filled with drift. In the southern part of the county are broad spreads of gravel and brick earth, formed by the Thames; these have been excavated for brick-making and building purposes about Ilford, Romford and Grays, and have yielded the remains of hippopotamus, rhinoceros and mammoth. More recent alluvial deposits are found in the valley at Walthamstow and Tilbury, in which the remains of the beaver have been discovered.

The roads of this county with a clay soil foundation were for generations repaired with flints picked by women and children from the surface of the fields. Gravel is difficult of access. With the exception of chalk for lime (mainly obtained at Ballingdon in the north and Grays in the south), septaria for making cement, and clay for bricks, the underground riches of the county are meagre.

INDUSTRIES AND COMMUNICATIONS

Agriculture and Industries.—As an agricultural county Essex ranks high, being one of the chief grain-producing counties. The wheat and barley are of high quality, the wheat being exported for seed purposes, while the barley is especially used in malting. Beans and peas are largely grown, as are vegetables for the London market. Hop-growing was once important. From the comparative dryness of the climate Essex does not excel in pasturage, and winter feeding receives the more attention.

The south-west of the county, being contiguous both to the river and to London, is the seat of large and varied industries, including food and chemical works, engine shops at Stratford, powder works in the vicinity of Waltham Abbey, and powder stores at Purfleet on the Thames. The extensive water-works for east London, by the Lea near Walthamstow, may also be mentioned. The docks at Plaistow and Tilbury on the Thames employ many hands. Apart from this industrial district, there are considerable engineering works, especially for agricultural implements, at Chelmsford, Colchester and elsewhere; silk works at Braintree and Halstead; large breweries at Brentwood, Chelmsford and Romford; and lime and cement works at Grays Thurrock (*see* section *Geology* above). The oyster-beds of the Colne produce the famous Colchester natives, and there are similar beds in the Crouch and Roach, for which Burnham-on-Crouch is the centre; and in the Blackwater (Maldon).

Railways.—Railway communications fall principally within the L.N.E.R. system, (1) the main line to Ipswich runs from south-west to north-east across the county by Stratford, Ilford, Romford, Brentwood, Chelmsford, Witham, Mark's Tey, Colchester and Manningtree. From this line various branches extend eastward to the sea: (a) at Shenfield (beyond Brentwood) via Billericay, Wickford and Rochford to Southend-on-Sea, with branches from Wickford returning via Maldon to the main line at Witham, and going east to Burnham and Southminster; (b) at Kelvedon (beyond Witham) to Tollesbury on the Blackwater; (c) Colchester going, via Wivenhoe, to Brightlingsea, and to Clacton, Frinton and Walton-on-the-Naze respectively. (2) The Cambridge line of the same company runs from south to north along the western border, entering the county across the Stort, which it follows to Bishop's Stortford, whence it strikes across the northwest corner of the county to Great Chesterford. This line throws out branches eastward: (a) from Bishop's Stortford (Herts.) via Dunmow and Braintree to the first line at Witham; (b) from Elsenham to Thaxted; (c) from Audley End via Saffron Walden and Haverhill, in a wide loop along the northern border through both Halstead (Colne Valley section) and Sudbury to Mark's Tey. (3) The angle between these two main lines is served by branch lines (a) to Chingford at the southern end of Epping Forest, (*b*) via Leyton, Woodford, Buckhurst Hill, Loughton and Epping to Chipping Ongar, while short interconnecting lines serve the populous districts nearer London, now also reached by the District railway to Barking. (4) The southern portion of the county from west to east along the Thames is served by the L.M.S.R. (Tilbury and Southend section) via (a) West Ham, Plaistow, East Ham, Barking and Upminster to Southend and Shoeburyness at the mouth of the Thames, together with (b) a southerly loop along the river by Purfleet, Grays and Tilbury, which rejoins the Southend line at Pitsea, while there is also a line joining Grays with Upminster and thence with the L.N.E.R. system at Romford.

On the Thames, besides the great docks at Plaistow and Silvertown (the Victoria and Albert and the King George V. docks) and the deep-water docks at Tilbury (*q.v.*) the principal calling places for vessels are Grays, Purfleet and Southend, while Barking on the Roding has also shipping trade, and the Lea affords important water-connections. Elsewhere, the principal port is Harwich, at the mouth of the Stour, an important port for passenger traffic to the Continent. Other towns ranking as lesser estuarine ports are: Brightlingsea and Wivenhoe on the Colne, forming a member of the Cinque Port of Sandwich; Colchester; Maldon on the Blackwater; and Burnham-on-Crouch. The Stour, Chelmer, and Lea and Stort are the principal navigable inland waterways.

Population and Administration.—The area of the administrative county, with its associated county boroughs, is 979,532 acres (of the former geographical county, 986,975 ac.); pop. (1921) 1,470,257, made up as follows: administrative county (municipal boroughs and urban and rural districts) 964,443 ac., pop. 920,141; county boroughs (West Ham, East Ham and Southend-on-Sea, *qq.v.*) 15,089 ac., pop. 550,116. Of this total the rural districts represent 862,361 ac. with a population of 273,814 (0·3 persons per acre), the greater part of the population being concentrated in the south-west corner adjoining London, where, as in Leyton and West Ham, densities of 100 to 135 persons per acre are reached.

The county is divided for parliamentary purposes into eight (county) divisions, each returning one member, namely; Epping, Saffron Walden, Harwich, Maldon, south-eastern Romford, Walthamstow and (in the centre) Chelmsford; while the following parliamentary boroughs also return one member in each constituency or division, namely, West Ham (four divisions), East Ham, Leyton and Walthamstow (two divisions each), and Ilford and Southend-on-Sea (one division each). There are seven municipal boroughs, with populations (1921) as follows: Chelmsford, 20,769; Colchester, 43,393; Harwich, 13,046; Maldon, 6,590; Saffron Walden, 5,874; Ilford (an urban district till 1926), 85,194; Leyton (like Ilford, created in 1926), 128,430. The urban districts are: Barking, 35,523; Braintree, 6,970; Brentwood, 6,853; Brightlingsea, 4,500; Buckhurst Hill, 5,008; Burnham-on-Crouch, 3,434; Chingford, 9,482; Clacton, 17,051; Epping, 4,196; Frinton-on-Sea, 3,032; Grays Thurrock, 17,359; Halstead, 5,923; Loughton, 5,749; Romford, 19,442; Shoeburyness, 6,413; Tilbury, 9,610; Waltham Holy Cross, 6,847; Walthamstow, 129,395; Walton-on-the-Naze, 3,664; Wanstead, 15,298; Witham, 3,717; Wivenhoe, 2,329; Woodford, 21,236. (In the figures for Clacton, Frinton and Walton, corrections of over 30% must be made, due to excess of summer visitors over the resident population.) Dagenham (9,127) was created an urban district in 1926 out of a former parish in Romford. The rural districts are: Belchamp, Billericay, Braintree, Bumpstead, Chelmsford, Dunmow, Epping, Halstead, Lexden and Winstree, Maldon, Ongar, Orsett, Rochford, Romford, Saffron Walden, Stansted, Tendring; of these Romford (29,485) alone exceeds 25,000.

Essex is in the south-eastern circuit, and assizes are held at the shire hall at Chelmsford. Colchester, Maldon, Saffron Walden

and West Ham have separate courts of Quarter Sessions, and Colchester and Southend-on-Sea have their own police. The southwest corner of the county falls within the area of the metropolitan police district of Greater London, which includes West and East Ham, Ilford, Leyton, the urban districts of Barking, Wanstead, Walthamstow, Dagenham, Buckhurst Hill, Chingford, Loughton, Waltham Holy Cross, Woodford, and the parish of Chigwell in Epping R.D., an area of over 60,000 ac. and about 900,000 population. The county is ecclesiastically within the diocese of Chelmsford and is divided into two archdeaconries. The county is included in the Eastern military command; Warley is a depot of the Essex regiment, and there is a garrison at Tilbury. At Shoeburyness there are a school of gunnery and an extensive ground for testing Government artillery of the largest calibre. The seaward limit of the Port of London authority on the Thames is a line drawn from Havengore Creek, 3 m. N.E. of Shoeburyness, to Warden Point on the opposite coast of Kent.

HISTORY AND ANTIQUITIES

History (*see* also below under Essex, Kingdom of).—Essex probably originated as a shire in the time of Aethelstan. According to the Domesday Survey it comprised 19 hundreds, corresponding very closely in extent and in name with those of the present day. Essex and Hertfordshire were under one sheriff until the time of Elizabeth. At the time of the Survey Count Eustace held a vast fief in Essex, and the court of the Honour of Boulogne was held at Witham. The stewardship of the forest of Essex was held by the earls of Oxford until they were deprived of it for adherence to the Lancastrian cause. In 1421 certain parts of Essex inherited by Henry V. from his mother were brought under the jurisdiction of the duchy of Lancaster.

Essex was part of the see of London from the time of the foundation of the bishopric in the 7th century. The archdeaconries are first mentioned in 1108; that of Essex extended over the south of the county; the north of the county was divided between the archdeaconries of Middlesex and Colchester. Colchester was constituted a suffragan bishopric by Henry VIII. In 1836 Essex was transferred to the diocese of Rochester, with the exception of nine parishes which remained in London. In 1845 the archdeacon of Middlesex ceased to exercise control in Essex. In 1875 Essex was transferred to the newly created diocese of St. Albans, and in 1914 to that of Chelmsford.

Owing to its proximity to the capital Essex was intimately associated with all the great historical struggles. The nobility of Essex took a leading part in the struggle for the charter, and of the 24 guardians of the charter, four were Essex barons. The castles of Pleshey, Colchester and Hedingham were held against the king in the Barons' War of the reign of Henry III., and 5,000 Essex men joined the peasant rising of 1381. During the Wars of the Roses the Lancastrian cause was supported by the de Veres, while the Bourchiers and Lord Fitz-Walter were among the Yorkist leaders. Several Essex men were concerned in the Gunpowder Plot, and in the Civil War of the 17th century the county rendered valuable aid to the parliament.

After the Conquest no Englishman retained estates in Essex of any importance, and the chief lay barons at the time of the Survey were Geoffrey de Mandeville and Aubrey de Vere. The de Veres, earls of Oxford, were continuously connected with the county until the extinction of the title two centuries ago. Pleshey was the stronghold of the Mandevilles, and, although the house became extinct in 1189, its descendants in the female line retained the title of earls of Essex. Essex has always been mainly an agricultural county, and the ordinary agricultural pursuits were carried on at the time of the Domesday Survey, which also mentions salt-making, wine-making, bee-culture and cheese-making, while the oyster fisheries have been famous from the earliest historic times. The woollen industry dates back to Saxon times, and for many centuries ranked as the most important industry. In the 16th century Colchester was noted for its cloth-weaving, and also possessed a valuable leather industry, at which period Essex was considered an exceptionally wealthy and prosperous county; Norden, writing in 1594, describes it as "moste fatt, frutefull, and full of all profitable things."

The county returned four members to parliament in 1290. From 1295 it returned two members for the county and two for Colchester. Maldon acquired representation in 1331 and Harwich in 1604. Under the Reform Act of 1832 the county returned four members in four divisions until 1868 when it returned six members in three divisions.

Antiquities.—Ashingdon church tower, believed to have been erected by Canute after his victory over Edmund Ironside, shows recognizable traces of Saxon masonry. But the comparative scarcity of stone and the unusual abundance of timber led to the extensive employment of the latter material and consequent later destruction. Several of the Essex churches, as Blackmore, Mountnessing, Margaretting and South Benedict, have massive porches and towers of timber; and St. Andrew's church, Greenstead, with its walls of solid oak, continues an almost unique example of its kind. Of the four round churches in England one is in Essex at Little Maplestead; it is both the smallest and the latest. The churches of South Weald, Hadleigh, Blackmore, Heybridge and Hadstock may be mentioned as containing Norman work; the church of Castle Hedingham for its fine Transitional work; Southchurch, Danbury and Boreham as being partly Early English; Ingatestone, Stebbing and Tilty for specimens of Decorated architecture; and Messing, Thaxted, Saffron Walden, and the church of St. Peter ad Vincula at Coggeshall, near Colchester, as specimens of Perpendicular. The finest remains of stained glass windows are those of Margaretting. A remarkable series of paintings, probably of the 12th century, but much restored in the 14th, exists in the chancel of Copford church; and in the church at Ingatestone there was discovered in 1868 an almost unique fresco representation of the seven deadly sins. Fourteenth century brasses are preserved at Pebmarsh, Corringham, Aveley, Little Horkesley and at South Ockendon (1400); and ancient wooden effigies at Danbury, Little Leighs and Little Horkesley.

Essex was rich in monastic foundations, though the greater number have left but meagre ruins behind. The Benedictines had an abbey at Saffron Walden, nunneries at Barking and Wickes, and priories at Earl's or Monk's Colne and Castle Hedingham; the Augustinian canons had an abbey at Waltham (*see* Waltham Abbey) and priories at Thoby, Blackmore, Bicknacre, Little Leighs, Little Dunmow and St. Osyth (*see* Brightlingsea); there were Cistercian abbeys at Coggeshall, Stratford and Tilty; the Cluniac monks were settled at Prittlewell, the Premonstratensians at Beleigh Abbey, and the Knights Hospitallers at Little Maplestead. Barking Abbey is said to date its first origin from the 7th century; most of the others arose in the 12th and 13th centuries. Besides the keep at Colchester there is a fine Norman castle at Castle Hedingham. Havering-atte-Bower, a palace that was occupied by many queens, is replaced by a modern house. New Hall, which was successively occupied by Henry VIII., Elizabeth, the earl of Essex, George Villiers, duke of Buckingham, and Cromwell, still stands. Audley End is a noble example of the domestic architecture of the Jacobean period; Layer Marney shows Italian influences in the time of Wolsey. Horeham Hall was built in the reign of Henry VII., and Gosfield Hall is of about the same date.

Bibliography.—*See* Norden, *Speculi Britanniae Pars: an Hist. and Geogr. Descrip. of the County of Essex* (1594) (edited for the Camden Society by Sir Henry Ellis, 1840, from the original ms. in the Marquis of Salisbury's library at Hatfield); Nicholas Tindal, *Hist. of Essex* (1720); N. Salmon, *The Hist. and Antiq. of Essex* (1740)—based on the collections of James Strangman of Hadleigh (v. *Trans. of Essex Arch. Soc.* vol. ii.); P. Morant, *Hist. and Antiq. of the County of Essex* (1768); P. Muilman, *New and Complete Hist. of Essex from a late Survey, by a Gentleman* (Chelmsford, 6 vols., 1770–72, London, 1779); Elizabeth Ogbourne, *Hist. of Essex* (London, part i., 1814); *Excursions through Essex, illustrated with one hundred engravings* (2 vols., 1818); T. Wright, *Hist. and Topography of Essex* (1831); W. Berry, *Pedigrees of Families in Essex* (1841); A. Suckling, *Memorials of the Antiquities, &c., of the County of Essex* (1845); W. Andrews (ed.), *Bygone Essex* (1892); J. T. Page (ed.), *Essex in the Days of Old* (1898); *Victoria County History, Essex; Transactions of the Essex Arch. Soc.* from 1858. An account of various ms. collections connected with the county is given by H. W. King in vol. ii. of the *Transactions* (1863). *See* also J. C. Cox, *Essex* (1919).

ESSEX, KINGDOM OF, an early English kingdom, of whose origin and early history we have no record except the statement of Bede that its settlers were of the Old Saxon race. In connection with this it is interesting to notice that the East Saxon dynasty claimed descent from Seaxneat, not Woden. The form Seaxneat is identical with Saxnot, one of three gods mentioned in a short continental document probably of Old Saxon origin. Bede does not mention this kingdom in his narrative until 604, the year of the consecration of Mellitus to the see of London. The boundaries of Essex were in later times the rivers Stour and Thames, but the original limits of the kingdom are uncertain; towards the west it probably included most of Hertfordshire, and in the 7th century the whole of Middlesex. In 604 we find Essex in close dependence upon Kent, being ruled by Sabert, sister's son of Aethelbert, under whom the East Saxons received Christianity. The three sons of Sabert, however, expelled Mellitus from his see, and even after their death in battle against the West Saxons, Eadbald of Kent was unable to restore him. In 653 we find Northumbrian influence paramount in Essex, for King Sigebert at the instance of Oswio became a Christian and received Cedd, the brother of St. Chad, as bishop, Tilbury and *Ythanceastere* (on the Blackwater) being the chief scenes of his work. Swithhelm, the successor of Sigebert, was on terms of friendship with the East Anglian royal house, King Aethelwald being his sponsor at his baptism by Cedd. It was probably about this time that Erconwald, afterwards bishop of London, founded the monastery of Barking. Swithhelm's successors Sigehere and Sebbe were dependent on Wulfhere, the powerful king of Mercia, who on the apostasy of Sigehere sent Bishop Jaruman to restore the faith. There are grounds for believing that an East Saxon conquest of Kent took place in this reign. A forged grant of Ceadwalla speaks of the fall of Kent before Sigehere as a well-known event; and in a Kentish charter dated 676 a king of Kent called Swebhard grants land with the consent of his father King Sebbe. In 692 or 694 Sebbe abdicated and received the monastic vows from Waldhere, the successor of Erconwald at London. His sons Sigeheard and Swefred succeeded him as kings of Essex, Sigehere being apparently dead. As the laws of Ine of Wessex speak of Erconwald as "my bishop," it is possible that the influence of Wessex for a short time prevailed in Essex; but a subsequent charter of Swefred is approved by Coenred of Mercia, and Offa, the son of Sigehere, accompanied the same king to Rome in 709. From this time onwards the history of Essex is almost a blank. In 743 or 745 Aethelbald of Mercia is found granting privileges at the port of London, and perhaps the western portion of the kingdom had already been annexed, for henceforward London is frequently the meeting-place of the Mercian council. The violent death of Selred, king of Essex, is mentioned in the *Saxon Chronicle* under the year 746; but we have no more information of historical importance until the defeat of the Mercian king Beornwulf in 825, when Essex together with Kent, Sussex and Surrey, passed into the hands of Egbert, king of Wessex. After 825 we hear of no more kings of Essex, but occasionally of earls. About 870 Essex passed into the hands of the Danes and was left to them by the treaty between Alfred and Guthrum. It was reconquered by Edward the Elder. The earldom in the 10th century apparently included several other counties, and its most famous holder was the ealdorman Brihtnoth, who fell at the battle of Maldon in 991.

The following is a list of kings of Essex of whom there is record: Sabert (d. *c.* 617); three sons of Sabert, including probably Saweard and Seaxred; Sigebert (Parvus); Sigebert II.; Swithhelm (d. *c.* 664); Sigehere (reigned perhaps 664–689); Sebbe, son of Seaxred (664–694); Sigeheard (reigning in 693–694); Swefred (reigning in 693–694 and in 704); the two last being sons of Sebbe; Swebriht (d. 738); Selred (d. 746); Swithred, grandson of Sigeheard (succ. 746); Sigeric, son of Selered (abd. 798); Sigered, son of Sigeric (reigning in 823).

See Bede, *Hist. Eccl.*, ed. C. Plummer (Oxford, 1896), ii. 3, 5; *Saxon Chronicle* (Earle and Plummer, Oxford, 1899), *s.a.* 823, 894, 904, 913, 921, 994; William of Malmesbury, *Gesta Regum*, Rolls Series (ed. Stubbs, 1887–89); *Simeon of Durham*, *s.a.* 746 (ed. T. Arnold, 1882) and appendix, *s.a.* 738; Florence of Worcester (ed. B. Thorpe, 1848–49); H. Sweet, *Oldest English Texts*, p. 179 (1885). (F. G. M. B.)

ESSEX INSTITUTE, THE, an American institution at Salem, Mass., founded for the promotion of the study of history, science and art in Essex county, was formed in 1848 by the union of the Essex Historical Society and the Essex County National History Society. It is supported by an annual assessment upon its members and by the income from its funds. Its museum contains one of the largest American collections of historical objects illustrating the life of the English settler, including type-rooms, costumes, furniture, china, glass, war relics, tools, medals and coins. Its numerous portraits include examples by Stuart, Blackburn, Smibert, Trumbull, Greenwood, Frothingham, Vinton, Osgood and others. The library contains over 500,000 volumes, among which are several specialized collections, such as Essex county imprints, China and the Chinese (over 4,000 vol.), commercial, marine, directories and newspapers. In the rear garden is a fine specimen of a 1684 dwelling, furnished in the period.

ESSLINGEN, a town of Germany, in the republic of Württemberg, in a fertile district on the Neckar, 9 m. S.E. from Stuttgart, on the railway to Ulm. Pop. (1925) 40,562. Esslingen, which dates from the 8th century, became a town in 886. It became a free imperial city in 1209 and was surrounded with walls by order of the emperor Frederick II. Its liberty was frequently threatened by the rulers of Württemberg, but it did not become part of that country until 1802. It is surrounded by mediaeval walls with towers and bastions, and has numerous suburbs. On a commanding height above the town lies the old citadel. The inner town has an old (1430) and a new Rathaus, formerly a palace. The church of Our Lady (Frauenkirche) is a fine Gothic building of the 15th century with a beautifully sculptured doorway and a lattice spire 240 ft. high. The church of St. Dionysius, dating from the 13th century, possesses a fine screen and a ciborium of 1486. The municipal archives at Esslingen contain much valuable literature bearing especially on the period of the Reformation. The town has railway, machine and electrical works; cloth, gloves and metal goods are also manufactured here, and there are spinning-mills. Famous for its wines, and possessing the oldest sparkling wine cellarage in Germany. Esslingen does a considerable trade in wine and fruit.

ESTABLISHMENT, a word applied to certain religious bodies in their relation to the State.

Perhaps the best definition which can be given, and which will cover all cases, is that establishment implies the existence of some definite and distinctive relation between the State and a religious society (or conceivably more than one) other than that which is shared in by other societies of the same general character. It denotes any special connection with the State, or privileges and responsibilities before the law, possessed by one religious society to the exclusion of others; in a word, establishment is of the nature of a monopoly.

But it does not imply merely privilege. The State and the Church have mutual obligations towards one another: each is, to some extent, tied by the existence of this relationship, and each accepts the limitations for the sake of the advantages which accrue to itself. The State does so in view of what it believes to be the good of all its members; for "the true end for which religion is established is not to provide for the true faith, but for civil utility" (Warburton), even if the latter be held to be implied in the former. On the other hand, the Church accepts these relations for the facilities which they involve, *i.e.*, for its own benefit.

It will be seen that this definition excludes, and rightly, many current presuppositions. Establishment affirms the *fact*, but does not determine the precise *nature*, of the connection between the State and the religious society. It does not tell us, for example, when or how it began, whether it is the result of an unconscious growth (as with the Gallican Church previous to the French Revolution), or of a determinate legislative act (as with the same Church re-established by the Concordat of 1801). It does not tell us whether an endowment of the religious society by the State is included; what particular privileges are enjoyed by the religious society; and what limitations are placed upon the free exercise of its life. These things can be ascertained only by actual

inquiry; for the conditions are precisely similar in no two cases.

Of the sovereign States existent in 1928 about two-thirds were without establishments, among them the United States, France, Germany, Poland, Hungary and Japan. But among the nations having no State religion some give support to ecclesiastical organizations. Thus, in the Argentine Republic the Roman Catholic Church is State-supported, and in the Netherlands the Protestant, Roman Catholic, Jansenist and Jewish churches receive financial assistance from the Government. In Belgium the ministers of all religious congregations are assisted by the national treasury. Besides England, the nations supporting establishments include Spain, Sweden, Italy, Bulgaria, Greece, Finland, Bolivia and Peru. Of the total number of such countries about one-half are monarchies and one-half republics, while in the States without establishments the proportion is, respectively, about one-third and two-thirds.

Church of England.—The word Establishment as applied to the Church of England denotes the existence of a special relationship between Church and State without defining its exact nature. The statement that this Church is "established by law" denotes that it has a peculiar status before the law; but this is all. It cannot be said that it was established at any particular time, or by any particular legislative act. There were no doubt periods when the existing relations between Church and State were modified or re-defined, notably in the 16th and 17th centuries; but the relations themselves are far older. They existed from the first; the English Church and State grew up side by side, and from the very beginning they were in close relations with one another. But although the state of things which it represented was there from the first, the term "established," or "established by law," came into use only at a later date. Until there was some other religious society to be compared with it, such a distinctive epithet would have had no point.

The questions which arise out of the relations between Church and State are difficult and their difficulties are increased by the imperfections and ambiguities of language; which lead us to forget that *Church* and *State* are abstract terms; that the concrete reality underlying each is an aggregate of individuals knit together by an ideal bond; and that the same persons who from one point of view constitute the State constitute the Church also, the Church being the nation on its religious side. The theory of a Church Establishment rests historically on the assumption that, this being so, it is the right and duty of a Christian State to exert its influence for the maintenance and propagation of religion. But the case is materially changed when the unity of Christian belief has been split up into a multitude of conflicting sects. The application of the general principle to such a state of things is then beset with grave difficulties both of theory and in practice.

Religious Establishments have been defended and attacked on grounds of principle. Their authority is, in fact, founded on utility; and is to be argued, not as a matter of right or wrong, but on certain broad lines of moral and political science which we are left to discover and apply by the light of our own reason and conscience. Their application will vary with circumstances. Man is the measure of all things, or, in the language of religion, "the Sabbath was made for man." This is particularly the case when questions of property are involved. Should circumstances lead to a separation between Church and State, what is to be held with regard to the property which has previously been enjoyed by the former either by the gift of the State or under the sanction of the law? It requires some hardihood to argue that its secularization is, as such, unlawful; or to deny that the title of the Church to its possession is less subject than that of secular corporations to the *altum dominium* of the State.

The *locus classicus* on the question as a whole is the chapter in Paley's *Principles of Moral and Political Philosophy*, "Of Religious Establishments and of Toleration." The conclusion arrived at is, "That a comprehensive national religion, guarded by a few articles of peace and conformity; together with a legal provision for the clergy of that religion; and with a *complete* toleration of all dissenters from the Established Church, without any other limitation or exception than what arises from the conjunction of dangerous political dispositions with certain religious tenets—appears to be, not only the most just and liberal, but the wisest system which a state can adopt: inasmuch as it unites the several perfections which a religious constitution ought to aim at—liberty of conscience, with means of instruction; the progress of truth, with the peace of society; the right of private judgment, with the care of the public safety."

The Concordat.—In mixed countries like England, a Church Establishment, which has in itself the nature of privilege, is unlikely either to be introduced, or, if it has been abolished, to be restored. Where it exists and works for the greater good of the greater number, it may reasonably be retained. Should it, however, become a source of inconvenience or discord, its sufficient reason would disappear. Were the Dissenters to be in a majority, the Establishment itself should be revised and qualified, Paley thinks; were there a certain parity of sects, he suggests a scheme of concurrent endowment. In England many of the reforms which he desired have now been introduced; and the judgments of the Courts of Appeal have been uniformly in the direction of inclusion: the less we define, it has been recognised, the better: "Vitals in religion are few." It is the tendency of the larger Churches to develop on the lines of a Concordat, on the one hand between religion and secular thought, and on the other between conflicting Church parties. In an age when the clerical and the lay minds are diverging more and more widely, and the fissiparous tendencies of religious parties appear to be on the increase, it is difficult to see how the coherence of the body corporate can be retained. Whether this difficulty can, or cannot, be overcome is the religious, perhaps not only the religious, problem of our time.

Disestablishment is in theory the annulling of establishment; but since an established Church is usually rich, disestablishment generally includes disendowment, even where there is no state endowment of religion. It is, in short, the abrogation of establishment, coupled with such a confiscation of Church property as the State thinks good in the interests of the community.

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ESTABLISHMENT OF A PORT, the technical expression for the time that elapses between the moon's transit across the meridian at new or full moon at a given place and the time of highwater at that place. The interval (constant at any one place) may vary from 6 mins. (Harwich) to 11 hrs. 45 mins. (North Foreland). At London Bridge it is 1 hr. 58 mins. (*See* Tide.)

ESTAING, CHARLES HECTOR, Comte d' (1729–1794), French admiral, was born at the château of Ruvel, Auvergne. In 1757 he accompanied count de Lally to the East Indies, with the rank of brigadier-general. In 1759 he was made prisoner at the siege of Madras, but was released on parole. On his return to France in 1760 he fell into the hands of the English and, on the ground of having broken his parole, was thrown into prison at Portsmouth, but soon released. In 1778 he obtained the command of a fleet intended to assist the United States against Great Britain. He sailed on April 13, and between July 11 and 22 blockaded Howe at Sandy Hook. In concert with the American generals, he planned an attack on Newport; but before the concerted attack could take place, he put to sea against the English fleet,

under Lord Howe. A storm shattered his fleet, and he had to put into Boston for repairs. He then sailed for the West Indies on Nov. 4 where he captured St. Vincent and Grenada. On July 6, 1779 he fought a drawn battle with Admiral John Byron, who retired to St. Christopher. Though superior in force, D'Estaing would not attack the English in the roadstead, but set sail to attack Savannah. All his attempts were repulsed with heavy loss. He returned to France in 1780. He was in command of the combined fleet before Cadiz when the peace was signed in 1783. In 1787 he was elected to the assembly of the notables; in 1789 he was appointed commandant of the national guard; and in 1792 he was chosen admiral by the National Assembly. On the trial of Marie Antoinette in 1793 he bore testimony in her favour. He was himself brought to trial, and was executed on April 28, 1794.

See Viscomte de Noailles, *Marins et soldats français en Amérique* (1903); Beatson, *Naval and Military Memoirs of Great Britain*, vol. v.

ESTATE, the state or condition in which a man lives, now chiefly used poetically and in such phrases as "man's estate," or "of high estate"; "state" has superseded most of the uses of the word except (1) in property, and (2) in constitutional law.

1. In the law of property the word is employed in several senses. In the widest sense a man's estate comprises his entire belongings; so much of it as consists of land and certain other interests associated therewith is his "real estate"; the rest is his "personal estate." The word is more particularly applied to interests in land, and in popular and general use "an estate" means the land itself. The strict technical meaning at common law of "an estate" was a freehold in lands. "The first thing that the student has to do," says Joshua Williams (*Law of Real Property*), "is to get rid of the idea of absolute ownership. Such an idea is quite unknown to the English law. No man is in law the absolute owner of lands. He can only hold an estate in them." That is, the notion of tenure, of holding by a tenant from a lord, prevails. The last lord of all from whom all land was ultimately held was the king. Persons holding directly from the king and granting to others were the king's tenants *in capite*, and were the mesne lords of their tenants.

Legal estates in land were of three kinds: (1) Fees simple, under which the land on the death of the owner intestate descended to his common law heir, and if he had no such heir escheated to the lord of whom it was held, who claimed on the ground that though he had no estate in the land himself, yet as the lord of whom it was held, he was entitled to it on the failure of the estate granted to the tenant in fee simple; (2) fees tail, under which the land, on the death of the tenant in tail, descended to the heir of his body, whether he died intestate or not, and if he left no heir of the body the land reverted to the grantor who after granting the fee tail still was the owner in fee simple, in remainder of the land; (3) life estate, which were of two kinds, estates for the life of the tenant and estates for the life or lives of some other person or persons (called estates *pur autre vie*). The chief distinction was that an estate *pur autre vie* might survive the tenant, and then, unless it was limited to him and his heir, the land became ownerless till someone took possession of it (called the "general occupant").

All this has now, so far as England is concerned, been abolished by The Law of Property Act. Now, the only legal estate that can subsist in land is fee simple, and it is practically absolute ownership since escheat and the other incidents of tenure including kinship are abolished. Fee tail and life estates can subsist only as equitable interests, so equitable fee tail may be disposed of by the will of the tenant in tail.

Interests in land not of freehold were not regarded at common law as any part of the ownership, but merely as hirings of the land. They were divided into (i.) interests, a time certain (often called terms, the instruments creating them being termed leases or demises, and the interests leaseholds); (ii.) tenancies at will, that is, where lands or tenements are let by one man to another to have and to hold at the will of the lessor; (iii.) tenancies at sufferance, where one comes into possession of land under a lawful title, and continues in possession after his title has determined.

Under the Law of Property Act, 1925, absolute terms are the only legal interests besides fees simple which can now subsist in lands. Accordingly the old common law as to personalty, which permitted only absolute ownership and hiring of goods, now applies to land.

(2) In constitutional law an estate is an order or class having a definite share as such in the body politic, and participating either directly or by its representatives in the Government. The system of representation by estates took its rise in western Europe during the 13th century, at a time when the feudal system was being broken up through various causes, notably the growing wealth and power of the towns. In the feudal council the clergy and the territorial nobles had alone had a voice; but the 13th century, to quote Stubbs, "turns the feudal council into an assembly of estates, and draws the constitution of the third estate from the ancient local machinery which it concentrates." This is, allowing for differences of detail, true of other countries as well as England. To the two estates already existing, clergy and nobles, is added a third, that of the commons (burgesses and knights of the shire) in England, that of the *roturiers* in France (known as the *tiers état*).

The system of estates, based on the mediaeval conception of society as divided into definite orders, formed the basis of whatever constitutional forms survived in Europe till the French Revolution. In England, of course, it had early become obscured, the House of Commons representing the whole nation outside the narrow order of the peers. The phrase "three estates," as applied to the English Constitution at present, is misleading. It is now usually understood of the lords spiritual, the lords temporal and the commons.

In the constitutional struggles of the European continent, from the Revolution onward, the rival theories of representation by estates and of popular representation have played a great part. The crucial moment of the French Revolution was when the vote according to "order" was rejected, and the estates of the clergy and nobles were merged with the *tiers état*, the States-General thus becoming the National Assembly. This was the precedent followed, generally speaking, during the 19th century in the other countries in which constitutional government was established.

The plural form ESTATES or STATES was the name commonly given to an assembly of estates. When such an assembly was not merely local or provincial it was called the Estates-General or States General, *e.g.*, in France the assembly of the deputies of the three estates of the realm as distinct from the provincial estates, which met periodically in the so-called *pays d'états*. (*See* also REPRESENTATION.)

For further details about the estates in England and elsewhere *see* W. Stubbs, *Constitutional History*; vol. ii. (1896); H. Hallam, *The Middle Ages* (1855); F. W. Maitland, *Constitutional History of England* (1908); A. Luchaire, *Histoire des institutions monarchiques de la France* (1883–85); G. Waitz, *Deutsche Verfassungsgeschichte* (Kiel, 1865–78); and A. S. Rait, *The Scottish Parliament* (1901).

United States.—Generally speaking, the common law system of estates prevails in America. With the Revolution the various States succeeded to the rights of king as overlord with the result that the owner of an estate in fee simple holds directly of the State. If he died without heirs the land escheats to the State. In a few States, by statute or judicial decision land is not held of the State but the system of allodial ownership prevails. The differences, however, are not marked inasmuch as the State also succeeds to the allodial owner should he die without heirs.

The estate tail also exists in the United States. In many States it has been abolished by statute, such statutes operating either to give the donee in tail an estate in fee simple or an estate for life. In Iowa, the estate tail was abolished by judicial decision, the existence of such an estate in land being regarded as inimical to the spirit, genius and institutions of America. Some States by interpreting legislation as impliedly repealing the old English statute of *De Donis* have thereby abolished the estate tail. The old English devices of common recoveries and fines that enabled a tenant in tail to transform his estate into a fee simple were recognized in America. Statutes in practically all

States now enable the tenant in tail to accomplish this result with greater ease, a properly recorded conveyance by him being deemed sufficient.

The common law life estate has survived with little change. In dealing with estates *pur autre vie*, statutes have generally abolished the common law doctrine of the common occupant and made specific provisions for the disposition of the residue where the tenant dies and under the old view the land becomes ownerless.

ESTATE AND HOUSE AGENTS. A person exercising the calling of a house agent in England is required, under a penalty, to take out yearly a licence upon which is charged excise duty, unless he is licensed as an auctioneer or appraiser, or is an agent employed in the management of landed estates, or a solicitor or conveyancer who has taken out his annual certificate as such. In this connection a person is deemed to be a house agent if he advertises for sale or for letting, or in any way negotiates for the selling or letting of any furnished house or part of any furnished house (any storey or flat rated and let as a separate tenement being for this purpose a house); subject, however, to the qualification that no one is to be deemed to be a house agent by reason of his letting, or offering to let, or in any way negotiating for the letting of, any house the annual rent or value of which does not exceed £25.

His business is to endeavour to find a person willing to become a purchaser or tenant and then to communicate his offer to the owner. Unless express authority is given to the agent to sell or let, and for that purpose to enter into a binding contract, the principal reserves his right to accept or refuse the offer. As a rule, a house or estate agent has no authority to receive payment on behalf of the principal. Where he is employed to procure a tenant, he must use reasonable diligence to ascertain that the person to whom the property is let through his agency is fit to be a tenant. He does not, however, in any way guarantee the payment of the rent. A house agent may not, for or in expectation of payment, prepare any deed relating to the sale or letting of real or personal estate. There is, however, no similar prohibition as to agreements not under seal.

House agents are usually remunerated by way of commission. The scale adopted by the Institute of Estate and House Agents embodies the rates usually charged. In the absence of express provision upon the subject between the principal and the agent, commission is payable when the latter has found a purchaser or tenant willing to buy or take property upon the terms upon which the principal intimated to him his willingness to sell or let it.

Most auctioneers, in addition to holding auctions, carry on the business of house and estate agency. (*See* AUCTION; PRINCIPAL AND AGENT; VALUATION.)

ESTATE DUTIES. From early times the occasion of death has provided a convenient opportunity for the sovereign or the state to participate in the reckoning which necessarily follows a man's death. The casualties incident to feudal tenure were in effect taxes on successions to property levied by the sovereigns of England through the "*inquisitio post mortem.*" The court of wards and liveries established by Henry VIII. regulated these enquiries until its abolition in the reign of Charles II. Death duties as such first appeared upon grants of probate and administration, being copied from Holland in June, 1694, during the reign of William and Mary. Imposed first at a low rate of only 5s. for each probate for property above £20 in value, the duties between 1779 and 1797 were charged on an ascending scale. Under the influence of the Napoleonic Wars the rates were further increased and the graduation extended up to estates of the value of £1,000,000 sterling. In 1804 a probate duty similar to that in force in England was imposed in Scotland. Another succession tax was first imposed in Great Britain in 1780, when stamps were required on receipts for legacy. When it was discovered that by the absence of a receipt the duty would be avoided a further act was passed in 1796 by which the duty was imposed upon the legacy. The act was confined to legacies of personal estate—a bill proposed by Pitt for similar duties on legacies charged upon and devises of real estate having been withdrawn. This legacy duty distinguished the recipients of legacies according to the nearness or remoteness of their relationship with their benefactor. At the beginning the lowest rate was 2% for brothers and sisters and their descendants and the highest rate was 6% for strangers in blood.

In 1805 the charge of legacy duty was extended to testamentary gifts of the proceeds of sales of real property but it was not until 1853, by the Succession Duty Act of that year, that (under the name of succession duty) a death duty corresponding in principle to the legacy duty was thrown on acquisitions of two main categories of property which had previously escaped the charge of a death duty. These consisted of personal property which was not previously liable to legacy duty, composed mainly of settled movable property, and real property. After the introduction of the new duty, leasehold property devolving under a will or intestacy was charged therewith instead of with legacy duty, and in 1888 succession duty replaced the legacy duty which since 1805, as already noted, had been charged on testamentary gifts of the proceeds of sale of real property.

Another succession duty, known as account duty, was imposed in 1881 and partook of the nature of a preventive of the evasion of probable duty rather than of a new tax. It was confined to personal or movable property and imposed upon such descriptions of property as property taken as *donatio mortis causa*, and property passing under any voluntary settlement by deed or any other instrument not taking effect as a will, whereby an interest in the property for any period determinable by death was reserved to the settlor. Temporary estate duty was introduced in 1889 at the rate of 1% on all personal property exceeding the value of £10,000 passing by will or intestacy or included in "Account" and also on successions exceeding the value of £10,000. This tax was levied in addition to the probate and legacy or succession duties.

In 1894 the littered state of this part of the field of taxation was partially cleared up by the imposition of the estate duty and the sweeping away of the probate duty (which in Scotland had come to be called inventory duty), account duty and temporary estate duty. These taxes, however, remained leviable in connection with deaths which occurred during specified periods, the last of which did not expire until May 12, 1914. Three duties are left, which fall into two classes. The first class is represented by the estate duty—a duty payable with reference to the acquisition of property on death; the second class comprises the old legacy duty and succession duty, each of which, as already stated, is a duty payable with reference to the acquisition of property by beneficiaries. Details of the present legacy duty and succession duty are given under the head of LEGACY DUTY.

The British Estate Duty.—1. The estate duty was imposed by the Finance Act, 1894, but the provisions of that act have been varied from time to time by amendments contained in subsequent finance and other acts. Speaking broadly, estate duty is an *ad valorem* graduated tax leviable upon the principal value of all property situate in Great Britain (whether immovable or movable, settled or not settled), which passes upon the death, after Aug. 1, 1894, of any individual; the liability in respect of such property attaches without reference either to the domicile of the deceased or to the distribution of the property among the beneficiaries, or to the method by which such distribution is regulated.

2. Property so passing includes the following:—

(a) Property of which the deceased was at the time of death competent to dispose (*e.g.*, by the exercise of a general power of appointment), whether actually disposed of or not.

(b) Gifts made by the deceased during illness, in contemplation, and intended only to become absolute in case of death (*donationes mortis causâ*).

(c) Gifts made by the deceased *inter vivos* without reservation within three years preceding death (excluding, however, gifts made for public or charitable purposes more than 12 months before his death; gifts made in consideration of marriage; reasonable gifts proved to have been part of his normal expenditure; and gifts not exceeding £100 in value in case of any donee).

(d) Gifts made by the deceased *inter vivos*, at any time, if

bona fide possession of the gift was not immediately assumed and thenceforth retained by the donee to the entire and irrevocable exclusion of the donor.

(e) Property which the deceased had voluntarily transferred from his own absolute ownership to the joint ownership of himself and some other person so that some beneficial interest therein passed by survivorship on his death to such other person.

(f) Moneys receivable under policies of insurance on the life of the deceased, effected and kept up by him wholly or partially for the benefit of a donee.

(g) Any annuity (subject to minor exceptions) or other interest, which the deceased provided, either alone or with some other person, to the extent of the beneficial interest arising by survivorship on his death.

(h) Property in which the deceased, or any other person, had an interest ceasing on the death of the deceased, to the extent to which a benefit arises by the termination of that interest.

(i) Property passing under any instrument executed by the deceased (not taking effect as a will) under which he reserved an interest, or any right to resume his interest, in the property.

3. Immovable property situate out of Great Britain, devolving as such, is not liable to estate duty in any circumstances.

4. Movable property situate out of Great Britain is, speaking generally, only chargeable with estate duty either (i.) when the deceased was the owner and was domiciled in some part of Great Britain; or (ii.) when the deceased was only interested for life, and at his death the property formed the subject of a British trust or was vested in a British trustee.

5. Immovable property means lands and houses and all interests therein, including leasehold interests; movable property includes all other property, whether tangible (such as goods, furniture, etc., having a physical situation), or intangible (such as stocks, shares, securities, etc., which, in strictness, consisting only of rights, have no physical situation).

Rates of Estate Duty.—6. Estate duty is charged at an *ad valorem* rate on the net principal value of the estate in accordance with the rates shown in the table in next column.

Provision is made for two fixed duties in the case of estates not exceeding a gross value of (*a*) £300, and (*b*) £500, viz., 30s. and 50s. respectively. The net principal value of the estate is represented by the aggregation of the principal values of all the items of property, less deductions for reasonable funeral expenses, and, subject to certain restrictions, for debts and incumbrances incurred or created by the deceased *bona fide* for full consideration. The principal value of any property is defined to be the price which, in the opinion of the commissioners of inland revenue, the property would fetch if sold in the open market at the time of the death of the deceased. The rule of aggregation for determination of the net principal value subject to duty is, however, subject to certain complex exceptions.

7. The statutes provide for exemptions of certain property from estate duty, among which may be mentioned (*a*) the exemption of estates of a total net principal value not exceeding £100; (*b*) the exemption of the property of common seamen, marines, soldiers or airmen who are slain or die in His Majesty's service; (*c*) the exemption, or partial exemption (i.) of the property passing on the death of certain persons killed in war, (ii.) of certain pensions granted by the Government of British India, (iii.) of perpetual rights of presentation to ecclesiastical benefices, and (iv.) of certain articles which are ascertained to be of national, scientific, historic or artistic interest. Moreover, certain British Government securities issued during the World War, and during a further period of one year after its termination, are also (under the terms of their issue), expressly exempted from the duty when held by persons who are neither domiciled nor ordinarily resident in the United Kingdom.

8. To avoid double taxation of movable property situated in a British dominion which, by reason of the same death is liable (i.) to the British estate duty (in the circumstances mentioned in paragraph 4 above) and (ii.) to a death duty in the dominion, arrangements exist under statutory powers by which, when certain conditions are fulfilled, such property pays only so much duty as

Great Britain: Rates of Estate Duty

Small estates—where the gross value does not exceed £300—a fixed duty of 30s. may be paid.
Small estates—where the gross value exceeds £300 and does not exceed £500—a fixed duty of 50s. may be paid.
} Inclusive of all other death duties.

Estates not exceeding £100 net are exempt. Agricultural property is rated on a slightly different basis.

Where the net principal value of the estate		Rate of duty % when the death occurred:					
Exceeds	And does not exceed	After Aug. 1, 1894, and before April 19, 1907*	After April 18, 1907, and before April 30, 1909	After April 29, 1909, and before Aug. 16, 1914	After Aug. 15, 1914, and before Aug. 1, 1919†	After July 31, 1919, and before June 30, 1925†	After June 29, 1925†
£	£						
100	500	1	1	1	1	1	1
500	1,000	2	2	2	2	2	2
1,000	5,000	3	3	3	3	3	3
5,000	10,000	3	3	4	4	4	4
10,000	12,500	4	4	5	5	5	5
12,500	15,000	4	4	5	5	5	6
15,000	18,000	4	4	5	5	6	7
18,000	20,000	4	4	5	5	6	8
20,000	21,000	4	4	6	6	7	8
21,000	25,000	4	4	6	6	7	9
25,000	30,000	4½	4½	6	6	8	10
30,000	35,000	4½	4½	6	6	9	11
35,000	40,000	4½	4½	6	6	9	12
40,000	45,000	4½	4½	7	7	10	13
45,000	50,000	4½	4½	7	7	10	14
50,000	55,000	5	5	7	7	11	15
55,000	60,000	5	5	7	7	11	16
60,000	65,000	5	5	7	8	12	16
65,000	70,000	5	5	7	8	12	17
70,000	75,000	5	5	8	8	13	17
75,000	80,000	5½	5½	8	8	13	18
80,000	85,000	5½	5½	8	9	13	18
85,000	90,000	5½	5½	8	9	13	19
90,000	100,000	5½	5½	8	9	14	19
100,000	110,000	6	6	9	10	14	20
110,000	120,000	6	6	9	10	15	20
120,000	130,000	6	6	9	10	15	21
130,000	140,000	6	6	9	10	16	21
140,000	150,000	6	6	9	10	16	22
150,000	170,000	6½	7	10	11	17	22
170,000	175,000	6½	7	10	11	17	23
175,000	200,000	6½	7	10	11	18	23
200,000	225,000	6½	7	11	12	19	24
225,000	250,000	6½	7	11	12	20	24
250,000	300,000	7	8	11	13	21	25
300,000	325,000	7	8	11	14	22	25
325,000	350,000	7	8	11	14	22	26
350,000	400,000	7	8	11	15	23	26
400,000	450,000	7	8	12	16	24	27
450,000	500,000	7	8	12	16	25	27
500,000	600,000	7½	9	12	17	26	28
600,000	750,000	7½	9	13	18	27	28
750,000	800,000	7½	10	13	18	27	29
800,000	1,000,000	7½	10	14	19	28	29
1,000,000	1,250,000	8	10 On one million; 11 On the remainder	15	20	30	30
1,250,000	1,500,000	8	10; 11	15	20	32	32
1,500,000	2,000,000	8	10; 12	15	20	35	35
2,000,000	2,500,000	8	10; 13	15	20	40	40
2,500,000	3,000,000	8	10; 14	15	20	40	40
3,000,000	..	8	10; 15	15	20	40	40

*Other rates of estate duty, viz., ½, 1½, 2½ and 3½% may also arise in the circumstances set out in section 12, sub-section 2, of the Finance Act, 1900.

†The amount of duty is, where necessary, to be reduced so as not to exceed the highest amount which would be payable at the next lower rate plus the amount by which the value of the estate exceeds the value on which the highest amount of duty would be so payable at the lower rate.

British Estate Duties: Estates Passing and Field of Estate Duty

Capital value of estates		Value of estates			Net receipt of duty					
		Average of pre-war years 1911–12, 1912–13, and 1913–14	1925–26	1926–27	Average of pre-war years 1911–12, 1912–13 and 1913–14		1925–26		1926–27	
Exceeding	Not exceeding									
£	£	£	£	£	£000	%	£000	%	£000	%
..	1,000	18,452	29,538	30,801	253	1·34	419	·8	435	·74
1,000	5,000	37,870	68,737	70,009	1,137	6·02	2,047	3·87	2,087	3·53
5,000	10,000	26,053	48,699	49,033	1,030	5·45	1,933	3·66	1,945	3·29
10,000	50,000	72,855	130,809	136,011	4,134	21·88	10,348	19·57	11,998	20·30
50,000	100,000	30,784	51,759	49,743	2,292	12·13	7,399	13·99	8,077	13·68
100,000	500,000	50,832	77,944	81,885	5,191	27·48	16,001	30·27	18,340	31·03
500,000	1,000,000	14,791	25,174	23,578	1,924	10·19	6,793	12·85	6,776	11·46
1,000,000	..	19,821	26,568	25,407	2,929	15·51	7,927	14·99	9,433	15·97
Totals		£271,458	£459,228	£466,467	£18,890	100%	£52,867	100%	£59,091	100%

The corresponding system of the United States is called estate or inheritance tax and will be found treated in the article *Taxation*, in the section on the United States.

is equal to the larger of the two taxes.

9. The accompanying table shows the value of estates liable to duty and the net receipt of the duty for the average of the three pre-war years, 1911–12, 1912–13, 1913–14, and for the two years 1925–26 and 1926–27.

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ESTAUNIÉ, EDOUARD (1862–), French novelist, was born at Dijon on Feb. 4, 1862. Estaunié, who became an academician in 1924, has written novels which carry on the great traditions of the French psychological novel. They are profound in their analysis, which is based on a detailed account of the characters, demanding prolonged attention from the reader. Throughout runs the thesis that the external life of each individual masks an internal life, usually very different and much more important. Incidentally, the novels provide vivid and penetrating pictures of provincial France. The more important of them are: *L'Empreinte* (1896), a study of the influence of Jesuit education; *La Vie secrète* (1908), the title of which is indicative of Estaunié's main contention; *Les Choses voient* (1913), in which three pieces of furniture relate the history of three generations; *L'Ascension de Monsieur Baslivre* (1920), the story of the official and the private life of a French civil servant; *L'Appel de la route* (1922).

ESTCOURT, RICHARD (1668–1712), English actor, made his first London appearance in 1704 as Dominick, in Dryden's *Spanish Friar,* and continued to take important parts at Drury Lane, being the original Pounce in Steele's *Tender Husband* (1705), Sergeant Kite in Farquhar's *Recruiting Officer,* and Sir Francis Gripe in Mrs. Centlivre's *Busybody.* He was an excellent mimic and a great favourite socially. Estcourt wrote a comedy, *The Fair Example, or the Modish Citizen* (1703), and *Prunella* (1704), an interlude.

EST DE FRANCE, COMPAGNIE DES CHEMINS DE FER, established in 1854, serves the east of France in various regions.

From Paris, three main railway lines serve this region: to the north the line from Paris to Charleville via Rheims, to the centre the line from Paris to Strasbourg via Nancy, to the south the line from Paris to Basle via Troyes. Two arteries assure the economical relations existing between the north and the south-east of France.

The Vosges region already utilises the motive power of its streams in a great number of flourishing industries. Portieux glass works, Baccarat and Cirey glass cutting works, Arches and Etival paper mills, materials imported from Alsace with bleaching on the grass. The Lorraine bearing is divided into three basins: the group from Nancy to Pont-St.-Vincent, Neuves-Maisons, Frouard, Pompey, Pont-à-Mousson; the Briey group the two centres of which are Joeuf and Homécourt; the Longwy group finally which includes Villerupt, Micheville, Saulnes, Longwy and Mont-Saint-Martin. Finally the Sarrebruck coal valley extends under the level Pont-à-Mousson, Nomény, but at a depth (800 to 1,200 metres) which has not yet allowed of its exploitation. The salt industry at Saint-Nicolas-du-Port, Rosières, Verangéville, Dombasle, is combined with that of soda, and the Solvay process has extended it.

The Eastern region does not lack tourist sites of repute. The valleys of the Vosges attract every year to Gérardmer, Bussang and Saint-Dié and a great number of other summer stations, an always increasing number of visitors. Its large towns are interesting to visit owing to the highly artistic remains preserved from olden times. There are numerous thermal stations, some of which, like Vittel, have attained a world-wide reputation. Where the railway ends there are to be found excellent services of motor cars to the outlying districts. (GRU.)

ESTE, one of the oldest of the former reigning houses of Italy. It is in all probability of Lombard origin, and descended, according to Muratori, from the princes who governed in Tuscany in Carolingian times. The lordship of the town of Este was first acquired by Alberto Azzo II., who also bore the title of marquis of Italy[1] (d. *c.* 1097); he married Kunitza or Kunegonda, sister of Welf or Guelph III., duke of Carinthia. Welf died without issue, and was succeeded by Welf IV., son of Kunitza, who married a daughter of Otto II., duke of Bavaria, and who obtained the duchy of Bavaria in 1070. Through him the house of Este became connected with the princely houses of Brunswick and Hanover. The Italian titles and estates were inherited by Folco I. (1060–1135), son of Alberto Azzo by his second wife Gersende, daughter of Herbert I., count of Maine. The house of Este played a great part in the history of mediaeval and Renaissance Italy, and it first comes to the front in the wars between the Guelphs and Ghibellines; as leaders of the former party its princes received at different times Ferrara, Modena, Reggio and other fiefs and territories.

Obizzo I., son of Folco, was the first to bear the title of marquis of Este. He entered into the Guelphic league against the emperor Frederick I., and was comprehended in the treaty of Venice of 1177 by which municipal *podestàs* (foreigners chosen as heads of cities to administer justice impartially) were instituted. He was elected podestà of Padua in 1178, and in 1184 he was reconciled with Frederick, who created him marquis of Genoa and Milan. By the marriage of his son Azzo to the heiress of the Marchesella family he acquired great influence in Ferrara although he was opposed by the hardly less powerful house of Torelli.

Obizzo died in 1194 and Azzo V. having predeceased him, the marquisate devolved on his grandson Azzo VI. (1170–1212), who became head of the Guelph party, and to him the people of Ferrara sacrificed their liberty by making him their first lord (1208). But during his lifetime civil war raged in the city, between the Este and

[1]Margrave of the Empire (*Marchio Sancti Imperii*) in Italy. (*See* MARQUESS.)

the Torelli, each party being driven out again and again. Azzo (also called Azzolino) died in 1212 and was succeeded by Aldobrandino I., who in 1213 concluded a treaty with Salinguerra Torelli, the head of that house, to divide the government of the city between them. On his death in 1215 he was succeeded by his brother Azzo VII. (1205–1264), surnamed Novello, but Salinguerra Torelli usurped all power in Ferrara and expelled Azzo (1222). In 1240 Pope Gregory IX. determined on another war against the emperor Frederick II., but deemed it wise to begin by crushing the chief Ghibelline houses. Thus Azzo found himself in league with the pope and various Guelph cities in his attempt to regain Ferrara. That town underwent a four months' siege, and was at last compelled to surrender; Salinguerra was sent to Venice as a prisoner, and Azzo ruled in Ferrara once more. The Ghibelline party was annihilated, but the city enjoyed peace and happiness within, although her citizens took part in the wars raging outside. The Guelph cause triumphed, Frederick being defeated several times, and after his death Azzo helped in crushing the terrible Eccelino da Romano (*q.v.*) who upheld the imperial cause, at the battle of Cassano (1259). He died in 1264 and was succeeded by Obizzo II. (1240–1293) his grandson, who in 1288 received the lordship of Modena, and that of Reggio in 1289.

Obizzo II. died in 1293 and was succeeded by his son Azzo VIII., but the latter's brothers, Aldobrandino and Francesco, who were to have shared in the government, were expelled and became his bitter enemies. The misgovernment of Azzo led to the revolt of Reggio and Modena, which shook off his yoke. He died in 1308, and left a disputed succession.

The history of the house now becomes involved and of little interest until we come to Nicholas III. (1384–1441), who ruled Ferrara, Modena, Parma and Reggio, waged many wars, was made general of the army of the Church, and in his later years governor of Milan, where he died, not without suspicion of poison. To him succeeded Lionello (1407–1450), a wise and virtuous ruler and a patron of literature and art; then Borso (1413–1471), his brother who was created duke of Modena and Reggio by the emperor Frederick III., and duke of Ferrara by the pope. In spite of the wars by which all Italy was torn, Ferrara enjoyed a period of peace and prosperity under Borso; he patronized literature, established a printing press at Ferrara, surrounded himself with learned men, and his court was of unparalleled splendour. He also protected industry and commerce, and ruled with great wisdom. His brother Ercole I. (1431–1505), who succeeded him in 1471, was less fortunate, and had to engage in a war with Venice, and by the peace of 1484 was forced to cede the district of Polesine to the republic. But the last years of his life were peaceful and prosperous. Boiardo the poet was his minister, and Ariosto obtained his patronage.

Ercole's daughter Beatrice d'Este (1475–1497), duchess of Milan, one of the most beautiful and accomplished princesses of the Italian Renaissance, was betrothed at the age of five to Lodovico Sforza (known as *il Moro*), duke of Bari, regent and afterwards duke of Milan, and was married to him in Jan. 1491. She availed herself of her position as mistress of one of the most splendid courts of Italy to surround herself with learned men, poets and artists, such as Niccolò da Correggio, Bernardo Castiglione, Bramante, Leonardo da Vinci and many others. In 1492 she visited Venice as ambassador for her husband in his political schemes, which consisted chiefly in a desire to be recognized as duke of Milan. On the death of Gian Galeazzo Sforza, Lodovico's usurpation was legalized, and after the battle of Fornovo (1495) both he and his wife took part in the peace congress of Vercelli between Charles VIII. of France and the Italian princes, at which Beatrice showed great political ability. But her brilliant career was cut short by death through childbirth, on Jan. 3, 1497. To her patronage and good taste are due to a great extent the splendour of the Castello of Milan, of the Certosa of Pavia and of many other famous buildings in Lombardy.

Her sister Isabella d'Este (1474–1539), marchioness of Mantua, was carefully educated both in letters and in the arts like Beatrice, and was married when barely sixteen to Francesco Gonzaga, marquis of Mantua (1490). She showed great diplomatic and political skill, especially in her negotiations with Cesare Borgia (*q.v.*), who had dispossessed Guidobaldo da Montefeltro, duke of Urbino, the husband of her sister-in-law and intimate friend Elisabetta Gonzaga (1502). She received the deposed duke and duchess, as well as other princes in the same condition, at her court of Mantua, and like her sister she gathered together many eminent men of letters and artists, Raphael, Andrea Mantegna and Giulio Romano being among those whom she employed. Both she and her husband were greatly influenced by Baldassare Castiglione (1478–1529), author of *Il Cortigiano,* and it was at his suggestion that Giulio Romano was summoned to Mantua to enlarge the Castello and other buildings. Isabella was "undoubtedly, among all the princesses of the 15th and 16th centuries, the one who most strikingly and perfectly personified the aspirations of the Renaissance" (Eugène Müntz); but her character was less attractive than that of her sister.

To Ercole I. succeeded his son Alphonso I. (1486–1534), the husband of Lucrezia Borgia (*q.v.*), daughter of Pope Alexander VI. He was gifted with great mechanical skill, and his artillery was of world-wide reputation. On the formation of the league of Cambrai against Venice in 1508, he was appointed to the supreme command of the papal troops by Julius II., but after the Venetians had sustained a number of reverses they made peace with the pope and joined him against the French. Alphonso was invited to co-operate in the new combination, and on his refusal war was declared against him, but although he began by losing Modena and Reggio, he subsequently inflicted several defeats on the papal troops. He fought on the side of the French at the battle of Ravenna (1512), from which, although victorious, they derived no advantage. Soon afterwards they retired from Italy, and Alphonso, finding himself abandoned, tried in vain to make his peace with the pope, through the mediation of Fabrizio Colonna. Leo X. proved equally bent on the destruction of the house of Este, when he too was cut off by death. Alphonso availed himself of the troubles of the papacy during the reign of the equally hostile Clement VII. to recapture Reggio (1523) and Modena (1527).

He died in 1534, and was succeeded by his son Ercole II. (1508–1559), who married Renée, daughter of Louis XII. of France, a friend of Calvin. The duke and his brother, Cardinal Ippolito the Younger, were patrons of literature and art, and the latter built the magnificent Villa d'Este at Tivoli. He was succeeded by Alphonso II. (1533–1597), remembered for his patronage of Tasso. With him the main branch of the family came to an end, and although at his death he bequeathed the duchy to his cousin Cesare (1533–1628), Pope Clement VIII., renewing the Church's hostility to the house of Este, declared that prince to be of illegitimate birth (a doubtful contention), and by a treaty with Lucrezia, Alphonso's sister, Ferrara was made over to the Holy See. Cesare held Modena and Reggio, but with him the Estensi cease to play an important part in Italian politics. For two centuries this dynasty had been one of the greatest powers in Italy, and its court was perhaps the most splendid in Europe.

The subsequent heads of the family were: Alphonso III., who retired to a monastery in 1629 and died in 1644; Francis I. (1610–1658), who commanded the French army in Italy in 1647; Alphonso IV. (1634–1662), the father of Mary Beatrice, the queen of James II. of England, who fought in the French army during the Spanish War, and founded the picture gallery of Modena; Francis II. (1660–1694), who originated the Este library, also at Modena, and founded the university; Rinaldo (1655–1737), through whose marriage with Charlotte Felicitas of Brunswick-Lüneburg the long-separated branches of the house of Este were reunited; Francis III. (1698–1780), who married the daughter of the regent Philip of Orleans. Francis III., wished to remain neutral during the war between Spain and Austria (1740), but the imperialists having occupied and devastated his duchy, he took the Spanish side and was appointed *generalissimo* of the Spanish army in Italy. He was re-established in his possessions by the treaty of Aix-la-Chapelle (1748), and on being reconciled with the empress Maria Theresa, he received from her the title of governor of Lombardy in 1754. With his son Ercole III. Rinaldo (1727–1803), who at the peace of Campoformio lost his duchy,

the male line of the Estensi came to an end. His only daughter, Marie Beatrice (d. 1829), was married to the archduke Ferdinand, third son of the emperor Francis I. Ferdinand was created duke of Breisgau in 1803, and at his death in 1806 he was succeeded by his son Francis IV. (*q.v.*), to whom the duchy of Modena was given at the treaty of Vienna in 1814. He died in 1846 and was succeeded by Francis V. (*q.v.*), who lost his possessions by the events of 1859. With his death in 1875 the title and estates passed to the archduke Francis Ferdinand, heir to the Austro-Hungarian throne. The children of Lady Augusta Murray, daughter of the earl of Dunmore, by her marriage with Augustus Frederick, duke of Sussex, sixth son of George III. of Great Britain, assumed the old name of d'Este, and claimed recognition as members of the royal family; but as the marriage was in violation of the royal marriages act of 1773, it was declared invalid, and their claims were set aside.

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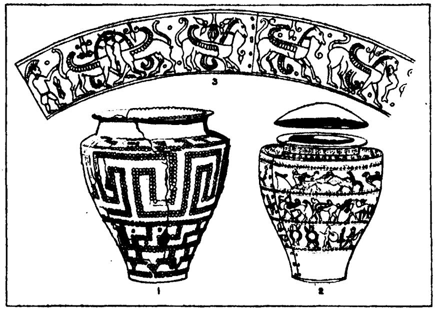
ESTE, town and Episcopal see, Venetia (anc. *Ateste*, *q.v.*), Italy, province of Padua, 20 m. S.S.W. of Padua by rail. Pop. (1921) 8,874 (town); 12,818 (commune). It lies 49 ft. above sea-level below and south of the Euganean Hills. The Adige ran close to the town until A.D. 589 but is now 9 m. S. of it. The external walls of the castle still rise above the town on the north. For its mediaeval history *see* above: ESTE (family of).

Archaeology.—Este was known to the Romans as Ateste and there are remains of Roman building. It has been reserved for the archaeologists to discover that Este was the chief centre of civilization in eastern Italy north of the Po for 800 years before the Roman occupation. A sacred precinct of the Venetic goddess Rhetia has been found here, and boundary stones of 135 B.C. divide the Ateste territory from that of Patavium.

To understand the prominent rôle played by this half-forgotten city it is necessary to understand its extraordinary geographical history. At the present day the Adige flows eight miles to the south of the town, but up to A.D. 589, when its course was suddenly changed by a catastrophic flood, the turbulent river washed the very walls. Vineyards and orchards, which now cover the whole countryside, were only planted in the Middle Ages, and actually hide a long line of sand-dunes in which the ancient cemeteries are situated. In Roman and pre-Roman days the place was practically a seaport, with almost the same outlook and natural advantages as the famous Adria at the mouth of the Po. Consequently the Atestines were so placed that they could cultivate a seaborne commerce, while at the same time they could travel by easy land routes round the head of the Gulf of Venice to Istria. On the south they were guarded by the broad and formidable stream of the Po, which effectually protected them against all attacks from that quarter. The Etruscans never penetrated into Venetia, and the Romans themselves never conquered the country, but peacefully occupied it under agreement with the inhabitants in 184 B.C. Down to the beginning of the Christian era the people of Este retained their own language and customs.

These Atestines—to use a geographical term which avoids all controversy as to the tribal identity or priority of Veneti, Euganei, or others—must be regarded as a branch of the same stock as the Villanovans. They were perhaps the latest of the cremating invaders to cross the Alps and who settled in northern Italy. Indeed, some Italian archaeologists have attempted to establish a 1st Atestine period contemporary with the 1st Benacci of Bologna; but the supposed traces of it are extremely slight, so that it is only with the beginning of the so-called second period that there is enough material for adequate treatment. This 2nd Atestine period may be dated from 950 B.C. to 500 B.C. That is to say it begins at the same time as the 2nd Benacci of Bologna and lasts down to the end of the Arnoaldi (*see* "VILLANOVANS"). The third period may be placed at 500 B.C. to 350 B.C., at which latter date the Gaulish invasions put an end to all the flourishing arts and industries of northern Italy. When these revived again to some extent under the Romans they had lost in Este, as in other places, a great deal of their individuality, and tended to become merged in the general complex of a civilization from which more of the local character had disappeared.



FROM R. MAC IVER, "IRON AGE OF ITALY" (CLARENDON PRESS)

RELICS EXCAVATED ON THE SITE OF THE ANCIENT TOWN OF ATESTE—MODERN ESTE—SHOW IT TO DATE BACK TO THE EIGHTH CENTURY B.C. Fig. 1.—Bronze studded pottery jar. Fig. 2.—Decorated jar and lid. Fig. 3.—Scene from a Boldù-Dolfin "situla" or bronze bucket

The close cousinship of the Bolognese Villanovans and the Atestines is proved by the complete identity not only of the burial rite, cremation, but of the forms and details of their graves. Moreover the contents of these graves are to a great extent identical during the whole of the second period. Amongst both peoples are found weapons and implements of the same type; there are the same bronze girdles, the same patterns of bracelets and necklaces, the same ornaments of amber and glass. Even the numerous varieties of *fibulae* are identical in the two regions and follow precisely the same steps of evolution. But with all this similarity there are also a good many points of difference; objects are found at Bologna which do not occur at Este and vice versa. It is particularly in respect of its metal work and the production of large bronze vases, or *situlae*, that Este shows its independence from the very first. The technique is the same as the Bolognese; casting was not used, but thin plates of copper or bronze were hammered out by hand and bent over to the required shape, after which they were fastened in place by rivets, often so emphasized as to form a simple ornamental motive. Large vessels made in this way occur very early in the second period, already assuming the form of the *situla* which was used as the ritual ossuary for holding the cremated ashes. On the other hand the large water jars of bronze which are among the best Bolognese products after the 8th century B.C. do not occur at Este. It is evident that these two great manufacturing centres remained quite separate and independent, though exercising a certain amount of reciprocal influence upon one another. Each was held in high repute over the whole of Italy and exported its wares far and wide, even beyond the Alps. But the Etruscan motives, which broke through the geometrical tradition and substituted decorations based on animal life and the growth of plants, did not reach Este before 500 B.C. though they had been gradually influencing Bolognese art for several generations before this.

A markedly individual product of the second period at Este is the pottery. This is a black ware, generically similar to the black ware found all over Italy and in many other parts of Europe during the Iron Age, but peculiar in the style of its decoration. The patterns are not incised, but are produced by embedding large studs of bronze in the wet clay before firing. This process results in turning out a very handsome and showy jar ornamented with

bold geometrical motives, such as those shown in fig. 1. It is a style obviously inspired by metal-work, the potter deliberately setting himself to produce the effect of repoussé ornament in a cheaper and more malleable material. The only other district in which this curious technique was practised is Falerii in central Italy. As the finest and most numerous examples, however, are found at Este, this city must be given the credit, if not for the invention, at least for the development of the idea. Bronze-studded pottery is closely delimited in chronological range. It disappears early in the third period, when it is replaced by a ware which is even more distinctively Atestine. This is a pottery painted with red ochre and graphite in alternate zones of cherry-red and lustrous black, the margins between each zone being defined by raised ridges of clay in relief. It was much admired and exported from end to end of Venetia, finding its way even as far west as Lago Maggiore.

The third period, especially the first half of the 5th century B.C., marks the zenith of Atestine art. In these two or three generations the creative spirit of the bronze-workers, stimulated by the introduction of foreign models from a variety of sources, of which the nearest and the most effective was the Etruscan, reached its high water mark. It is in the manufacture and decoration of bronze girdles and ossuaries that the spirit is chiefly displayed. The development and the decadence of this art may be traced in a fine series of bronze *situlae* in the local museum. It begins almost precisely in the year 500 B.C. with the Benvenuti *situla*, illustrated in fig. 2. This must be studied in connection with two other famous examples, the Certosa and the Arnoaldi *situlae* of Bologna. It was for a long time maintained, and is still held by some writers, that all three were produced in the workshops of Este; but of late years the best critical opinion inclines rather to regard the Certosa and Arnoaldi *situlae* as products of Bologna. In any case it is quite evident that the Benvenuti *situla* reproduces a general scheme of decoration inspired by Etruscan life and motives. The Certosa *situla* depicts an Etruscan funeral-procession and scenes from the life of the countryside. In the Benvenuti example there are similar scenes, the herdsman with his ox and dog, or the horse that is exhibited by the groom to his master. But with these are such purely Etruscan motives as the winged sphinx, as well as the stock Etruscan pictures of a military procession, a feast and a boxing match. Many *situlae* of this style were manufactured at Este and they were so popular that they were exported over the Alps even as far as the Danube. Atestine *situlae* or imitations of them have been found over an area which extends in a half-circle from Krain on the east to the Brenner on the west; the most famous specimens are those of Moritzing, Matrei, Welzelach, Meclo, Watsch, Kuffarn and Hallstatt. All these Alpine versions, however, are rather clumsy travesties of the fine Italian originals.

The artistic spirit of Este itself began to degenerate very appreciably in the 4th century. This can be seen from the *situlae* of the Boldù-Dolfin graves, which, though they are technically as well made as those of three or four generations earlier, betray a total lack of artistic taste. Instead of the fresh scenes of country life or the pleasant little pictures of cattle, deer and birds which gave a pleasing grace to the bronzes of the 5th century, the Boldù-Dolfin ossuaries show only clumsy imitations of fantastic mythological beasts, taken from the now unmeaning répertoire of a tenth-hand copyist (fig. 3). The artist has been swamped in the progress of mass-production; the Atestine factories had become too successful. Consequently the art of the 4th century B.C. has lost all freedom and individuality. As a factory centre Este was doubtless important down to Roman times, but it contributed nothing of value to civilization after A.D. 400. The student of manners, however, will find much that is interesting in the figurines of the Baratela collection, and the philologist values the Euganean inscriptions of the 4th century A.D. which are to be seen in the museum.

BIBLIOGRAPHY.—D. Randall-MacIver, *The Iron Age in Italy* (Oxford, Clarendon Press, 1927), which gives the Italian authorities. The *situlae* have been the subject of an extensive literature. Minutely studied by G. Ghirardini in *Monumenti Antichi* and in recent years by P. Ducati in a special monograph on *La situla della Certosa*, they have been well treated, as concerns their general date and history by M. Hoernes in his *Urgeschichte der bildenden Kunst*. (D. R.-M.)

ESTÉBANEZ CALDERÓN, SERAFÍN (1799–1867), Spanish author, known as "El Solitario." His *Escenas andaluzas* (1847), written in a curiously affected style, is a vivid record of picturesque scenes and local customs despite its eccentric mannerisms and its archaic vocabulary. He left an unfinished history, *De la conquista y pérdida de Portugal* (1883).

See A. Cánovas del Castillo, *"El Solitario" y su tiempo* (1883).

ESTELLA, a town of northern Spain, province of Navarre, on the left bank of the river Ega, 15 m. W.S.W. of Pamplona. Pop. (1920) 5,603. Estella, built on the site of a former Roman settlement, contains several monasteries, three fine mediaeval churches, and a college which was formerly a university. It has cloth-making and leather industries and a considerable trade in fruit, wine and cattle. In 1928 a railway from Victoria was approaching completion. Situated amid mountains commanding the roads from Castile and Aragon, Estella occupies a position of considerable strategic importance. It was long the headquarters of Don Carlos, who was proclaimed king here in 1833. In 1874, when driven from other places, the Carlists retired to Estella but on Feb. 16, 1876; those in the town finally surrendered. (For an account of the Carlist rising *see* SPAIN: *History*.)

ESTERHÁZY OF GALÁNTHA, a noble Magyar family. Its origin has been somewhat doubtfully traced to Salamon of Estoras, whose sons Péter and Illyés divided their patrimony in 1238. Péter founded the family of Zerházy, and Illyés that of Illyesházy, which became extinct in the male line in 1838. The first member of the family to emerge definitely into history was Ferencz Zerházy (1563–94), vice lord-lieutenant of the county of Pressburg, who took the name of Esterházy when he was created *Freiherr* of Galántha, an estate acquired by the family in 1421. His eldest son, Dániel (d. 1654), founded the house of Czesznek, the third, Pál (d. 1641), the line of Zólyom (Altsohl), and the fourth, Miklós, that branch of the family which occupies the most considerable place in Hungarian history, that of Fraknó or Forchtenstein.

This MIKLÓS [Nicholas] ESTERHÁZY of Galántha (1582–1645) was born at Galántha on April 8, 1582. He opposed the two great Protestant champions of the period, Gabriel Bethlen (Bethlen Gabor) and George I. Rákóczy. In 1611 he married Orsolyá, the widow of the wealthy Ferencz Mágocsy, thus coming into possession of her gigantic estates, and in 1622 he acquired Fraknó. He received many honours from Matthias II. and Ferdinand II., including the order of the Golden Fleece. At the diet of Sopron, 1625, he was elected palatine of Hungary. As a diplomatist he powerfully contributed to bring about the peaces of Nikolsburg (1622) and Linz (1645) (*see* HUNGARY: *History*). His political ideal was the consolidation of the Habsburg dynasty as a means towards freeing Hungary from the Turkish yoke and he himself, in 1623, defeated the Turks on the banks of the Nyitra. He died at Nagy-Heflán on Sept. 11, 1645, leaving five sons.

See *Works of Nicholas Esterházy*, with a biography by Ferencz Toldi (Hung.) (Pest, 1852); *Nicholas Count Esterházy, Palatine of Hungary* (a biography, Hung.) (Pest, 1863–70).

His third son PAL [Paul] (1635–1713), prince palatine, founded the princely branch of the family of Esterházy. He was born at Kis Marton (Eisenstadt) on Sept. 7, 1635. In 1663 he fought, along with Miklós Zrinyi, against the Turks, and distinguished himself under Montecuculi. In 1667 he was appointed commander-in-chief in south Hungary, where he defeated the malcontents at Leutschau and Györk. In 1681 he was elected palatine. In 1683 he participated in the deliverance of Vienna from the Turks, and entered Buda in 1686 at the head of 20,000 men. Thoroughly reactionary, and absolutely devoted to the Habsburgs, he contributed more than any one else to the curtailing of the privileges of the Magyar gentry in 1687, when he was created a prince of the Empire, with (in 1712) succession to the first-born of his house. His "aulic tendencies" made him so unpopular that his offer of mediation between the Rákóczy insurgents and the government was rejected by the Hungarian diet, and the negotiations, which led to the peace of Szatmár, were entrusted to János Pállfy. He died on March 26, 1713. He loved the arts and sciences, wrote

several religious works and was one of the chief compilers of the *Trophaeum Domus Inclytae Estoratianae.*

See Lajos Merényi, *Prince Paul Esterházy* (*Hung.*) (Budapest, 1895).

Prince PÁL ANTAL, grandson of the prince palatine Pál, was a distinguished soldier, who rose to the rank of field-marshal in 1758. On his death in 1762 he was succeeded by his brother.

Prince MIKLÓS JOZSEF [Nicholas Joseph] (1714–90), also a brilliant soldier, was a patron of the fine arts. Emperor Joseph II. conferred the princely title, which had previously been limited to the eldest-born of the house, on all his descendants, male and female. Esterházy died in Vienna on Sept. 28, 1790. He rebuilt in the renaissance style Schloss Esterházy, the splendour of which won for it the name of the Hungarian Versailles. Haydn was for thirty years conductor of his private orchestra and general musical director, and many of his compositions were written for the private theatre and the concerts of this prince.

His grandson, Prince MIKLÓS [Nicholas] (1765–1833) was born on Dec. 12, 1765. He made at Vienna an important collection of paintings and engravings (which came to the Hungarian Academy at Budapest in 1865), and at his summer palace of Kis Marton (Eisenstadt) he erected a monument to Haydn. When the French invaded Austria in 1797, he raised a regiment of 1000 men at his own expense. In 1809, when Napoleon invited the Magyars to elect a new king to replace the Habsburgs, overtures were made to Prince Nicholas, who refused the honour and, further, raised a regiment of volunteers in defence of Austrian interests; but his immense expenditures in this way and on building and the arts involved the family in financial difficulties for two generations. He died at Como on Nov. 24, 1833.

His son, Prince PÁL ANTAL [Paul Anthony] (1786–1866), entered the diplomatic service. In 1806 he was secretary of the embassy in London, and in 1807 worked with Prince Metternich in the same capacity in Paris. In 1810 he was accredited to the court of Dresden, where he tried in vain to detach Saxony from Napoleon, and in 1814 accompanied his father on a secret mission to Rome. He took a leading part in all the diplomatic negotiations consequent upon the wars of 1813–15, especially at the congress of Châtillon, and on the conclusion of peace was, at the express desire of the prince regent, sent as ambassador to London. In 1824 he represented Austria as ambassador extraordinary at the coronation of Charles X., and was the premier Austrian commissioner at the London conferences of 1830–36. In 1842 he attached himself to "the free-principles party." He was minister for foreign affairs in the first responsible Hungarian ministry (1848), but resigned his post in Sept. because he could see no way of reconciling the court with the nation. His last years were spent in comparative poverty and isolation, as even the Esterházy-Forchtenstein estates were unequal to the burden of supporting his fabulous extravagance and had to be placed in the hands of curators.

The cadet branch of the house of Fraknó, the members of which bear the title of count, was divided into three lines by the sons of Ferencz Esterházy (1641–83).

The eldest of these, Count ANTAL (1676–1722), distinguished himself in the war against Rákóczy in 1703, but changed sides in 1704 and commanded the left wing of the Kuruczis at the engagements of Nagyszombat (1704) and Vereskö (1705). In 1706 he defeated the imperialist general Guido Stahremberg and penetrated to the walls of Vienna. Still more successful were his operations in the campaign of 1708, when he ravaged Styria, twice invaded Austria, and again threatened Vienna, on which occasion the emperor Joseph narrowly escaped falling into his hands. In 1709 he was routed by the superior forces of General Sigbert Heister at Palota, but retreated very skilfully. In 1710 he joined Rákóczy in Poland and accompanied him to France and Turkey. He died in exile at Rodosto on the shores of the Black Sea. His son Bálint József [Valentine Joseph], by Anna Maria Nigrelli, entered the French army, and was the founder of the Hallewyll, or French, branch of the family, which became extinct in the male line in 1876 with Count Ladislas.

See *Count Esterházy's Campaign Diary* (Hung.), ed. by K. Thaly (Pest, 1901).

Count BALINT MIKLÓS (1740–1805), son of Bálint József, was an enthusiastic partisan of the duc de Choiseul, on whose dismissal, in 1764, he resigned the command of the French regiment of which he was colonel. He conveyed to Marie Antoinette the portrait of Louis XVI. on the occasion of their betrothal, and the close relations he maintained with her after her marriage were more than once the occasion of remonstrance on the part of Maria Theresa. At the French court he stood in high favour with the comte d'Artois. He was raised to the rank of maréchal de camp, and made inspector of troops in the French service in 1780. At the outbreak of the French Revolution, he was stationed at Valenciennes and facilitated the escape of the French *emigrés* by way of Namur; but, in 1790, he hastened back to Paris to assist the king. At the urgent entreaty of the comte d'Artois in 1791 he quitted Paris for Coblenz, accompanied Artois to Vienna and was sent to the court of St. Petersburg the same year to enlist the sympathies of Catherine II. for the Bourbons. He died at Grodek in Volhynia on July 23, 1805.

See *Mémoires*, ed. by E. Daudet (Fr.) (Paris, 1905), and *Lettres* (Paris, 1906).

Two other sons of Count Ferencz (d. 1685), Ferencz and József, founded the houses of Dotis and Cseklész (Landschütz) respectively. Of their descendants, Count MÓRICZ (1807–90) of Dotis, Austrian ambassador in Rome until 1856, became in 1861 a member of the ministry formed by Anton Schmerling and in 1865 joined the clerical cabinet of Richard Belcredi. His bitter hostility to Prussia helped to force the government of Vienna into the war of 1866. His official career closed in 1866, but he remained one of the leaders of the clerical party.

See also Count János Esterházy, *Description of the Esterházy Family* (Hung., Budapest, 1901). (R. N. B.; X.)

ESTERS, in organic chemistry, compounds formed by the condensation of an alcohol and an acid, with elimination of water. Since this process is analogous to the neutralization of an acid by a basic hydroxide in salt formation these esters were formerly called ethereal salts. But this older term is misleading, since esters, unlike salts, are not conductors of electricity in solution. In the case of the polybasic acids, all the hydrogen atoms can be replaced in this way, and the compounds formed are known as neutral esters. If, however, some of the hydrogen of the acid remains undisplaced, then acid esters result. These acid esters retain some of the characteristic properties of the acids, forming, for example, salts, with basic oxides. Esters may be prepared by heating the silver salt of an acid with an alkyl iodide; by heating the alcohols or alcoholates with an acid chloride; by distilling the anhydrous sodium salt of an acid with a mixture of the alcohol and concentrated sulphuric acid; or by heating for some hours on the water bath a mixture of an acid and an alcohol with a small quantity of hydrochloric or sulphuric acids (E. Fischer and A. Speier, 1896).

The esters of the aliphatic and aromatic acids are colourless neutral liquids, which are generally insoluble in water, but readily dissolve in alcohol and ether. Methyl oxalate, $C_2O_4(CH_3)_2$, is a solid (m.p. 54° C). Many possess a fragrant odour and are prepared in large quantities for use as artificial fruit essences; for example, *ethyl acetate* (acetic ether) $CH_3{\cdot}CO_2{\cdot}C_2H_5$, *butyl acetate, ethyl butyrate,* $C_3H_7{\cdot}CO_2C_2H_5$ (b.p. 121° C, odour of pineapple), *isoamyl isovalerate* $C_4H_9{\cdot}CO_2{\cdot}C_5H_{11}$ (b.p. 196°, odour of apples). They hydrolyse readily when boiled with solutions of caustic alkalies or mineral acids, yielding the constituent acid and alcohol. When heated with ammonia, they yield acid amides (*q.v.*). With Grignard reagents (*q.v.*) they furnish tertiary alcohols, except in the case of ethyl formate $H{\cdot}CO_2{\cdot}C_2H_5$ (b.p. 55° C), where secondary alcohols are obtained.

N. Menschutkin (1879–82) examined the rate of esterification of many acids with alcohols and found that the normal primary alcohols were all esterified at about the same rate, the secondary alcohols more slowly than the primary, and the tertiary alcohols still more slowly. The nature of the acid used affected the result, for in an homologous series of acids it was found that as the mole-

cule of the acid became more complex, the rate of esterification became less. The formation of an ester by the interaction of an acid with an alcohol is a "reversible" or "balanced" action, for as M. Berthelot and L. Péan de St. Gilles (1862) have shown in the case of the formation of ethyl acetate (b.p. 75° C) from ethyl alcohol and acetic acid, a point of equilibrium is reached beyond which the reacting system cannot pass, unless the system be disturbed in some way by the removal of one of the products of the reaction. V. Meyer (1894) showed that in benzenoid compounds ortho-substituents hindered esterification of alcohols by acids in the presence of hydrochloric acid, this hindrance being particularly marked when two substituents are present in the ortho positions to the carboxyl group. In such a case the ester is best prepared by the action of an alkyl halide on the silver salt of the acid, and when once prepared can only be hydrolysed with great difficulty. The oils, fats and waxes (*q.v.*) are largely the esters of the higher fatty acids and glycerol. The esters of the higher fatty acids when distilled under atmospheric pressure are decomposed into an olefine and a fatty acid.

Esters of the mineral acids may be prepared by the general methods described above. The neutral esters are as a rule insoluble in water and distil unchanged; on the other hand, the acid esters are generally soluble in water, are non-volatile, and form salts with bases. *Ethyl hydrogen sulphate* (sulphovinic acid), $C_2H_5{\cdot}HSO_4$, obtained by the action of concentrated sulphuric acid on alcohol, is a colourless oily liquid with acid reaction, slowly decomposing in aqueous solution. On heating it forms diethyl sulphate and sulphuric acid. *Dimethyl sulphate,* $(CH_3)_2SO_4$, a colourless liquid which boils at 187°–188° C, with partial decomposition, is used as a methylating agent. Great care should be taken in using dimethyl and diethyl sulphates, as the respiratory organs are seriously affected by the vapours. *Ethyl nitrate,* $C_2H_5{\cdot}ONO_2$, a colourless liquid which boils at 86·3° C, is prepared by the action of nitric acid on ethyl alcohol. *Ethyl nitrite,* $C_2H_5{\cdot}ONO$, is a liquid which boils at 18° C; the crude product obtained by distilling a mixture of alcohol, sulphuric and nitric acids and copper turnings is used in medicine under the name of "sweet spirits of nitre." *Amyl nitrite,* $C_5H_{11}{\cdot}ONO$, boils at 96° C, and is employed in the preparation of anhydrous diazonium salts (*see* DIAZO-COMPOUNDS). It is also used in medicine.

ESTES PARK, a village at the eastern entrance to the Rocky Mountain national park, in Larimer county, Colo., U.S.A., 55m. N.W. of Denver, at an altitude of 7,500 feet. The nearest railroad station is Lyons, on the Burlington route, 21m. south-east. The population of the precinct was 539 in 1920. It is an important touring centre and summer resort, with some 30 hotels. There is an air port, Stanley field.

ESTHER. The book of Esther relates how a Jewish maiden, cousin and foster-daughter of Mordecai, became the queen of the Persian king Ahasuerus (Xerxes, *see* AHASUERUS); how Esther and Mordecai frustrated Haman's endeavour to extirpate the Jews; how Haman, the grand vizier, fell, and Mordecai succeeded him; how Esther obtained the king's permission for the Jews to destroy all who might attack them on the day which Haman had appointed by lot for their destruction; and, lastly, how the feast of Purim (Lots?) was instituted to commemorate their deliverance.

The story of Esther is the work of a skilled narrator. The principal characters are well drawn, the style is simple, the interest sustained. There are two very conspicuous blemishes: the lack of any religious element and the apparent delight in the wholesale slaughter of gentiles. There is no allusion to a divine being, no mention of religious feeling or observance (except fasting). The plane of exaggeration on which the whole narrative is based must be taken into account (a banquet lasting 180 days, the 12 months perfuming of each maiden before her presentation to the king, Esther's preparation lasting four years, Haman's gallows 50 cubits high, a year's warning to the victims of the plot, etc.) was doubtless designed to weaken the impression of reality. The book aims to paint a stirring picture of the supposed events which led to the institution of the festival of Purim, celebrated on the 14th and 15th of Adar (*see* PURIM), and thus to help ensure its perpetual observance; but historical verity is disclaimed at the outset (precisely as is the case in the book of Judith).

The true origin of the feast remains obscure, and even the name has not been satisfactorily explained. Since the names Esther and Mordecai are derived from Ishtar and Marduk, some scholars (notably Zimmern and Jensen) have sought to find the basis of the story in Babylonian, Persian or Elamite mythology. (*See* Paton, *Comm.*, pp. 76–94.) No one of these attempts is convincing, however.

Esther is one of the latest books of the Old Testament. This appears plainly in the character of the Hebrew in which it is written (Driver, *Introd.;* Paton, p. 59). Kuenen's conjectured date of its composition, *c.* 130 B.C., seems to have the best support, and has found favour with many scholars. We first hear of the feast of Purim in 2 Macc. xv. 36 (1st century B.C.). The remarkable subscription to the standard Greek recension gives the date, 114–113 B.C., at which the Greek translation (of our Hebrew, or of an expanded text?) was brought to Egypt. The book enjoyed great popularity among the Jews, as shown by the many recensions and by the distinction of a special scroll (*megillah*). Our Hebrew seems to give the oldest and best version. The standard Greek renders a somewhat longer text, besides containing extensive additions (*see* below). Another Greek recension, abbreviated and differing in other respects, was published by Lagarde (*Libr. Vet. Test pars prior*). The Old Latin, Jerome's Vulgate, two Targums (from the Gaonic period), and a late and unimportant Syriac version, are also to be mentioned. The variation in the principal texts (Hebrew, Greek and Latin) seems to be due mainly to reproduction from memory. Although much read, the book was not easily ranked as sacred scripture. The Jews gave it admission to the canon only after much controversy, and among the early Christians it was often rejected; the Nestorian Church, especially, continued to ignore it.

BIBLIOGRAPHY.—The most complete account of all matters relating to the book of Esther is given by L. B. Paton's *Book of Esther* (Int. Crit. Commentary, 1908). *See* also his "Text-critical Apparatus" in *O.T. and Semitic Studies in Memory of W. R. Harper* (1908), ii., pp. 1–51; the comms. of Wildeboer (1898) and Siegfried (1901), Nöldeke's article "Esther" in the *Ency. Biblica.*, and the articles "Esther" and "Megillot" in the *Jewish Encyclopaedia*.

(T. K. C.; C. C. T.)

Additions to Book of Esther.—This term designates the six long passages which are found in the standard Greek version, and now have a place in the O.T. Apocrypha. They are the following: A (preceding Heb. chap. i.): Mordecai's dream, and his discovery of a conspiracy. B (following Heb. iii. 13): the letter of the king, ordering the extermination of "a certain evilly disposed people." C (following Heb. chap. iv.): prayers of Mordecai and Esther. D: an expanded narrative, 16 verses, replacing Heb. v. 1, 2. E (following Heb. viii. 12): the letter of the king in favour of the Jews. F (following the last verse, x. 3, of Heb.) includes: (*a*) Mordecai's interpretation of his dream, and his declaration as to the institution of Purim; (*b*) the subscription giving a date (*see* above).

The earliest sure attestation of the additions is given by Josephus, *Ant.* xi. 6. The "Lucianic" Greek edited by Lagarde (*see* above) contains them; so also does the Old Latin, translated from still another Greek version and containing further expansions as well as omissions. Jerome, in the Vulgate, rendered the additions from the Greek, beginning with F at the close of his translation of the Hebrew book, and continuing with the others in their disconnected sequence. The meaningless disorder in the English Apocrypha is the result of translating Jerome's text without rearrangement or explanation.

The additions cannot have been present in the original Hebrew. Their character, both literary and religious, is markedly different, and their omission would be inexplicable. They testify, on the one hand, to the desire to introduce into the book the religious element which is so conspicuously lacking, and on the other hand to the lively circulation of the story, especially in the first decades of its popularity, in a variety of freely handled versions, Hebrew, Greek and Aramaic. The additions themselves, moreover, represent more than one original language and at least two distinct re-

censions. It is beyond question that B and E (*see* above) were composed in Greek, and that they never stood in other than Greek forms of the story. The style in which they are written is conclusive as to this, and they are doubtless the work of one and the same hand. It is equally capable of demonstration that the Greek of A, C, D and F(*a*) is the result of translation from Hebrew; these sections stood originally in a Hebrew book. The original language of F(*b*) (the subscription) was presumably Greek, though this can hardly be declared certain.

BIBLIOGRAPHY.—Paton's *Commentary* and his *Critical Notes* (*see* above); also Fritzsche, *Handbuch zu den Apokryphen*, i. (1851), pp. 69–108; Fuller, in the *Speaker's Apocrypha*, i. (1888), pp. 361–402 (with translations from the Targums); Ryssel, in Kautzsch's *Apokryphen;* Gregg, in Charles' *Apocrypha*. The Aramaic version (late) of Mordecai's dream is given in Lagarde's *Hagiographa Chaldaice* and Merx's *Chrestomathia Targumica*. (C. C. T.)

ESTHERVILLE, a city of northern Iowa, U.S.A., on the Des Moines river, 5m. from the Minnesota State line; the county seat of Emmet county. It is served by the Rock Island and the Minneapolis and St. Louis railways. The population (90% native white) was 5,084 in 1925 (State census). It is the trading centre for a farming, stock-raising and dairying region, and has wagon shops, cement works and a tile factory. The city was founded about 1858 and incorporated in 1881. Since 1916 it has had a city-manager form of government.

ESTIENNE or **ÉTIENNE** (latinized to Stephanus), a French family of scholars and printers.

The founder of the house was HENRI ESTIENNE (d. 1520), of a noble family of Provence, who came to Paris in 1502, and set up a printing establishment at the top of the rue Saint-Jean de Beauvais. He died in 1520, and, his three sons being minors, the business was carried on by his foreman, Simon de Colines, who in 1521 married his widow.

ROBERT ESTIENNE (1503–1559) was Henri's second son. After his father's death he acted as assistant to his stepfather, and superintended the printing of a Latin edition of the New Testament (1523). He had intimate relations with the new Evangelical preachers and soon after this time definitely joined the Reformed Church. In 1526 he became head of the firm, and adopted as his device the celebrated olive-tree. In 1528 he married Perrette, a daughter of the scholar and printer Josse Bade (Jodocus Badius), and in the same year he published his first Latin Bible, an edition in folio, upon which he had been at work for the last four years. In 1532 appeared his *Thesaurus linguae Latinae* (later editions 1536, 1543), a dictionary of Latin words and phrases, which as late as 1734 was considered worthy of being re-edited. In 1539 Robert was appointed king's printer for Hebrew and Latin, and in 1540 for Greek. In 1541 he was entrusted by Francis I. with the task of procuring from Claude Garamond, the engraver and type-founder, three sets of Greek type for the royal press. With the middle size Robert printed the *editio princeps* of the *Historia Ecclesiastica* of Eusebius and others (1544). The smallest size was first used for the 16mo edition of the New Testament known as the *O mirificam* (1546), while with the largest size was printed the magnificent folio of 1550. This edition brought the printer into disputes with the faculty of theology, and in 1551 he left his native town and took refuge at Geneva, where he published in 1552 a caustic answer to his persecutors under the title *Ad censuras theologorum Parisiensium. . . .* A French translation was published by him in the same year (printed in Rénouard's *Annales de l'imprimerie des Estienne*). At Geneva Robert became an ardent partisan of Calvin, several of whose works he published. He died there on Sept. 7, 1559.

The text of Etienne's New Testament of 1550, either in its original form or in such slightly modified form as it assumed in the Elzevir text of 1634, remains to this day the traditional text. But this is due rather to its typographical beauty than to any critical merit. The readings of the fifteen mss. which Robert's son Henri had collated for the purpose, were merely introduced into the margin. The text was still almost exactly that of Erasmus. It was, however, the first edition ever published with a critical apparatus of any sort. Of the whole Bible Robert printed eleven editions—eight in Latin, two in Hebrew and one in French; while of the New Testament alone he printed twelve—five in Greek, five in Latin and two in French. In the Greek New Testament of 1551 (printed at Geneva) the present division into verses was introduced for the first time. The *editiones principes* which issued from Robert's press were eight in number, viz. *Eusebius*, including the *Praeparatio evangelica* and the *Demonstratio evangelica* as well as the *Historia ecclesiastica* already mentioned (1544–1546), *Moschopulus* (1545), *Dionysius of Halicarnassus* (February 1547), *Alexander Trallianus* (January 1548), *Dio Cassius* (January 1548), *Justin Martyr* (1551), *Xiphilinus* (1551), *Appian* (1551), the last being completed, after Robert's departure from Paris, by his brother Charles, and appearing under his name. These editions, all in folio, except the *Moschopulus*, which is in 4to, are unrivalled for beauty. Robert also printed numerous editions of Latin classics, of which perhaps the folio *Virgil* of 1532 is the most noteworthy, and a large quantity of Latin grammars and other educational works, many of which were written by Maturin Cordier, his friend and co-worker in the cause of humanism.

CHARLES ESTIENNE (1504 or 1505–1564), the third son of Henri, was also a man of considerable learning. He studied medicine, took his doctor's degree at Paris, and was for a time tutor to Jean Antoine de Baïf, the future poet. In 1551, when Robert Estienne left Paris for Geneva, Charles, who had remained a Catholic, took charge of his printing establishment, and in the same year was appointed king's printer. In 1561 he became bankrupt, and he is said to have died in a debtors' prison.

His principal works are *Praedium Rusticum* (1554), a collection of tracts which he had compiled from ancient writers on various branches of agriculture, and which continued to be a favorite book down to the end of the 17th century; *Dictionarium historicum ac poëticum* (1553), the first French encyclopaedia; *Thesaurus Ciceronianus* (1557), and *De dissectione partium corporis humani libri tres*, with well-drawn woodcuts (1548). He also published a translation of an Italian comedy, *Gli Ingannati*, under the title of *Le Sacrifice* (1543; republished as *Les Abusez*, 1549), which had some influence on the development of French comedy; and *Paradoxes* (1553), an imitation of the *Paradossi* of Ortensio Landi.

HENRI ESTIENNE (1531–1598), sometimes called Henri II., was the eldest son of Robert. In the preface to his edition of Aulus Gellius (1585), addressed to his son Paul, he gives an interesting account of his father's household, in which Latin was used as a common language. At fifteen he became a pupil of Pierre Danès, at that time the first Greek scholar in France. In 1545 he began to attend the lectures of Jacques Toussain, royal professor of Greek, and was employed by his father to collate a ms. of Dionysius of Halicarnassus. In the year 1547 he went to Italy, where he spent three years in hunting for and collating mss. and in intercourse with learned men. In 1550 he visited England, where he was favourably received by Edward VI., and then Flanders, where he learnt Spanish. In 1551 he joined his father at Geneva, which henceforth became his home. In 1554 he published, as the firstfruits of his researches, two first editions, viz. a tract of Dionysius of Halicarnassus and the so-called "Anacreon." In 1556 he discovered at Rome ten new books (xi.–xx.) of Diodorus Siculus. In 1557 he issued at Geneva three first editions, viz. *Athenagoras, Maximus Tyrius*, and some fragments of Greek historians, including Appian's Ἀννιβαλική, and Ἰβηρική and an edition of Aeschylus, in which for the first time the *Agamemnon* was printed in entirety and as a separate play. In 1559 he printed a Latin translation from his own pen of Sextus Empiricus, and an edition of Diodorus Siculus with the new books. Under his father's will he became in 1559 owner of his press, subject, however, to the condition of keeping it at Geneva. In 1566 he published his best-known French work, the *Apologie pour Hérodote*. Some passages being considered objectionable by the Geneva consistory, he was compelled to cancel the pages containing them. Within sixteen years twelve editions were printed. In 1572 he published his *magnum opus*, the *Thesaurus Graecae linguae* (5 vols. fol.). The publication in 1578 of his *Deux Dialogues du nouveau françois italianizé* brought him into a fresh dispute with the consistory. To avoid their censure he went to Paris, and resided at the French court for a year. On his return to Geneva he was summoned before the consistory, and, proving contumacious, was imprisoned for a week. From this time his life became more and more of a nomad one. He is to be found at Basel, Heidelberg, Vienna, Pest, everywhere but at Geneva, these journeys being undertaken partly in the hope of procuring patrons and purchasers. His press stood nearly at a standstill. A few editions of classical authors were brought out, but each successive one showed a

falling off. Such value as the later ones had was chiefly due to the notes furnished by Casaubon, who in 1586 had married his daughter Florence. In 1597 he left Geneva for the last time. After visiting Montpellier, where Casaubon was now professor, he started for Paris, and died at Lyons at the end of January 1598.

Few men have ever served the cause of learning more devotedly. For over thirty years the amount which he produced, whether as printer, editor or original writer, was enormous. The productions of his press, though printed with the same beautiful type as his father's books, are, owing to the poorness of the paper and ink, inferior to them in general beauty. The best, perhaps, from a typographical point of view, are the *Poëtae Graeci principes* (folio, 1566), the *Plutarch* (13 vols. 8vo, 1572), and the *Plato* (3 vols. folio, 1578). It was rather his scholarship which gave value to his editions. He was not only his own press-corrector but his own editor. Though by the latter half of the 16th century nearly all the important Greek and Latin authors that we now possess had been published, his untiring activity still found some gleanings. Eighteen first editions of Greek authors and one of a Latin author are due to his press. Estienne only resorted to conjecture when authority failed him. He was the first to show what conjecture could do towards restoring a hopelessly corrupt passage. The work, however, on which his fame as a scholar is most surely based is the *Thesaurus Graecae linguae*. After making due allowance for the fact that considerable materials for the work had been already collected by his father, and that he received considerable assistance from the German scholar Sylburg, he is still entitled to the very highest praise as the producer of a work which was of the greatest service to scholarship and which in those early days of Greek learning could have been produced by no one but a giant. Two editions of the *Thesaurus* were published in the 19th century—at London by Valpy (1815–1825) and at Paris by Didot (1831–1863).

It was one of Henri Estienne's great merits that, unlike nearly all the French scholars who preceded him, he did not neglect his own language. In the *Traité de la conformité du langage françois avec le Grec* (published in 1565, but without date; ed. L. Feugère, 1850), French is asserted to have, among modern languages, the most affinity with Greek, the first of all languages. *Deux Dialogues du nouveau françois italianizé* (Geneva, 1578; ed. P. Ristelhuber, 2 vols., 1885) was directed against the fashion prevailing in the court of Catherine de' Medici of using Italian words and forms. The *Project du livre intitulé de la Précellence du langage françois* (Paris, 1579; ed. E. Huguet, 1896) treats of the superiority of French to Italian. An interesting feature of the *Précellence* is the account of French proverbs, and, Henry III. having expressed some doubts as to the genuineness of some of them, Henri Estienne published, in 1594, *Les Premices ou le I. livre des Proverbes epigrammatizez* (never reprinted and very rare).

Finally, there remains the *Apologie pour Hérodote*, his most famous work. The ostensible object of the book is to show that the strange stories in Herodotus may be paralleled by equally strange ones of modern times. Virtually it is a bitter satire on the writer's age, especially on the Roman Church. A modern edition was published by Liseux (ed. Ristelhuber, 2 vols., 1879), after one of the only two copies of the original uncancelled edition that are known to exist.

The primary authorities for an account of the Estiennes are their own works. In the garrulous and egotistical prefaces which Henri was in the habit of prefixing to his editions will be found many scattered biographical details. Twenty-seven letters from Henri to John Crato of Crafftheim (ed. F. Passow, 1830) have been printed, and there is one of Robert's in Herminjard's *Correspondence des Réformateurs dans de pays de langue française* (9 vols. published 1866–1897), while a few other contemporary references to him will be found in the same work. The secondary authorities are Janssen van Almeloveen, *De vitis Stephanorum* (Amsterdam, 1683); Maittaire, *Stephanorum historia* (London, 1709); A. A. Rénouard, *Annales de l'imprimerie des Estienne* (2nd ed., Paris, 1843); the article on Estienne by A. F. Didot in the *Nouv. Biog. gén.*; Mark Pattison, *Essays*, i. 67 ff. (1889); L. Clément, *Henri Estienne et son œuvre française* (Paris, 1899). There is a good account of Henri's *Thesaurus* in the *Quart. Rev.* for January 1820, written by Bishop Blomfield.

ESTIMATES. In British national finance, the expenditure of public money is safeguarded by the yearly preparation, by each spending department of State, of an official estimate of the amount required to carry on the business of the department in the forthcoming financial year. The British financial year begins in April and ends in March, so that the estimates for the financial year 1929–30 have to be prepared early in 1929.

The estimate of each department is called for by the Treasury, which on Oct. 1 of each year sends a request for the statement to each department concerned. As the period to which the estimate relates begins in the following April, the Treasury request is thus made six months in advance. These estimates are carefully checked by the Treasury, whose officials scrutinize them and compare carefully item by item with the expenditures of former years. The estimates receive more than civil service criticism. The chancellor of the exchequer for the time being is by virtue of his office anxious to keep down expenditure, for additions to expenditure make difficulties for him and compel him, unless revenue on the basis of existing taxation is swelling or likely to swell, to proceed to the unpopular task of imposing new taxation.

If any spending department of State furnishes to the Treasury estimates in which fresh items appear, or in which old items show considerable increases, the Treasury in such case returns the estimate to the issuing department with a request for explanation, or even with a demand for reduction. Thus in the first place the estimates of the British spending departments have to seek and gain acceptance by the Treasury. That is a cardinal principle of British national finance, and it casts a peculiarly onerous responsibility upon the Treasury, and upon its political chief, the chancellor of the exchequer, who is recognized as the first lieutenant of the British prime minister. When the chancellor of the exchequer rises in the House of Commons to announce the details of his budget, he has in effect made himself responsible for the presentation to parliament of reasonable estimates.

It is not always easy for a spending department to estimate in advance the sums it will require to carry on its business during a period which begins six months after the Treasury demands its figures, and ends 18 months after that demand is made and in cases requiring additional expenditure a supplementary estimate has to be submitted for the approval of the Treasury in the same manner as the estimates of the year. The outbreak of war, for example, or such a matter as the China Expeditionary Force of 1926–27 may cause a big supplementary estimate to be presented.

The British spending departments are: (1) the army, (2) the navy, (3) the air force, and (4) the big group known as the civil service. The estimates of the army, navy and air force concern matters of high policy, and the Treasury officials can do little with them. The civil service estimates concern many categories, including public works, civil departments, salaries and expenses, administration of law, education, foreign and colonial services, national insurance, labour exchanges, etc. In addition, there are the departments producing revenue, viz., customs and excise, inland revenue, and the post office.

The post office brings into the British revenue much more than it costs to run. Nevertheless, the estimates presented by the post office include the gross outgoings, although the whole of these outgoings are actually much less than is received by the post office in the course of the year. This manner of presenting the accounts always makes the national expenditure look larger than it really is.

The estimates, as sanctioned by the Treasury, are printed and placed before the House of Commons in the form of small booklets, in which the figures asked for are compared with those of the previous year and details given of any sums, such as fees, etc., received by the department in the course of its work and not paid into the revenue (*see* APPROPRIATIONS IN AID). The House of Commons possesses the constitutional right to criticize every estimate submitted to it, but in practice this right is largely curtailed by the exigencies of government. Thoroughly to debate even the main items in the estimates would take up the greater part of the time of the British parliament, which has never yet simplified the subject by referring such estimates to a special committee. It is true that the estimates are technically considered in committee, but that committee, the "committee of supply" is nothing more or less than the entire House of Commons sitting as a committee, with the Speaker out of the chair and the mace under the table.

With the great growth of parliamentary business in the latter part of the 19th century and the beginning of the 20th century, the parliamentary time given to the discussion of the estimates was contracted and reduced to 20 allotted days. So that the Government of the day should not be freed from criticism, however, it is the British constitutional practice to give the Opposition the right to name what estimates they wish discussed on each of the allotted days. The value of this provision lies in the fact that

if any particular spending department is thought to be misbehaving itself in administration, the Opposition has the opportunity to call the conduct of the department in question by calling for the discussion of its particular estimates. The constitutional form used is that the Opposition puts down an amendment to the vote of supply proposing to reduce it by £100. (*See* BUDGET; PARLIAMENT; EXCHEQUER.)

ESTON, urban district, Cleveland parliamentary division, North Riding of Yorkshire, England, 4 m. E.S.E. of Middlesbrough, on a branch of the L.N.E. railway. Pop. (1921), 30,635. It is situated at an altitude of between 100 and 150 ft. at the foot of the north-westward facing scarp of Eston Beacon (1,800 ft.). This is one of the principal centres from which the great ironstone deposits of the Cleveland hills are worked, and there are extensive blast furnaces, iron-foundries and steam saw-mills in the district. Numerous early earthworks fringe the hills to the south. Morton, 3 m. S.W. of Eston, was the birthplace of Captain Cook (1728).

ESTONIA, independent republic created February 1918, extending from 57° 27′ N. to 59° 42′ N. and from 21° 46′ E. to 28° 21′ E.: bounded north by the Gulf of Finland, west by the Baltic sea and the Gulf of Riga, south by Latvia and east by Russia. Area 47,559 sq.km. (2,328 sq.km. occupied by 1,512 lakes and 4,167 sq.km. by 818 islands); Saaremaa (Osel), Hiiumaa (Dagö), Muhumaa (Moon) and Vormsi (Vorms) are its largest islands. The coast is low and the greatest elevation is 450 ft. Moraines cover the surface and are thickest in the south and south-east. They rest on the Devonian in the south and on the Silurian in the north; beneath are Cambrian strata appearing in the cliffs as limestone, sandstone or oilshale. On the islands and in northern Estonia the limestone plain prevails. The river beds are shallow, there is much spring flooding, also bog land from which peat is obtained. The climate is continental save near the sea. The annual precipitation is 535 mm. of which about 25% is snow, which falls between November and April, August has most rain and December most snow. The prevailing winds are south-west and west. Two-thirds of the land (one-third meadow and pasture), is under cultivation. Cattle breeding is increasing at the expense of grain cultivation. Winter rye is the most important crop; summer rye and winter and summer wheat, buckwheat, peas, beans, lentils and forage for cattle food, including root crops are also produced. Potato cultivation is diminishing with less demand for potato spirit. Flax is increasingly grown, the fibre is exported and oil cake is used for cattle food. Dairy products have nearly doubled since 1922 and the number of horses, cows, sheep and pigs is much larger than in pre-war times. Forests of fir, pine, birch, aspen and alder, cover 20% of the land, mainly in the south-west and north-east. Of the timber cut 35% is exported, partly as planks, pit-props and sleepers and partly as finished wooden articles. The largest pulp mill in Estonia was destroyed by the Russian army and has not been rebuilt, but there are about 60 small paper and cardboard factories. Under war conditions, industrial capital was lost, plant and buildings destroyed and skilled workers dispersed. Metal industry, including shipbuilding, manufacture of agricultural implements, electrical apparatus, small wares, etc., is still small, but cotton, linen and woollen manufactures have become important exports; stone and chemicals are also exported. Oil shale began to be exploited for fuel in 1919 when 9,648 tons of oil were extracted. In 1925 production reached 287,000 tons, and since 1925 all railways use it. The cotton and paper mills work on hydro-electric power. Phosphorite fertiliser is worked from the lower Silurian beds. The trade turnover is increasing and there is a satisfactory balance. Textiles and dairy produce come next to timber and timber products in exports, raw cotton is the chief import. Germany, Great Britain and Russia take most of the exports and Germany, U.S.A. and Great Britain provide most of the imports. Transit trade from Russia is increasingly small. Estonia is essentially a maritime country and Tallinn (Revel), its chief port, and capital city, pop. (1926) 127,000, is open all the year, though in some years ice-breakers are temporarily necessary. East of Tallinn the Gulf of Finland is difficult through drift ice; the Gulf of Riga is frozen for 60 to 90 days per annum. Paldiski (Baltic port) is also open and with the help of ice-breakers ships can usually reach Pärnu and Narva-Joësuu (Hungerburg, chief timber port). River communication is poor. Tallinn is connected with Latvia and Russia by broad gauge railways; a branch to Pärnu was constructed in 1927. There are narrow gauge railways.

BY COURTESY OF THE Y.W.C.A.
WOMAN OF ESTONIA, IN NATIVE DRESS

The Esths or Estonians, who call themselves *Tallopoeg* and *Maames*, were known to the Russians as *Chukhni*, to the Letts as *Iggauni* and to the Finns as *Virolaiset*. They are of Finnish or Ural-Altaic extraction and resemble Finns (*q.v.*) physically. Since 1873 an Estonian Literary Society has helped to preserve the language, of which there are three dialects, Tartu, Tallinn and Pärnu. A Lutheran catechism was published in Estonian in the 16th century and a translation of the New Testament in 1713. National Songs resembling the Finnish Kalevala (*q.v.*) were collected and published by Kreutswald (1857). All children of eight must attend school until they have completed a four years' course or until they are fifteen; poor children are given books, clothing and footwear. The population in 1925 was 1,114,630, 87·7% Estonians, 8·2% Russians, 1·7% Germans, 0·7% Swedes and 1·6% other nationalities. Children of non-Estonian nationality receive instruction in their own language. Secondary schools provide 25% of free places, and completion of the course gives entrance to Tartu University, Tallinn Technical Institute, Tallinn Economic College, the Conservatoires at Tallinn and Tartu and the Art School at Tartu, without examination. There are technical, agricultural, commercial and naval schools. There are the Estonian Literary Society and scientific societies and a National Museum near Tartu. The library of Tartu University contains important manuscripts, with a special Arabic section. There is no national church, but 78% of the population are Lutherans and 18·8% Greek-Orthodox.

Language.—The Estonian language belongs to the west-Finnish group of the Finno-Ugrian family. Its nearest relatives are Finnish and Livian, Vepse, Votyak, etc. The east-Finnish group (Mordvinian, Syrjenian, Vogulian, etc.) represents an extra-European ramification of the family, of which Hungarian (Magyar) and Estonian are noteworthy examples. The nearness of Estonian to Finnish is as the relation between German and Danish, or Russian and Polish. The language is spoken by nearly 1,500,000 people.

The basis and structure of the language has not departed very far from Finnish, and many problems of early Finnish philology can be solved by reference to current Estonian words. From its position, however, the language has been subject to the influx of vocabulary from foreign tongues, the chief loan-words coming from Lithuanian, Gothic and the Slav languages.

There are two main spoken dialects included in the three mentioned above, the northern or "Revel-speech" and the southern, but the written language follows the northern phonology and spelling, and this has become the standard. The alphabet has 23 letters, the others (c. f. q. w. x. y. z) only appearing in foreign words. It is a highly inflected language, having a noun-declension of 16 cases.

The pronouns are declined through the same cases and the verb-system is very complicated. The pronouns are numerous and undergo declension. These declensions are of two kinds, strong and weak. The termination for weak declensions in the singular is *-d*, plural *-de* and *-id*.

The numerals present an interesting feature and from one to ten they are

1 *üks*, 2 *kaks*, 3 *kolm*, 4 *neli*, 5 *viis*, 6 *kuus*, 7 *seitse*, 8 *kaheksa*, 9 *üheksa*, 10 *kümme*.

Even these are declined (generally through seven cases) and ordinals and fractions are regularly formed from the cardinal

numbers. The stress accent is always on the first syllable of the word, and the laws of letter-attraction operate here as in other Finno-Ugric languages. The pronunciation is simple.

Administration.—Estonia is an independent republic with a representative assembly of 100 members elected by universal secret suffrage on the principle of proportional representation. There is complete freedom of conscience and no censorship of the press. Every citizen over 20 is enfranchised after one year's Estonian citizenship, with the exception of criminals, lunatics, deaf-mutes, etc. Insurance against sickness is compulsory and the state provides temporary occupation for the unemployed. All persons over 60 years of age receive relief if necessary and there are 46 government homes for children in need. The curative mud of the shallow seas has developed health resorts which attract foreign as well as local patients.

See M. Haltenberger, *Landeskunde von Esti* (Tartu, 1926); E. Vesterinen, *Agricultural Conditions in Estonia* (Helsinki, 1923); *Mémoire sur l'indépendance de l'Estonie, presenté à la Conférence de la Paix par la Délegation estonienne* (1919); J. P. Parikas, *Eesti* (Illustrated Handbook in several languages) Tallinn (1923).

Defence.—The formation of a national army in Estonia, impossible under the rule of the tsar, began in March 1917. In April the 2nd Tallin Regiment was allowed to enlist only Estonians. After invading the country, the German authorities, in Nov. 1918, ceded their power to the Estonian Provisional Government, which formed a Defence League at once. During the World War Estonians of mature age saw much military service, which was of value when repelling a Russian invasion of 1918–19, when assistance was given to Estonia by Finland in repelling the invaders, the result being the recognition by the Russian Republic in Feb. 1920 of the independence of Estonia.

Every Estonian is liable for military service, commencing in the year following his 20th birthday. This service is in four stages, service in the active army for 18 months, followed by furlough, by service in the reserve, and in the Territorial force. The total period in the active army and first reserve is five years. Service in the Territorial forces lasts until the age of 55, in the active army and its reserves till 45. The budget strength of all ranks in 1927 was 17,340, including 1,500 military officers and officials. The army is organized nominally in three divisions of infantry and artillery, and one for air-defence and coast defence, which includes armoured cars and tanks, and armoured trains. The Government commands the army through the minister of war, who has under him the chief of staff of the army, with inspectors of the various arms, and the general staff, which is charged with administrative as well as with the usual duties. The division of armoured troops is of interest. It comprises two companies of tanks, one company of armoured cars, one of motor vehicles, and a stores company. There is a military air-force, organized as an air regiment, including a land service aviation group of two flights and a training flight, also a seaplane flight, a training section, and a technical section.

See also *The Estonian Handbook* (1927); League of Nations *Armaments Yearbook* (1928). (G. G. A.)

Navy.—The navy of Estonia is a miniature force consisting of two destroyers, both ex-Russian ships, one torpedo boat and seven miscellaneous vessels, gunboats, minelayers, etc. It is administrated by a combined Ministry of War. The personnel consists of about 1,500 officers and men.

THE PROBLEM OF RECONSTRUCTION

Before the World War Estonia was one of the principal sources of food supply for St. Petersburg (now Leningrad), and Revel was one of Russia's main northern outlets to the sea and a seat of considerable industry—shipbuilding, metallurgical shops, textile mills, etc.

The problem of reconstruction with which the government was faced after the Treaty of Dorpat was extremely difficult. An agricultural revolution had been created by the expropriation law of Oct. 1919. The big industries were destitute of floating capital after six years of inflation. The whole machinery of government and administration had to be reorganized and built up from its foundations.

Agriculture.—The most essential task was the reorganization of agriculture. About 40% of the total area consists of prairie and meadow, 23% is under plough, and 20% under forest. With the assistance of co-operative societies, Estonian agriculture was developed on specialist lines in cattle-breeding, dairy-farming, and flax production. The total exports of butter, which is controlled by the state, increased from 1,032 tons in 1922 to 6,443 tons in 1925.

The areas under cereals and average cereal crops are about the same as they were before the World War, and Estonia remains a corn-importing country. The area under flax has grown steadily from year to year.

Industrial Production.—Estonia possesses certain raw materials, the most important of which are wood and oil shale. The shale, the deposits of which are roughly estimated at 3,500–5,000 million tons, is unusually rich in oil. It is utilized to a growing extent in Estonian factories and on the railways in its crude state in place of coal. A certain number of concessions for its more scientific exploitation have been granted to foreign firms.

The forests constitute an additional source of fuel and the raw material of the saw mills, three-ply, and paper industries. Cement is another product, the preparation of which is in no way dependent upon foreign raw materials. Of the industries which are dependent upon foreign raw materials cotton spinning has been the most successfully organized, the exports of cotton yarn having increased from 154 tons in 1922 to 1,282 in 1925.

Trade.—The principal exports of the country in 1925 were:—

	Value in millions of Estonian marks.
Dairy produce and other foodstuffs of animal origin	2,557
Wood and wood products	2,729
Cotton fabrics	1,094
Flax, raw	1,286
The total exports amounted to	9,664

Although Estonia was the first "window into Europe" for Soviet Russia, neither Russian transit nor the traffic in goods attained the height reached before the World War. (X.)

HISTORY

The Estonians first appear in history as a warlike race. More than one of the Danish kings made serious attempts to subdue them. In 1219 Waldemar II. undertook a crusade against them, in the course of which he founded the town and episcopal see of Revel. By his efforts the northern portion of the race were made submissive to the Danish crown; but, though conquered, they were incessantly in revolt, until in 1346, after a great rebellion in 1343, Waldemar IV. Atterdag sold for 19,000 marks his portion of Estonia, to the order of the Knights of the Sword, German crusaders who in 1224, after a quarter of a century's fighting had gained possession of the regions inhabited by the southern portion of the race. From that time for nearly 600 years the Estonians were practically reduced to a state of serfdom to the German landowners. In 1521 the nobles and cities of Estonia voluntarily placed themselves under the protection of the crown of Sweden; but after the wars of Charles XII., Estonia was formally ceded to his victorious rival, Peter the Great, by the peace of Nystad (1721). Serfdom was abolished in 1817 by Tsar Alexander I.; but the condition of the peasants was so little improved that they rose in open revolt many times in the middle of the 19th century. The determining feature of their history since 1881 was the attempt made by the Russian Government to russify the inhabitants of the province by harsh and repressive measures.

The Russian Revolution.—Acting on the proposal of the union of Estonian organizations, the Russian provisional Government, on March 12, 1917, united the northern districts of Livonia (inhabited by Estonians) and Estonia. Since the revolution of 1905 Estonia had been working for autonomy and when the Estonian diet met at Revel (Tallinn) on July 14, 1917, its task was to prepare a bill for this purpose. The Bolshevist *coup d'état* changed the course of events. The Estonian diet, on Nov. 15, declared its complete local independence. The Bolshevists, how-

ever, dissolved the diet; and although national regiments had been formed during the revolution, the fact that Revel was the Russian sea base, and lay exposed to fire from Russian ships, made it expedient to avoid conflict. The Baltic nobility of Estonia, taking their stand on the Treaty of Nystad (1721), declared themselves the authorized representatives of the country, and on Dec. 12, 1917, invoked the aid of German troops. The nobility approached the Estonian diet with the object of securing a joint appeal to Germany; but the diet, well aware of their schemes for German colonization and compulsory denationalization, decided, at the turn of the year 1917–18 to declare the independence of Estonia.

De Facto Recognition.—The resumption of hostilities by the Germans had disconcerted the Bolshevists, and advantage was taken of this fact to overthrow the Bolshevist rule at Revel and proclaim Estonia an independent republic on Feb. 24, 1918. The resolution of the diet was laid before the Allied Governments; favourable replies were received, the *de facto* recognition of Estonia by Great Britain, France and Italy following on May 3, May 13 and May 29 respectively.

The subsequent German occupation was designed to turn Estonia into a Baltic duchy in personal union with Prussia, in conformity with the wishes of the Baltic nobility; but although the representatives of the Estonian peasant-proprietors, when summoned to the Riga Assembly on April 10, 1918, refused their consent, Baron Dellingshausen, the leader of the Baltic nobility, forwarded the request for union with Prussia to Berlin, and received the German Emperor's consent on April 21, 1918. After the peace of Brest-Litovsk (*see* BREST-LITOVSK, TREATIES OF) Soviet Russia renounced her sovereign rights over Estonia by the supplementary agreement of Berlin on Aug. 27, 1918. With the collapse of Germany the Estonian provisional Government resumed its activities. K. Pats, the former president of the diet, released from imprisonment by the Germans, became Prime Minister; and J. Poska foreign minister.

The Bolshevik Invasion.—The German troops had not been completely withdrawn before a new danger threatened from the east. Narwa had been invested by the Bolshevists, who began to penetrate into Estonia (Nov. 28), aided by landings on the coast of the Gulf of Finland. Estonia's situation was rendered difficult by the fact that the Germans had removed all arms. Out of the cadres of the Estonian regiments of 1917 Gen. Laidoner had begun to organize an Estonian army, while Capt. J. Pitka created a marine force of volunteers and students, forming shock battalions and improvising armoured trains out of goods trucks. Assistance came first in the form of a loan amounting to 20,000,000 Finnish marks, a consignment of arms and a body of over 2,000 volunteers from Estonia's sister-nation, Finland. On Dec. 12, 1918, a British fleet under Admiral Sinclair arrived at Revel, which brought over a supply of arms and took the Gulf of Finland under its protection. Sinclair captured two Russian destroyers and handed them over to Estonia. On Jan. 4, 1919, when the Bolshevists held half Estonia in their grasp, their offensive was broken, and by the beginning of February the whole country was freed. The Constituent Assembly voted unanimously for independence, and formed a coalition Government.

Throughout the spring, Bolshevik attacks continued. In May, the Estonians took the offensive, carrying operations over into Russian territory. The "Northern Corps" of the Russian White Army under Gen. Rodzianko, which had retired into Estonia from Pskov, occupied Yamburg, the Estonians taking Pskov. As the result of an attack to the south, Northern Latvia was freed from the Bolshevists. In the neighbourhood of Riga an encounter occurred with Gen. R. von der Goltz's German volunteers, who had overthrown the Lettish democratic Government at Libau. Gen. Sir H. Gough, as chief of the Allied military mission, had ruled, in support of the demand of the Estonians, that von der Goltz should not lead his troops against Estonia. In defiance of this, von der Goltz broke the armistice, but on June 21–22, at the battle of Wenden-Ronneburg his army was put to flight and driven out of Northern Latvia. By the intervention of the Allies a new armistice was concluded at Riga on July 3, 1919, and von der Goltz was forced to evacuate.

Peace with Russia.—As neither the White Russians nor the Paris peace conference of the Allies would acknowledge her *de jure*, Estonia, on Aug. 31, accepted the peace proposals made by Soviet Russia. On Dec. 5, 1919, peace negotiations were opened at Dorpat. An armistice was declared on Dec. 31, and peace was concluded on Feb. 2, 1920. Russia agreed to acknowledge the independence of Estonia and to pay her 15,000,000 gold roubles (£1,500,000) from the Russian gold fund, but refused to return the funds, savings and money which had been removed. On the other hand, Estonia was released from any responsibility for Russia's debts abroad. Free transit to Estonian ports was conceded to Russia. This was the first peace treaty concluded between Soviet Russia and any of the border states.

Currency.—The economic progress which the country has achieved may be judged from the growth of its total exports from 2,287 million Estonian marks in 1921 to 9,637 million in 1926. Direct fiduciary inflation ceased in 1921, and the exchange improved slightly during the next two years. With the bank inflation of 1923–24 the exchange depreciated from about 340 to 460 (Aug. 1924) to the dollar. By the end of the year, however, the central bank, which is a government institution, had succeeded in bringing down the rate to about 373 Estonian marks to the dollar. The exchanges were kept stable at this rate from Jan. 1925 onwards, and it is proposed to introduce a new currency, a Kroon, equivalent to 100 of the present Estonian marks.

The measure of success with which Estonia has met her economic reconstruction, despite great initial difficulties, and despite inevitable errors, has been largely due to the fact that since 1921 she has managed to balance her budget. Indeed, not only has the budget been balanced, but the capital outlay incidental upon her economic reconstruction has been largely met out of current revenues. Her taxes have thus been to a considerable extent a form of forced savings.

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Internal Affairs.—On Oct. 10, 1919, while the war was still in progress, the Estonian Constituent Assembly had passed an Agrarian Reform bill, by which manorial estates of more than 330 hectares, a type of holding which covered more than half of the whole agricultural area, were to be divided in holdings averaging from 20 to 25 hectares. Thus the landless peasant population was satisfied. The last task of the Constituent Assembly was the adoption (June 15, 1920) of a democratic constitution providing for a Republican Government, with parliament (Riigikogu) consisting of 100 members elected by universal and secret ballot on the proportional representation system. Direct exercise of power by the people is provided through initiative and referendum. The prime minister is the head of the state.

When the civil war in Russia ended the Supreme Council of the Allies agreed to the *de jure* recognition of Estonia (Jan. 26, 1921). On Sept. 22 of the same year Estonia was admitted to the League of Nations. Recognition by the United States followed on July 28, 1922.

Estonia was the last of the border states to declare the Communist party illegal (autumn, 1923). At Revel a *putsch* was attempted early in the morning of Dec. 1, 1924. About 300 conspirators, composed partly of Russian red guards and Russian transit workers in Revel, provided with arms secretly imported from Russia, made a sudden and simultaneous attack on the Government and military institutions, but were immediately repulsed. The result of this revolutionary outburst was the closing of all Communist organizations and the founding of civil guards on the Finnish model, in which 30,000 men were enrolled. The Communist movement in Estonia became virtually extinct and relations with the Soviet Union acquired a more peaceful character, and finally negotiations for a non-aggression treaty became possible. Besides this Communist outburst, the German crisis of 1923 produced a financial depression, which, however, was soon

overcome. In order to facilitate the reform of the central note bank and the creation of a currency on gold basis, the Council of the League of Nations guaranteed through a Protocol, signed in Geneva on Dec. 10, 1926, an international loan of £1,350,000 net.

By 1927 the agrarian reform was almost completely realized. A law providing compensation for the nationalized estates was passed on March 5, 1926, and the petition of the expropriated German landowners, who were not satisfied with the compensation, was declined by the Council of the League on June 15, 1927. The status of the national minorities, who constitute 12·3 per cent. of the entire population, was determined by the law of Feb. 5, 1925, which guaranteed them complete cultural autonomy.

Foreign Policy.—Attempts to co-ordinate the foreign policy of the Baltic States had been made while they were still fighting for independence. At Warsaw, on March 17, 1922, Estonia, Poland, Latvia and Finland signed a political agreement, which, however, did not come into force, Finland refusing to ratify it on the ground that it might be directed against Germany. In 1925, an agreement was reached between the Baltic States for the establishment of a permanent court of arbitration. Estonia came to a final agreement with Latvia on Nov. 1, 1923, when a treaty of defensive alliance was concluded and an economic agreement signed. The economic clauses, which established unified tariffs and duty-free transit of goods, marked the first step in the direction of a complete customs union.

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ESTOPPEL, a rule in the law of evidence by which a party in litigation is prohibited from asserting or denying some alleged fact. Estoppel is said to arise in three ways—(1) by record or judgment, (2) by deed, and (3) by matter *in pais* or conduct. (1) Where a cause of action has been tried and final judgment has been pronounced, the judgment is conclusive—either party attempting to renew the litigation by a new action would be estopped by the judgment. (2) "A man shall always be estopped by his own deed, or not permitted to aver or prove anything in contradiction to what he has once so solemnly and deliberately avowed" (Blackstone, 2 *Com.* 295). (3) Estoppel by conduct is the most important head. The rule practically comes to this that, when a person in his dealings with another has so acted as to induce him to believe a thing to be true and to act on such belief, the former may not deny the thing to be true to the detriment of the latter in any proceeding between them; *e.g.*, a partner retiring from a firm without giving notice to the customers, cannot, as against a customer having no knowledge of his retirement, deny that he is a partner. As between landlord and tenant the principle operates to prevent the denial by the tenant of the landlord's title. Again, if a man accepts a bill of exchange he may not deny the signature or the capacity of the drawer. So a person receiving goods as baillee from another cannot deny the title of that other to the goods at the time they were entrusted to him. A person cannot, however, be prevented from denying the actuality of what he cannot legally do; for example, a corporation is not estopped as to acts which would be *ultra vires*. *See* EVIDENCE.

See L. F. Everest and E. Strode, *The Law of Estoppel* (1884); M. Cababé, *Principles of Estoppel* (1888).

ESTOUTEVILLE, GUILLAUME D' (1403–1483), French ecclesiastic, archbishop of Rouen, was sent to France as legate by Pope Nicholas V. to make peace between Charles VII. and England (1451), and undertook, *ex officio*, the revision of the trial of Joan of Arc; he afterwards reformed the statutes of the University of Paris. He then went to preside over the assembly of clergy which met at Bourges to discuss the observation of the Pragmatic Sanction (*see* BASEL, COUNCIL OF), finally returning to Rome, where he passed almost all the rest of his life. He was a great builder, Rouen, Mont St. Michel, Pontoise and Gaillon owing many noble buildings to his initiative.

ESTOVERS, a term in English law for the wood which a tenant for life or years may take from the land he holds for repair of his house, the implements of husbandry, and the hedges and fences, and for firewood. The O.E. word for estover was *bote* or *boot* (*q.v.*). These rights may of course be restricted by express covenants. Copyholders had similar rights over the land they occupied and over the waste of the manor, in which case they were known as "Commons of estovers." (*See* COMMONS.)

ESTRADA, LA, a town of north-western Spain, province of Pontevedra, 7 m. E. of Requeijo, its nearest station, on the Pontevedra-Santiago railway. Pop. (1920) 25,471. La Estrada is the chief town of a populous mountain district, producing maize, wheat, barley, potatoes, fruit, cattle and pigs. Leather and linen paper are manufactured in the town, and lumber from the mountain forests is floated down the river Ulla, 4 m. N., to the seaports on Arosa bay. There are mineral springs at La Estrada and at Caldas de Reyes, 11 m. W.S.W.

ESTRADES, GODEFROI, COMTE D' (1607–1686), French diplomatist and marshal, was born at Agen. He was the son of François d'Estrades (d. 1653), a partisan of Henry IV., and brother of Jean d'Estrades, bishop of Condom. In 1646 he was named ambassador extraordinary to Holland, and took part in the conferences at Münster. Sent in 1661 to England, he obtained in 1662 the restitution of Dunkirk. In 1667 he negotiated the treaty of Breda with the king of Denmark, and in 1678 the treaty of Nijmwegen, which ended the war with Holland. He took part in the principal campaigns of Louis XIV., in Italy (1648), in Catalonia (1655), in Holland (1672); and was created marshal of France in 1675. His *Lettres, mémoires et négociations en qualité d'ambassadeur en Hollande depuis 1663 jusqu' en 1668,* were posthumously published in 1709.

Of the sons of Godefroi d'Estrades, Jean François d'Estrades was ambassador to Venice and Piedmont; Louis, marquis d'Estrades (d. 1711), succeeded his father as governor of Dunkirk, and was the father of Godefroi Louis, comte d'Estrades, lieutenant-general, who was killed at the siege of Belgrade, 1717.

See Felix Salomon, *Frankreichs Beziehungen zu dem Scottischen Aufstand* (1637–1640), containing an excursus on the falsification of the letters of the comte d'Estrades; Philippe Lauzun, *Le Maréchal d'Estrades* (Agen, 1896).

ESTREAT, originally, a true copy or duplicate of some original writing or record; now used only with reference to the enforcement of a forfeited recognizance. At one time it was the practice to extract and certify into the Exchequer copies of entries in court rolls which contained provisions or orders in favour of the Treasury; hence the estreating of a recognizance was the taking out from among the other records of the court in which it was filed, sending it to the Exchequer to be enforced, or sending it to the sheriff to be levied by him, and then returned by the clerk of the peace to the lords of the Treasury. (*See* RECOGNIZANCE.)

ESTRÉES, GABRIELLE D' (1573–1599), mistress of Henry IV. of France, was the daughter of Antoine d'Estrées, marquis of Coeuvres, and Françoise Babou de la Bourdaisière. Henry IV., who in Nov. 1590 stayed at the castle of Coeuvres, became violently enamoured of her. Her father married her to Nicholas d'Amerval, seigneur de Liancourt, but in Dec. 1592, Gabrielle, whose affection for the king was sincere, became his mistress. She lived with him from Dec. 1592 onwards, and bore him several children, who were recognized and legitimized by him. She possessed the king's entire confidence; he willingly listened to her advice, and created her marchioness of Monceaux, duchess of Beaufort (1597) and Étampes (1598), a peeress of France. The king even proposed to marry her in the event of the success of his suit for the nullification by the Holy See of his marriage with Margaret of Valois; but before the question was settled Gabrielle died, on April 10, 1599. Poison was of course suspected; but her death was really caused by puerperal convulsions (*eclampsia*).

See *Gabrielle d'Estrées et la politique de Henri IV.* (1859); A. Desclozeaux, *Gabrielle d'Estrées, Marquise de Monceaux,* etc. (1889; Eng. trans. 1907).

ESTREMADURA or **EXTREMADURA,** an ancient territorial division of central and western Portugal, and of western Spain; comprising the modern districts of Leiria, Santarem and Lisbon, in Portugal, and the modern provinces of Badajoz and Cáceres in Spain. Pop. (1920) 2,662,782; area, 23,055 sq.m. The name of Estremadura appears to be of early Romance or Late Latin origin, and probably was applied to all the far western lands (*extrema ora*) bordering upon the lower Tagus, as far as the Atlantic ocean. It is thus equivalent to *Land's End,* or *Finisterre.*

1. Portuguese Estremadura is bounded on the N. by Beira, E. and S. by Alemtejo, and W. by the Atlantic ocean. Pop. (1920) 1,544,704; area, 6,937 sq.m. The greatest length of the province, from N. to S. is 165 m.; its greatest breadth, from E. to W., is 72 m. The general uniformity of the coast-line is broken by the broad and deep estuaries of the Tagus and the Sado, and by the four conspicuous promontories of Capes Carvoeiro, da Roca, Espichel and Sines. The Tagus is the great navigable waterway of Portuguese Estremadura, flowing from north-east to south-west, and fed by many minor tributaries, notably the Zezere. South of the Tagus the land is almost everywhere low, flat and monotonous. The Sado, which issues into Setubal Bay, is the only important river of this region. North of the Tagus, and parallel with its right bank, extends the mountain chain which is known at its northern extremity as the Serra da Aire and, where it terminates above Cape da Roca, as the Serra de Cintra. On its seaward side, except for the line of sheer and lofty cliffs between Cape Carvoeiro and Cape da Roca, the country is mostly flat and sandy, with extensive heaths and pine forests. The natural resources of Portuguese Estremadura, with its inhabitants, industries, commerce, communications, etc., are described under PORTUGAL. Separate articles are also devoted to Lisbon, the capital, and Abrantes, Cintra, Leiria, Mafra, Santarem, Setubal, Thomar, Torres Novas and Torres Vedras, the other chief towns. The women of Peniche, a small fishing village on the promontory of Cape Carvoeiro, have long been celebrated throughout Portugal for their skill in the manufacture of fine laces.

2. Spanish Extremadura is bounded on the N. by Leon and Old Castile, E. by New Castile, S. by Andalusia, and W. by the Portuguese province of Beira and Alemtejo, which separate it from Portuguese Estremadura. Pop. (1920) 1,118,078; area, 16,118 sq.m. Spanish Extremadura consists of a tableland separated from Leon and Old Castile by the lofty Sierra de Gredos, the plateau of Béjar and the Sierra de Gata, which form an almost continuous barrier along the northern frontier, with its summits ranging from 6,000 to more than 8,500 ft. in altitude. On the south the comparatively low range of the Sierra Morena constitutes the frontier of Andalusia; on the east and west there is a still more gradual transition to the plateau of New Castile and the central plains of Portugal. The tableland of Spanish Extremadura is itself bisected from east to west by a line of mountains, the Sierras of San Pedro, Montanchez and Guadalupe (4,000–6,000 ft.), which separate its northern half, drained by the river Tagus, from its southern half, drained by the Guadiana. The Tagus and Guadiana flow from east to west through a monotonous country, level or slightly undulating, often almost uninhabited, and covered with a thin growth of shrubs and grass. Perhaps the most characteristic feature of this tableland is the vast heaths of gum-cistus and lavender.

The climate in summer is hot but not unhealthy, except in the swamps which occur along the Guadiana. The soil is naturally fertile, but drought, floods and locusts render agriculture difficult, and sheep-farming is the most important of Extremaduran industries. (*See* SPAIN: *Agriculture.*)

Immense herds of swine are bred and constitute a great source of support to the inhabitants—the pork, bacon and hams being in high esteem. The beech, oak and chestnut woods afford an abundance of food for swine, and there are numerous plantations of olive, cork and fruit trees. *See* CÁCERES and BADAJOZ. In character and physical type, the people of this region are less easily classified than those of other Spanish provinces. Their failure to develop a distinctive local type of character and civilization is perhaps due to the adverse economic history of their country. The two great waterways which form the natural outlet for Estremaduran commerce flow to the Atlantic through a foreign and, for centuries, a hostile territory. Like other parts of Spain, Extremadura suffered severely from the expulsion of the Jews and Moors (1492–1610). Many ancient palaces at Trujillo and Cáceres recall the fact that Cortes (1485–1547), the conqueror of Mexico and Pizarro (*c.* 1471–1541), the conqueror of Peru, were both born in Estremadura, but their exploits, far from bringing permanent prosperity to their native province, only encouraged the emigration of its best inhabitants.

ESTREMOZ, a town of Portugal, 104 m. by rail E. of Lisbon, on the Casa Branca-Evora-Elvas railway. Pop. (1920) 8,591. Estremoz is built at the base of a hill crowned by a large dismantled citadel. There are marble quarries in the neighbourhood, and the Estremoz *bilhas,* red earthenware jars, are used throughout Portugal as water-holders and exported to Spain. At Ameixial (661) and Montes Claros, near Estremoz, the Spanish were severely defeated by the Portuguese in 1663 and 1665. Villa Viçosa (4,144), 10 m. S.E., is a town of pre-Roman origin, containing a royal palace.

ESTUARY, the mouth of a river where sea and fresh water meet and where tidal effects are conspicuous (Lat. *aestuarium,* a place reached by *aestus,* the tide). An estuary may result from the long-continued joint action of river and tidal erosion confined to a narrow structural depression, or an estuary may be the drowned lower portion of a river-valley. Isobaths are drawn to show sea-depths and the isobathic chart of the Severn estuary, for example, shows a progressive deepening seawards by means of V-shaped lines which become blunter westwards until the last one is a mere indentation pointing up channel; these lines may be indicative of the progress of the channel over the existing continental shelf. Where, as in the Severn and the Thames, the fresh water meets the sea gradually the water is thoroughly mixed, and there is very little change in salinity at high tide. The fresh water tends to flow over the denser salt water, but there is a continuous increase in salinity seawards, for the ebbing and flowing currents constantly mix the waters. On the other hand, where the river brings down a great quantity of fresh water into a narrow channel, the change of salinity from high to low water is very marked. Mill uses the Firth of Forth as an interesting example; here the landward half is a true estuary, but the seaward half has the water so thoroughly mixed that the salinity is almost uniform from surface to bottom, and increases but gradually towards the sea. In consequence, the Forth causes the sea to become slightly freshened throughout its whole depth for many miles from the land.

ESZTERGOM, a Hungarian town situated on a loess-covered terrace on the right bank of the Danube, nearly opposite its confluence with the Hron. Once the capital of Hungary and the site of its first church it is the seat of the primate of Hungary, but its chief claim to national importance lies in the fact that it was the birthplace of St. Stephen, the first "apostolic king" of Hungary. As one of the great centres of Magyar life it attracted the attention of the Mongols who destroyed it in 1241, but it was rebuilt and fortified by King Béla IV. Becoming thus a strong outer guard of Vienna the Turks attacked and held it for two periods, 1543–95 and 1604–83. During this time of stress the archbishopric, dating from 1001, was moved to Trnava (*q.v.*), where it remained till 1820. The cathedral on a hill 215 ft. above the river is a grandiose structure, erected 1821–70, on the lines of St. Peter's at Rome and contains in its treasury the 13th century Florentine Calvary of King Matthias and the double cross presented to King Stephen by Pope Silvester II. The town has many other churches and ecclesiastical buildings, including a beautiful primate's palace in Renaissance style, containing a rich collection of antiquities. The population is chiefly engaged in the weaving of cloth, wine-making and mixed farming. Pop. (1920) *c.* 20,000.

ÉTAGÈRE, a piece of light furniture very similar to the English what-not, which was extensively made in France during the latter part of the 18th century. As the name implies, it consists of a series of stages or shelves for the reception of ornaments or other small articles. Like the what-not it was very often corner-

wise in shape, and the best Louis XVI. examples in exotic woods are exceedingly graceful and elegant.

ETAH, a town and district of British India, in the Agra division of the United Provinces. The town is situated on the Grand Trunk road. Pop. (1921) 9,597. The district has an area of 1,720 sq.m. The district consists for the most part of an elevated alluvial plateau, dipping down on its eastern slope into the valley of the Ganges. The uplands are irrigated by the Ganges canal. Between the modern bed of the Ganges and its ancient channel lies a belt of fertile land, covered with a rich deposit of silt, and abundantly supplied with natural moisture. A long line of swamps and hollows still marks the former course of the river; and above it rises abruptly the original cliff which now forms the terrace of the upland plain. The neighbourhood of Etah is mentioned by Hsüan Tsang, the Chinese Buddhist pilgrim of the 7th century A.D., as rich in temples and monasteries. With the rest of upper India it passed under the sway of Mahmud of Ghazni in 1017, and thenceforth followed the fortunes of the Mohammedan empire. At the end of the 18th century it formed part of the territory over which the wazir of Oudh had made himself ruler, and it came into the possession of the British government in 1801, under the treaty of Lucknow. In 1921 the population was 829,760. There are cotton gins and presses at Kasganj (pop. 20,988) and Soron (pop. 10,175), which are the two chief trading centres of the district.

ÉTAMPES, ANNE DE PISSELEU D'HEILLY, Duchesse d' (1508–*c.* 1580), mistress of Francis I. of France, daughter of Guillaume of Pisseleu, sieur d'Heilly, a nobleman of Picardy. She was one of the maids of honour of Louise of Savoy. Francis I. made her his mistress, probably on his return from his captivity at Madrid (1526). In 1533 Francis gave her in marriage to Jean de Brosse, whom he created duc d'Étampes. The duchess upheld Admiral Chabot against the constable de Montmorency, who was supported by her rival, Diane de Poitiers, the dauphin's mistress. She was a friend to new ideas, and co-operated with the king's sister, Marguerite d'Angoulême. After the death of Francis I. (1547) she was dismissed from the court by Diane de Poitiers, and died in obscurity, probably in the reign of Henry III.

See Paulin Paris, *Études sur François Ier* (1885); E. Desjardins, *Anne de Pisseleu, Duchesse d'Étampes, et François Ier* (1904), which contains a bibliography.

ÉTAMPES, a town of northern France, capital of an arrondissement in the department of Seine-et-Oise, on the Orléans railway, 35 m. S. by W. of Paris. Pop. (1926) 9,411. Étampes (Lat. *Stampae*) existed at the beginning of the 7th century and in the early middle ages belonged to the crown domain. During the middle ages it was the scene of several councils, the most notable of which took place in 1130 and resulted in the recognition of Innocent II. as the legitimate pope. In 1652, during the war of the Fronde it suffered severely at the hands of the royal troops under Turenne. The lordship of Étampes, in what is now the department of Seine-et-Oise in France, belonged to the royal domain, but was detached from it on several occasions in favour of princes, or kings' favourites. St. Louis gave it to his mother Blanche of Castile, and then to his wife Marguerite of Provence. Louis, the brother of Philip the Fair, became Lord of Étampes in 1317 and count in 1327; he was succeeded by his son and grandson. Francis I. raised the countship of Étampes to the rank of a duchy for his mistress Anne de Pisseleu D'Heilly. The new duchy passed to Diane de Poitiers (1553), to Catherine of Lorraine, duchess of Montpensier (1578), to Marguerite of Valois (1582) and to Gabrielle d'Estrées (1598). The latter transmitted it to her son, César of Vendôme, and his descendants held it till 1712. It then passed to the families of Bourbon-Conti and of Orleans.

Étampes stretches between the railway on the north and the Chalouette, a tributary of the Juine, on the south. The Tour Guinette is a ruined keep built by Louis VI. in the 12th century. Notre-Dame du Fort (11th and 12th centuries), the chief church, is irregular in plan, with a fine Romanesque tower and spire, and a crenellated wall. The interior contains ancient paintings. St. Basile (12th and 16th centuries) preserves a Romanesque doorway, and St. Martin (12th and 13th centuries) a 16th century leaning tower. Two houses named after Anne de Pisseleu (*see* above), mistress of Francis I., and Diane de Poitiers, mistress of Henry II., are graceful examples of Renaissance architecture. There are a subprefecture and a tribunal of first instance. Flour-milling, printing and manufacture of hosiery are carried on.

ÉTAPLES, a town of northern France, in the department of Pas-de-Calais, on the right bank of the estuary of the Canche, 3 m. from the Straits of Dover, 17 m. S. of Boulogne by rail. Pop. (1926) 6,423. Étaples was a small fishing and commercial port, important during the middle ages. Boat-building is carried on. Le Touquet, in the midst of pine woods, and the neighbouring Paris-Plage, 3½ m. W. of Étaples at the mouth of the estuary, are much frequented watering places. Antiquarian discoveries have led to the conjecture that Étaples occupies the site of the Gallo-Roman port of *Quentovicus.* In 1492 a treaty was signed here between Henry VII., of England, and Charles VIII., of France. The town was used by the British in the World War.

ETAWAH, a town and district of British India, in the Agra division of the United Provinces. The town is situated on the left bank of the Jumna. Pop. (1921) 41,558. Deep fissures intersect the various quarters of the town, over which broad roads connect the higher portions by bridges and embankments. The Jamma Musjid (Great Mosque) is the chief architectural ornament of Etawah. It was originally a Hindu temple, and was adapted to its present use by the Mohammedan conquerors. Several fine Hindu temples also stand about the mound on which are the ruins of the ancient fort. The manufactures include cotton cloth, skin-bottles, combs and horn-ware.

The District of Etawah has an area of 1,691 sq.m., stretching across the level plain of the Doab, and beyond the valley of the Jumna, to the gorges of the Chambal, and the last rocky outliers of the Vindhyan range. The district exhibits a striking variety of surface and scenery. In the Doab portion the tract to the north-east of the river Sengar is rich and fertile, being watered by the Ganges canal; across the Sengar there is no canal and less fertility. Near the banks of the Jumna, the plain descends into the river valley by a series of wild ravines and terraces, inhabited only by a scattered race of hereditary herdsmen. Beyond the Jumna again a strip of British territory extends along the tangled gorges of the Chambal and the Kuari Nadi, far into the borders of the Gwalior state. Important experiments have been made in reclaiming ravines and afforestation.

Etawah was marked out by its physical features as a secure retreat for the turbulent tribes of the Upper Doab, and it was not till the 12th century that any of the existing castes settled on the soil. After the Mohammedan conquests of Delhi and the surrounding country, the Hindus of Etawah appear to have held their own for many generations against the Mohammedan power; but in the 16th century Baber conquered the district with the rest of the Doab, and it remained in the hands of the Moguls until the decay of their empire. After passing through the usual vicissitudes of Mahratta and Jat conquests during the long anarchy which preceded the British rule, Etawah was annexed by the wazir of Oudh in 1773, and ceded to the East India Company in 1801. In 1921 the population was 733,532.

ETCHING is the process of biting lines or areas by means of acid or some other chemical. By etching generally we mean the process of biting these lines in a metal plate with a view to its being printed from, and by an etching, the print taken from a plate so etched. Lines may indeed be etched on a metal plate which is itself intended to serve some decorative purpose, with no idea of prints being taken from it, but etching of this sort should more properly be treated in connection with decorative metal work and has no significance here. Etching, as above defined, has this important point in common with line engraving, that the lines which are to appear black on the print are incised as opposed to those in wood engraving which are in relief. The process of printing from an etched plate is, therefore, identical with that of printing from an engraved plate. Etching only differs from line engraving in the process by which the lines are incised; in the latter case, by an instrument of triangular section which scoops a shaving out of the metal; in the former, by chemical

action. A print from an etched plate may generally be distinguished from a print from an engraved plate, by the fact that in the former the lines do not diminish or increase gradually in thickness but do so in more or less abrupt stages; that the endings of the lines are square, whereas in the latter they taper gradually to an end. These differences are inherent in the different processes. It is obviously impossible to end a line abruptly by means of a triangular gouging instrument, such as a burin; if the burin were stopped suddenly the shaving it forms in its course would be left. In etching, on the other hand, the thickness or thinness of the lines being obtained by successive bitings and each successive biting being comparatively uniform over the plate, a line, which is intended to gradually diminish in size, has (microscopically perhaps) a form like that of an extended telescope. Engraving has, of course, been constantly used in combination with etching and it is often a matter of difficulty to distinguish between the parts which are purely etched, those which have been first etched and later strengthened by the engraving tool and those which have been directly engraved. A further word should be added on the subject of dry-point. This is merely the process of scratching with the etching needle direct on the plate. In its passage the needle leaves an irregular ridge on either side of the line which it makes (burr) to which the ink adheres, so that a dry-point line when printed has at first a slightly blurred, but rich effect: this burr wears away quickly and the scratched line by itself, when printed, is then faint and meagre. Dry-point, though it is independent of the use of mordants, is generally employed in conjunction with etching for the richness of its effect.

The number of satisfactory prints which may be taken from an etched plate varies according to the hardness of the metal and the depth to which the lines have been etched. A fine line on a copper plate may be almost obliterated after 200 or 300 impressions: a dry-point line will, as has been indicated, lose its characteristic effect very much sooner. Some of the prints taken from Rembrandt's plates 50 years ago are almost, though not quite, as good as those taken during his lifetime.

HISTORY

Etching, like engraving, was probably invented north of the Alps, and it is in Germany, France and England, and above all the Netherlands, that the greatest triumphs of the process have been achieved. It will be most convenient in a brief summary of its history to deal with its progress in the Teutonic countries from its beginning to the end of the 17th century, and then to return to Italy, France and Spain. As a means of decorating metal, particularly armour, etching was practised at least as early as the middle of the 15th century. It seems probable that, as the earliest engraving was the work of goldsmiths, so the earliest etching is to be credited to the armourers. The idea of printing from such a plate they no doubt borrowed from the goldsmiths. The first etching, to which an approximate date can be given, is a portrait of Kunz van der Rosen by Daniel Hopfer (working 1493–1536), which a rather complicated line of reasoning assigns to the year 1504 or earlier. Daniel Hopfer was one of a family of armourers working in Augsburg, but was an artist of much originality. Hans Burgkmair the elder (1473–1531), the dominating personality of the Augsburg school, and on whom the Hopfers largely depended, executed a single etching, no doubt learning the process from the lesser artists. The earliest etching which actually bears a date is one by the Swiss goldsmith, soldier and draughtsman, Urs Graf (d. 1529), of the year 1513, most probably done at Basle. Albrecht Dürer (1471–1528), with the eagerness for experiment which characterized him, tried etching, but apparently found it an unsympathetic medium and after a few experiments gave it up in favour of engraving. His half dozen etchings dated between 1515 and 1519, impressed though they are with that great artist's personality, are among the least satisfactory of his reproductive work. Iron, the metal used in all these first attempts, did not allow of much delicacy, and the result, compared with line engraving on copper, for which it was regarded as merely a less laborious substitute, unsatisfactory. However, it was a new process which everyone must try out for himself. In Holland Lucas van Leyden (1494–1533), who probably learnt the process from Dürer during the German's visit to the Netherlands in 1520–21, etched a few plates. These are technically superior to Dürer's, and of importance as probably the first examples of the use of copper for etching, which made it possible for line engraving to be used in combination with it. The fine portrait of Maximilian which Lucas van Leyden made in 1521 is an example of this combined use of etching and engraving, the whole of the emperor's face being finished with the burin. Dirick Vellert at Antwerp (working 1517–44), an artist of delicate accomplishment, uses a technique much resembling Lucas's, though the majority of his works are engraved. Nicolas Hogenberg of Munich (working 1523–37), whose artistic career was passed at Malines in the service of Margaret of Austria, was one of the first northern artists to use etching with rapidity and freedom, and his frieze of the entry of Charles V. into Bologna in 1530, in a number of plates, is important from its size as well as from its subject. Frans Crabbe (the Master of the Crayfish; d. 1553), who was associated with Hogenberg, also followed his example in etching, but his work is unequal in quality.

Dürer's followers in Nuremberg, Hans Sebald Beham (1500–50) and Georg Pencz (1500–50) etched only a few plates, for the most part in the years immediately following Dürer's experiments. Albrecht Altdorfer (about 1480–1538) of Ratisbon, also no doubt impelled by Dürer's example, tried his hand at etching as early as 1519, and later used it for the first pure landscapes produced. Augustin Hirschvogel (1503–53?) and Hans Sebald Lautensack (working 1524–63) in Vienna followed Altdorfer's example in landscape, but without quite the freshness and charm of its originator. The only succeeding etcher of importance in Germany is Jost Amman (1539–91), who worked at Nuremberg.

In the Netherlands, line engraving usurped the field in the latter half of the 16th century and comparatively little etching was done. Jan Cornelisz Vermeyen (1500–59), the court painter of the Emperor Charles V., had etched a number of plates. He is probably the earliest example in the Netherlands of the painter, with no training as an engraver, turning his hand to etching. His plates, some of them of large size, are still executed in rather a formal style but are extraordinarily fresh and effective. Marcus Gheeraerts the Elder (*c.* 1521–1604), of Bruges, was the author of a charming series of small plates illustrating Aesop (1567), which are etched with a delicacy and sensitiveness hardly equalled by Adrian van Ostade or Hollar. Gheeraerts spent the latter part of his life in England, where he issued further etchings, the first to be published in that country. Hieronymus Cock (1510?–70), the publisher, did some admirable landscapes of the conventional type, and the great Pieter Brueghel (1525?–69) and Frans Floris (*c.* 1517–70), the fashionable painter of the time in Antwerp, each etched one plate, while Hans Bol, the landscape painter and draughtsman of Malines (1534–1593), within rather narrow limits, was an etcher of considerable charm. Paul Bril of Antwerp (1554–1626), who passed practically the whole of his life in Italy, is chiefly interesting as a link between the conventional Italian landscapes evolved in the Venetian school and the native style of the Netherlands. Hercules Seghers (*c.* 1590–1645), an artist of real originality, is dependent on Bril's theatrical conventions, while still in contact with Rembrandt. Seghers's curious experiments in printing and colouring by hand, though they cannot be actually classed as colour prints, as he never attempted to print with more than one colour at a time, are interesting and unique. Esaias van de Velde (*c.* 1590–1630) and his brother Jan (*c.* 1596–1641) are the earliest of the Dutch etchers who looked to Holland for the subjects of their landscapes. Simple, almost meagre in technique as their etchings are, they render with a naïve charm and directness the views in their native land. Willem Buytewech (*c.* 1585–1625), from whose drawings the Van de Veldes worked, is well known as a painter of individuality, which appears in his few etchings.

The enumeration of the names of these few etchers who worked in the Netherlands at the end of the 16th and beginning of the 17th century, leads up to, but does not explain the importance,

which, with surprising suddenness, the medium attained in the hands of Rembrandt Van Rijn (1606–69), and Anthony Van Dyck (1599–1641). The latter's achievement, remarkable as it is, is limited in scope and quantity, but as it precedes Rembrandt's in point of time will be dealt with first. The famous "Iconography" was planned by Van Dyck as a series of engraved portraits of contemporaries eminent in the arts. Etching was to play only a subsidiary and preliminary part in it, and, in fact, it was only for 18 of the 100 plates issued that Van Dyck himself executed preliminary etchings. The rest were engraved in line by the professional engravers trained in the school of Rubens. These 18 etchings, too, were subsequently finished by these same engravers, and it is only in the very rare impressions taken from these plates, before the additions were made, that Van Dyck can be appreciated as an etcher. His methods are quite independent of previous practice and of the conventions of line engraving. No doubt, the fact that he regarded the etching as merely preparatory, was partly responsible for their freedom from preconception. His natural instinct for form, aided to a certain extent by the example of Barocci and Italian etchers, led him straight to the secret of etching which we have since come to recognize is the essential one. His methods seem so obvious, that it is difficult as well as superfluous to try to describe them. Economy of line and contrast between this and the whiteness of the paper is the main secret. The heads stand out realized with quite extraordinary force and precision. There is no use of dry-point or of tone on the surface of the plate: the effect is gained by clean draughtsmanship.

Van Dyck's example as an etcher had comparatively little immediate effect; it is in modern times that his influence is most apparent. The great influence which he excited during his lifetime and for the rest of the 17th century was on portrait *engraving*, through the "Iconography" in its completed, engraved state.

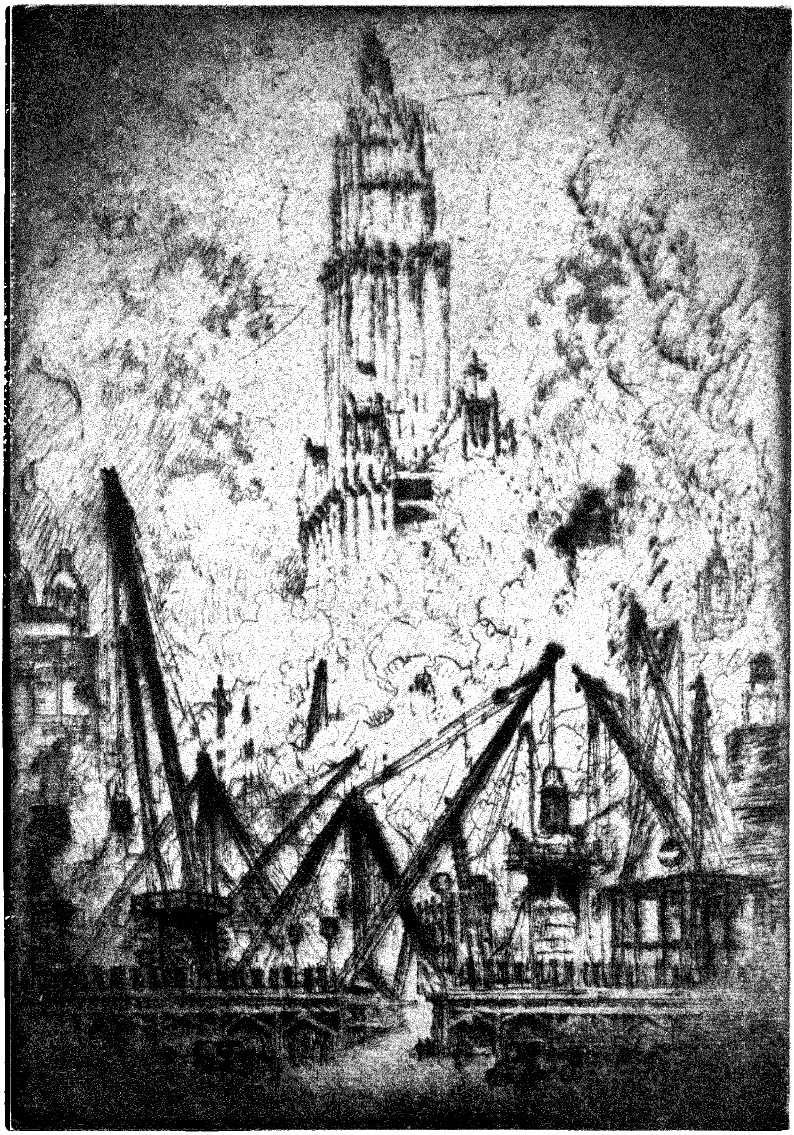
Rembrandt's importance as an etcher is greater than Van Dyck's in proportion to the superiority and greater versatility of his genius. The number of his etchings, varying indeed with the trend of criticism from the 140 accepted by Prof. H. W. Singer to the 300 allowed by Prof. A. M. Hind, is at all events considerable, and comprises every variety of subject, scenes from the Old and New Testament, *genre*, portrait, still life, landscape. In his treatment of each subject in turn, his method is as fresh and untrammelled as was Van Dyck's in relation to portrait. But unlike Van Dyck's, Rembrandt's approach was gradual, and final and complete as each successive achievement appears to us, to him nothing was satisfying or final. The earliest dated etching, the small portrait head of his mother of 1628, is a masterly achievement, reflecting with great exactness the style of portraiture of his early Leyden period. Between this date and about 1632, his style undergoes no material change, though his etchings vary enormously in quality and elaboration. About 1636 the influence of Rubens, apparent in his painting, is correspondingly seen in his etching in a different and lighter chiaroscuro, with a tendency to sharper contrasts in light and shadow. The so-called "100 guilder print" of 1649 (Christ blessing little children) marks the apogée of his next period, in which dry-point plays an important part, and where the whole plate is covered with a network of fine lines, giving almost the appearance of mezzotint. To 1653 belong two of his largest and perhaps his most wonderful plates the "Ecce Homo" and the "Three Crosses," in the latter of which his feeling for the dramatic moment, his tremendous power of expressing emotion in terms of chiaroscuro, are triumphantly exhibited. The technique has become slightly less elaborate; heavy individual lines are more apparent, there is less use of cross hatching and a tendency to model in vertical parallels and a masterly use of the effects of tone left on the surface and of dry-point. In the etchings which follow up to the last-dated one of 1661, there is a further tendency towards the still broader and more drastic treatment visible in his latest paintings, and a more complete reliance on heavily etched line without dry-point. The landscape etchings, most of which belong to the years about 1640 and 1650, stand somewhat apart in the comparative simplicity of their aim as studies from nature, with the exception of the most famous, the "Three Trees" of 1643, which is as dramatic as any of his subject etchings. The portraits are, for the most part, in the more careful and elaborate technique of his earlier period, and perhaps insisted on by his sitters. The greatest are among the numerous portraits he etched from the mirror in every variety of costume and character.

Rembrandt's contemporaries in Holland, except for his immediate associates and followers Jan Livens (1607–74), Ferdinand Bol (1618–80), Jacob (*c.* 1616–1708) and Philips Koninck (1619–88) and J. G. van Vliet, remain comparatively uninfluenced. Anthonis Waterloo (1609?–1677?), who enjoyed in the 18th century an enormous and exaggerated vogue, has indeed some claims to importance as a landscape etcher, and Alart van Everdingen (1621–75), in his small plates, mostly of Norwegian scenes, shows a delicate and observant talent. Jacob Ruysdael (*c.* 1628–82) may claim a place next to, though indeed far below, Rembrandt's as a landscape etcher. His delicate and exquisitely finished etchings are in the nature of detail studies of particular woodland scenes, diversified by still water reflecting the trees. Of the Dutch painters who looked for their theme to Italy, Nicholas Berchem (1620–83) and Karel du Jardin (1622–78) are the best known. Their landscapes included as important parts of the composition human figures and animals, and they serve as a link connecting the landscape with the animal and *genre* painters. Of the animal painters Paul Potter (1625–54) is the most famous; of the *genre* painters Adrian van Ostade (1610–85). Ostade uses etching with a painter's eye, and knows equally well how to render with extraordinary subtlety the subdued light of the squalid interior, and the glow of sunlight on a scene of rustic festivity.

The only etcher of note to work in England during the 17th century is Wenceslaus Hollar (1607–77), who was born at Prague but spent the greater part of his life in the British Isles. Of the very large number of etchings which he executed the majority was intended to serve merely utilitarian and topographical purposes, but in spite of this nearly everything that he did shows at least a touch of real artistic feeling.

Though etching, as we have seen, was probably invented north of the Alps, it is in Italy that its potentialities as an independent graphic medium were first realized. Francesco Mazzuoli (Parmegiano) (*c.* 1503–40) in his few plates uses the etching needle not as a substitute for the burin, but with the freedom of the pen. His etchings are obvious reproductions of his masterly but rather facile drawings, which enjoyed a very great contemporary popularity, and he most probably employed etching as a method of satisfying the demand for his drawings. Following his example, most of the great Italian painters thought it incumbent on them to make at least a few etchings. Of Parmegiano's immediate following the Venetian painter, Andrea Meldolla (Schiavone) (d. 1582), is the only etcher of importance, and his work in this direction is almost entirely derivative from that of his prototype. Battista Franco (1498?–1561), the Venetian follower of Michelangelo, did a certain amount of etching, but in a lighter and more formal style, and the work of the other Venetians like Battista and Marco' Angelo del Moro, G. B. and Giulio Fontana and Paolo Farinati, show rather a reaction against the freedom of Parmegiano's style, to which, however, Jacopo Palma the Younger (1544–1628) returns with some measure of success. Federico Baroccio of Urbino (1528–1612), in his two or three etchings, works out quite a new and striking method of his own, detailed and careful, but at the same time quite different from the conventional engraver's style, and a masterly rendering of the peculiar effects of chiaroscuro at which he aimed in his paintings. Annibale Carracci (1560–1609), the most brilliant exponent of the so-called eclectic school of Bologna, in his few etchings is less original, but they still have the stamp of a real artistic personality.

In etching, as in painting, the artists of Italy are roughly divided into two schools during the 17th century: the one following the orthodox teaching of the Bolognese Carracci, the other deriving from Michaelangelo da Caravaggio. The division is no longer a territorial one and the eclectics worked side by side with the "tenebristi" or follower of Caravaggio. This close con-

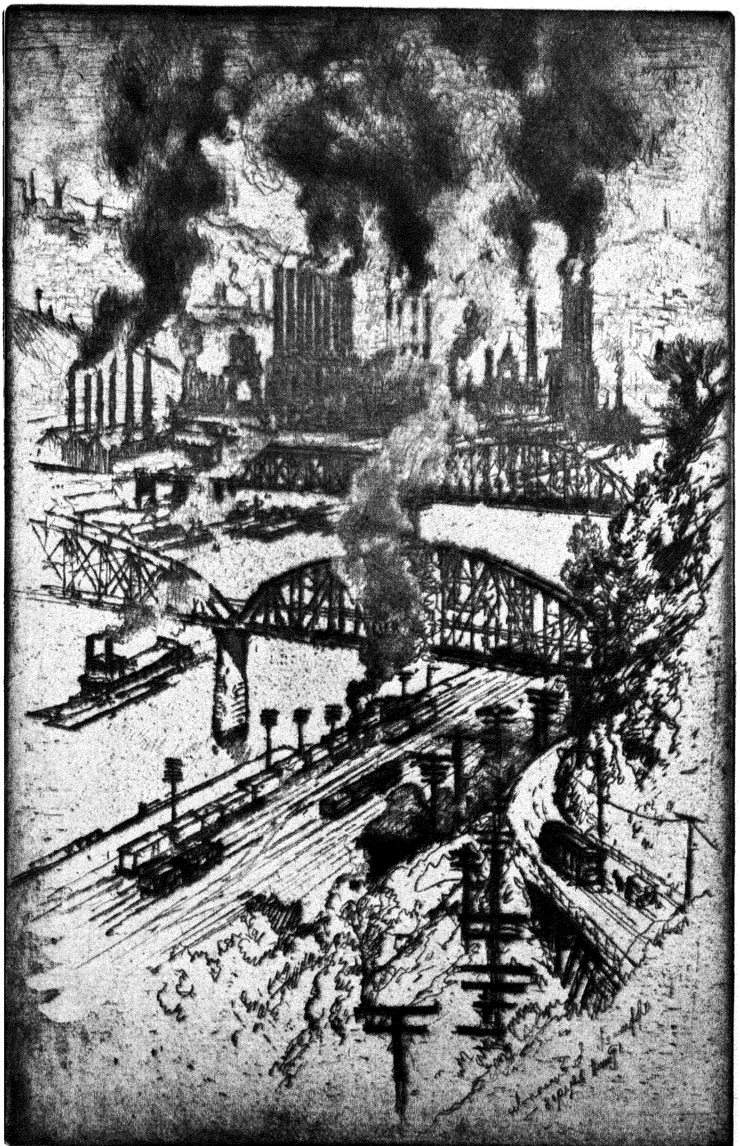


BY COURTESY OF MRS. JOSEPH PENNELL

THE CAISSONS, BY JOSEPH PENNELL (1860–1926)

One of a series of etchings by Pennell on American industrial subjects

ETCHING



BY COURTESY OF MRS. JOSEPH PENNELL

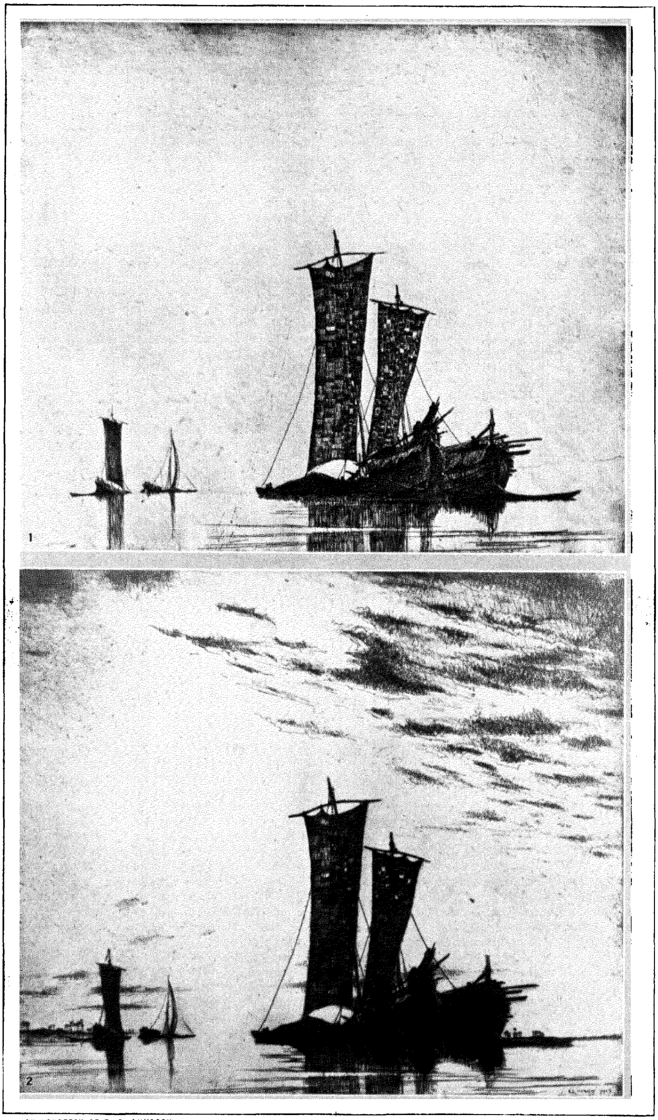
ON THE ROAD TO BESSEMER, BY JOSEPH PENNELL (1860–1926)

One of a series of etchings by Pennell on American industrial subjects

BY COURTESY OF E. S. LUMSDEN

STAGES IN THE TECHNIQUE OF ETCHING

1. Alcantara Bridge, Toledo. The first trial state of an etching by E. S. Lumsden, showing alterations on the copper
2. Second state. The distance and water have been scraped out and re-drawn
3. Third state. The lines of the water have been removed once more, and replaced by vertical strokes
4. Final (published) state. The lines of the water have been re-drawn a third time, once more horizontally. The bridge remains untouched throughout, the difference in strength being due to printing only



BY COURTESY OF E. S. LUMSDEN

THE TECHNIQUE OF ETCHING

1. First trial-proof of the *first published state* of an etching by E. S. Lumsden. Nitric acid has been used throughout
2. Seventh trial-proof of the *second published state* of this etching. Additional work was done on the sky and the boats were re-bitten

tact led by degrees to a mutual influence by one school on the other and the original line of demarcation becomes gradually obscured. Guido Reni (1575–1642), an actual pupil in the Carracci school at Bologna, is the most eminent of the eclectic etchers, and his well balanced, delicately sentimental style became the classic type for most of the etchers in France and Italy during the century. Simone Cantarini and Giovanni Antonio and Elisabetta Sirani are agreeable echoes of Guido. G. F. Barbieri (Guercino) (1591–1666) in his few etchings is more original and shows some Caravaggiesque influence as does Giuseppe Caletti (*c.* 1600–60). G. F. Grimaldi (1606–80?) the chief landscape etcher of the school, is conventional and dull. Carlo Maratta (1625–1713) carries on the Carracci style into the 18th century. The greatest etcher working in Italy in the 17th century is undoubtedly the Spaniard José de Ribera (1588–1652). His style, in so far as it is not to be classed as Spanish, is definitely Caravaggiesque, but his technique as an etcher is partly derived from the Bolognese. The sensitiveness of his outline, which plays an important part in his work, and the sureness with which he knows how to render the changes from brilliant light to darkest shadow, are extraordinary. Ribera's pupil, the Neapolitan Salvator Rosa (1615–1673), the painter of romantic bandit-infested landscapes, in his etchings, the less pretentious ones particularly, shows some of the charm which we associate with his fantastic world. In Genoa, Benedetto Castiglione (1616–70), whose talent has something in common with Salvator's, is attractive from the grace which characterizes his etchings and interesting from the fact that he was influenced by Rembrandt's work. In Venice, Giulio Carpioni (1611–74) etches with vividness and grace romantic scenes in a technique derived from the Carracci. Pietro Testa (1611–50), who worked in Rome, is an unequal but not uninteresting artist, with a curiously Venetian feeling for light which anticipates Tiepolo.

Little etching was done in France in the 16th century. The frescoes decorating the palace at Fontainebleau executed by Rosso Fiorentino, Primaticcio and their followers, were reproduced in etching by Antonio Fantuzzi, Leonard Thiry and other artists engaged in the work, but these are crude and hasty works. Jean Cousin (d. 1590) is credited with two or three etchings of more merit, and the architect and designer, Jacques Androuet Ducerceau (*c.* 1510–80), used etching for his delightful architectural compositions with a truly French grace. But with the 17th century and the names of Jacques Callot (1592–1635) and Claude Lorrain (1600–82), France attains a position of real importance in the history of etching. Callot, unlike most of his contemporaries and successors who depended almost entirely for their inspiration on Italian classicism, is essentially and originally French. Technically, his innovations consist in his handling of the individual line, by the thinning and thickening of which exclusively his effects are obtained, but he is also the inventor of a new world of minute fantastic figures, a sort of French stage fairyland. Besides their extraordinary elegance, such series as the *grandes* and the *petites misères de la guerre,* have a point and an emphasis in their narrative which is surprising on so minute a scale. The technique of subsequent etching could not and did not remain uninfluenced by Callot's practice, but his only close follower is an Italian, Stefano della Bella (1610–64). The French academicians of the *grand siècle,* Le Sueur, Le Brun and the rest with their ready-made classical formulae had no chance of success in a medium as personal as etching should be, and it remained for Claude Lorrain with his direct reactions to the landscape which he saw around him to produce the only great etchings of the period besides those of Callot. Though his conception of landscape painting was bound by certain theatrical conventions, in his drawings and etchings he approaches his subject directly and at the same time with the true landscape painter's instinct for selection. He is not a good etcher technically; there is something fumbling and amateurish in his work, but in spite of these disadvantages, he somehow succeeds in producing landscape etchings of an extraordinarily moving quality.

The 18th century did not find in etching its most characteristic means of expression. In France, whose artistic preponderance in Europe during the period, was undisputed, line engraving was more extensively and more successfully practised. Etching was to a large extent employed, it is true, but mostly as a preliminary to or in conjunction with engraving, and such mixed productions may more legitimately be classed as engravings (*q.v.*). Antoine Watteau (1684–1721), François Boucher (1703–70), Honoré Fragonard (1732–1806) and the brothers Augustin (1736–1807) and Gabriel de St. Aubin (1724–80), all practised etching to a limited extent. Jean Duplessi-Bertaux (1747–1813) etched historical scenes largely of republican and Napoleonic times with a spirit and delicacy quite in the tradition of Callot.

It is, however, in Italy and Spain that the great etchers of the century flourished. Giovanni Battista Tiepolo of Venice (1696–1770), whose brilliant decorative painting is the culmination of rococo art, showed as an etcher equal brilliance. His technique, recalling that of José Ribera and G. B. Castiglione, is yet entirely original in its almost complete avoidance of heavy defining shadow and his method of rendering the broad, grey shadows by systems of herring bone and irregularly arranged short lines. His scenes, laid in a brilliant and all-enveloping sunlight, comprise some of the stock 18th century sylvan and Arcadian *genre,* as well as more imaginative subjects, but treated alike with a peculiar point and irony. Antonio Canale (Canaletto) (1697–1768), Tiepolo's contemporary in Venice, distinguished as the most brilliant portrayer of his native city, was an etcher of almost equal distinction. His 31 etchings of Venice and the neighbourhood reproduce faithfully the quality of his painting. It is, indeed, remarkable in him and in Tiepolo how their etching is directly dependent on their painting. They seem each independently to have discovered that method of etching extraordinarily complicated and original, which would most exactly correspond to the essential quality of their painting. In each case the result is not, as might have been anticipated, a lifeless reproductive technique, but a brilliant addition to the repertoire of etching. Giovanni Battista Piranesi (1720–78), the third great Italian etcher of the century, though also a Venetian by birth, worked nearly all his life in Rome. The bulk of his very extensive etched work is archaeological, but his feeling for architectural composition and for the quality of the etched line entitle this work to be regarded from the artistic point of view.

Francisco Goya y Lucientes (1746–1828) inevitably finds a place at the beginning of any account of modern art, and indeed his work looks forward into the 19th rather than backward into the 18th century, so extraordinarily fresh and original it is and so free from any of the typically rococo elements which mark 18th century art. Yet technically, Goya derives from Tiepolo (he visited Italy during his youth) and his earliest work in etching, though it reproduces paintings by Velázquez, is very much in Tiepolo's style. But his original compositions, the series of the *Caprichos,* the *Proverbios,* the *Desastres de la Guerra* and last of all the *Tauromaquia,* show the evolution of an original technique with the use of aquatint for the backgrounds. The mysterious satirical works, the *Caprichos* and *Proverbios,* although the exact target at which their shafts are aimed is uncertain, are overwhelming in the bitterness and intensity of their satire and the horror of the imagination which they show.

With the notable exception of Goya's work there is comparatively little of interest to record in the field of etching during the first half of the 19th century. It is one of those periods of stagnation which occur before a revival. In England, work of distinction, based on that of Rembrandt's contemporaries such as Ruysdael, was done by John Crome (1768–1821) of Norwich, as well as by John Sell Cotman (1782–1842), most of the latter in the process, invented at the end of the 18th century, called soft-ground etching. The names of Thomas Girtin (1775–1802) and J. M. W. Turner (1775–1851), can hardly be omitted in view of their pre-eminence as landscape painters, but their work in etching, masterly as it is, was in neither case intended to be final. Girtin's etchings were preparatory to aquatints and Turner's to mezzotints. Andrew Geddes of Edinburgh (1783–1844) is the author of a number of plates of real distinction, marked by a considerable and intelligent use of dry-point, and Samuel Palmer

(1805–81) is a landscape etcher of individuality.

The painters of the "Barbizon" school of landscape in France, Théodore Rousseau (1812–1867), Charles Jacque (1813–1894), C. F. Daubigny (1817–78), J. F. Millet (1814–75) and Camille Corot (1796–1875), all etched. The most prolific and important for his influence on the etchers of the next generation was Jacque, whose style shows the influence of Ostade and the Dutch etchers of the 17th century, while C. F. Daubigny, as an etcher, shows great power and originality. Millet in his plates, executed in a style which resembles that of Ostade's etchings magnified to about four times their original size, portrays those subjects of peasants at work familiar in his paintings, with the same instinctive understanding. Corot used the etching needle only occasionally, but in a manner which, for all its seeming scratchy incompetence, vividly reproduces the atmospheric effects of his paintings. The greatest figure in French etching of the century, that of Charles Meryon (1821–68), stands rather curiously aloof from that of his contemporaries. Precluded by colour blindness from the practise of painting, he is that rather rare phenomenon—an etcher who is not a painter. Influenced by a study of the work of the admirable, but comparatively little known Dutch 17th century topographical and marine etcher, Reynier Zeeman, and obviously, to a certain extent, by Piranesi rather than by contemporaries, Meryon evolved for himself a system of line which, in its clarity and incisiveness, is unrivalled for the rendering of architectural subjects. His reputation, resting, as it does, on a small number of plates of the streets and churches of Paris, might, on the face of it, seem exaggerated, but the extraordinary perfection and inevitability of design which these show seem to create out of a restricted subject matter a formula of universal application.

The revival of etching in England in the 19th century was due, in large measure, to the influence of three men of whom undoubtedly the greatest was James McNeill Whistler (1834–1903). American by birth, but thoroughly cosmopolitan, a large part of his life was passed in England and it was here that his influence was perhaps most pronounced. His conception of etching, as of art in general, even more than his practise, has had the profoundest effect. Rembrandt was undoubtedly the chief influence on his etched work. His idea of an etching as an exact and inevitable composition from which no single one of the innumerable lines which go to make it up could be removed or displaced by a hairbreadth, is almost justified by the perfection of some of his exquisite plates. Sir Francis Seymour Haden (1818–1910), Whistler's brother-in-law, though an amateur, exercised a direct influence on English etching even greater than Whistler's, who had little immediate following. Haden was by no means an echo of Whistler: though inspired by him in the first instance, his was too independent a character to allow of anything in the way of imitation. He also went back to Rembrandt for inspiration and etched with an incisive strength and clarity which are admirable, though his work can hardly compare with the greatest. The third important influence on English etching was that of Alphonse Legros (1837–1911), a Frenchman and first Slade professor of art in London, where most of his life was spent. His was not a talent of extreme originality, but he had a great feeling for, and understanding of, etching and an extraordinary power of assimilating the methods and thoughts of the great masters.

Whistler had in Théodore Roussel (1847–1926) another Frenchman settled in England, a follower as fastidious as himself who later evolved an original method of colour etching; and in Walter Sickert (b. 1860), an artist of real originality who has since developed along his own lines and founded an important school. In the tradition of Seymour Haden may be counted Sir D. Y. Cameron (b. 1865), whose landscape etchings and dry-points are marked by faultless taste and distinction, and Muirhead Bone (b. 1876), who has specially developed the architectural theme. The most distinguished pupil of Alphonse Legros was William Strang, whose portrait etching in particular is admirable, but who perhaps fails by a lack of concentration in his powers to convince as a great etcher. The etched work of Augustus John (b. 1879) is the characteristic occasional work of an important painter, in the tradition of the great masters, while that of Franck Brangwyn (b. 1867) is distinguished by its impressive size and feeling for composition in landscape and architecture. Sir Frank Short (b. 1857), for many years director of the school of engraving at South Kensington, exercised, after Haden and Legros, the greatest influence on etching, and was himself an etcher of great technical ability, though perhaps better known as the reviver of the process of mezzotint.

The succeeding generation has been extraordinarily prolific in etchers of real distinction, and the first quarter of the 20th century may well come to be regarded as one of the important epochs in the history of etching. It is a matter of difficulty to class and arrange contemporary achievements, and it will suffice to name a few of the more prominent. As an etcher of landscape as well as of subject, largely Eastern, James McBey (b. 1883) has certainly attained an important position by the originality and strength of his work. Henry Rushbury (b. 1889), in a style something akin to Muirhead Bone's, is doing extremely fine work in landscape, while Sir George Clausen (b. 1852), E. S. Lumsden (b. 1883) and many others have a merited reputation in the same *genre*. F. L. Griggs (b. 1876) has revived the imaginary architectural composition originated by Piranesi, and made of it a delicate and original means of expression. In portraiture, Francis Dodd (b. 1874), Gerald Brockhurst (b. 1890) and Malcolm Osborne (b. 1880) have done admirable work.

In Holland, as might well be expected, much work of importance was done in the second half of the 19th century. J. B. Jongkind (1819–91), Josef Israels (1824–1911) and Mathijs Maris (1839–1917), though the work of the latter is the occasional essay of a painter, are artists of the first rank, while C. Storm van's Gravesande (b. 1841) and Marius Bauer (b. 1867), of whom the latter is still in the plenitude of his power, have contributed something considerable to etching. Scandinavia has produced one etcher of astonishing virtuosity in the person of Anders Zorn (1860–1920), and in Germany and Austria, while no artist of the very first rank has, so far as one can judge, appeared, much etching of real distinction has been and is still being done. Since Whistler the interest in etching in America has been very intense and a great deal of work has been done, largely, it is true, by artists working abroad, of whom Joseph Pennell, D. S. Maclaughlan (a Canadian by birth), Frank W. Benson, Herman J. Webster and Arthur W. Heintzelman are perhaps the most notable. (*See* also LINE ENGRAVING; DRY-POINT; WOODCUT; LITHOGRAPHY.)

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TECHNIQUE

Materials.—The essentials for producing an etching are: (1) A metal plate; (2) a mordant resist or "ground"; (3) a point which will cut through the ground; (4) a mordant; (5) ink, paper and press. For fine work artists generally prefer copper, for coarser, simpler designs zinc is equally capable of yielding the best results. But from the closer-textured copper a greater range in light and shade is possible.

Before applying the "ground" the plate's surface must be cleaned thoroughly, to allow as perfect contact as possible. This may be done by means of any solvent—turpentine, benzine, petrol or ammonia—with whitening and a soft rag. Tarnish may be removed with vinegar (or acetic acid) and common salt.

The Ground.—Rembrandt's is said to have been: (*a*) Virgin wax, 1 oz.; mastic, ½ oz.; asphaltum or amber, ½ oz.; or (*b*) wax, 2 oz.; Burgundy pitch, ½ oz.; common pitch, 2 oz.; asphaltum, 2 ounces. A similar recipe is in use to-day. The ingredients are melted together carefully—first the asphaltum, then the wax, and last the pitch or mastic. The mixture should be allowed to boil up two or three times and then poured into warm water to set, being formed into suitable balls while in the water.

A transparent ground may be manufactured with five parts of wax and three parts of gum-mastic by weight. The ground

is applied by melting on the heated plate and spreading as finely and evenly as possible by means of a so-called "dabber" or leather-covered roller. To make the dabber, a circular card about 2 in. in diameter is cut, a wad of cotton-wool placed upon it, and the whole covered with fine kid or silk. Before the ground cools the usual though by no means universal practice is to smoke it by passing the inverted plate backwards and forwards—taking care never to rest at one spot—over wax tapers or an oil lamp. This dark surface shows the line and strengthens the ground as a resist.

In place of smoking Rembrandt is said to have used a white lead powder. This has the advantage of causing the line-work to appear dark on a light surface, like drawing with a grey pencil on paper. Quite recently a Scottish etcher, Henry Daniel, has discovered that, for this purpose, oxi-chloride of bismuth has admirable qualities. It is spread over the still slightly-warm ground with a very soft, full brush. Not being really incorporated with the ground it is attacked and removed by the acid when biting begins, but this is no great disadvantage. Many etchers prefer a liquid made by dissolving ordinary ground in ether or chloroform. This is poured very quickly over the plate (in a tray) and the residue returned to its bottle.

Points.—Every etcher has a favourite point. A most satisfactory and easily made one is a long gramophone needle pushed butt-foremost into a pen-holder and secured with sealing-wax. This is an ideal, not too sharp yet fine tool. Another, which serves equally for additional dry-point work, is the engineer's pricker, the points of which can be changed and reversed while in the pocket. The object of the needle is to remove the *ground* without scratching too much into the *metal*. A very sharp point destroys freedom, and causes irregularity in the attack of the mordant.

Biting.—When the drawing has been made upon the prepared wax surface with as steady and equal pressure as possible, comes the *biting* or fixing of the design. If the plate is to be entirely submerged the back also must be first coated with a resist. For such a purpose a liquid varnish is necessary, as to re-heat the plate would destroy the lines drawn. The best ingredients are methylated spirit and shellac (in proportion two to one) to which some black pigment has been added to cause less fluidity and allow the varnish to be visible when dry.

Three mordants are commonly employed at the present day. The first, and most used by artists, is nitric or nitrous acid mixed with an equal quantity of water. The second, the so-called "Dutch mordant" is prepared by dissolving ½ oz. potassium chlorate in 5 oz. of hot water, and adding 1 oz. of hydrochloric acid. The third is iron perchloride, most used by process-etchers. Artists probably prefer nitric because it is much the most rapid in action, and because the constant and obvious ebullition makes easy the detection of any over-looked line or dust-hole in the ground. The other mordants attack more gently without bubbles, consequently "foul-biting," as it is called, may easily go on unnoticed until too late. On the other hand, iron perchloride, while reasonably fast, bites more deeply in proportion to the width of line, as the edges are not broken away and the ground undermined as happens with strong nitric. The iron also darkens copper, permitting the lines to be more easily watched if used with an unsmoked ground. Its only drawback is the formation of sediment, which retards the action at the bottom of the lines, but can be dispersed by keeping the bath in motion. If rocking is not sufficient, the plate must be bitten inverted—resting upon slips of wood or other material not affected by the mordant—after which the deposit can be distinctly seen at the bottom of the dish. Full (saturated solution) strength is too thick for fine etching, and half that or a little more is far quicker than the cold "Dutch" bath. In many ways iron perchloride is the most reliable of the three mordants.

Before beginning the biting it is well to place the plate in a bath of commercial acetic acid for a few minutes, in order to remove impurities which may otherwise clog the lines—perspiration from the hand while drawing, for instance. This is particularly needful when one portion of the drawing has been made considerably prior to another. It allows all parts to be attacked simultaneously, which in the case of a delicate distance, for instance, needing but a very short biting, is of the utmost importance.

Various Methods.—In working the more orthodox plan is to complete the drawing entirely before beginning to use the acid. Then the plate, placed bodily in the bath, is left sufficiently long for the most delicate lines to be etched. The determining of the exact moment for removal is largely a matter of experience. The plate is then washed with water, carefully dried by means of blotting-paper, and those lines which are deemed of sufficient depth "stopped out" with a fine brush and the shellac varnish. Allowing this to dry, the process is then repeated until those lines which are required to be deepest of all are bitten when the plate is, for the time at least, finished. In the earliest days of etching no stopping out was reverted to, Dürer and Hopfer biting their lines to one depth only; and, generally speaking, the fewer stoppings the simpler and better the result.

Then there is the method employed by Haden. It is the reverse of the preceding. With the grounded plate placed in the bath, the artist begins by drawing those passages which he desires to be the strongest of all. As the lines are drawn the acid attacks them and the etcher passes on to the next darkest parts, ending by drawing the faintest lines immediately before removing the plate from the bath. This obviously requires great speed and certain judgment, allowing of no mistakes or hesitation. It is the resulting spontaneity which so charms in Haden's work.

Lastly, there is the compromise between the above processes resorted to by Whistler in his later manner. The drawing is more or less completed—in Whistler's case out of doors—then a little acid is poured upon it and (controlled by a feather) moved about here and there, being permitted to stand longer on some lines, less long on others, until the whole is bitten without recourse to stopping out. At the same time new lines are added where required to give strength or closer texture, light lines often crossing stronger ones (as also in Haden's method) and yielding less formality in the result than is easily obtainable by the older way of working.

But the etcher is by no means compelled to do the whole of the work upon a single ground. It is often expedient to do part only, remove the wax by means of turpentine or other solvent, pull a proof as a guide, re-ground the plate and continue. In re-grounding (which cannot safely be done with the roller) care must be taken to fill in the already bitten lines, as their edges are very liable to be attacked in renewed biting. Insufficiently bitten work can also be rebitten by carefully laying a ground on the surface only (here the roller is perhaps safer than the dabber) while leaving the lines open. It is a hazardous undertaking, except where already deep lines are concerned, and generally results in loss of definition.

Proving.—When biting has been accomplished by one method or another and ground and backing removed, the plate is ready for "proving." The result will be the *first state* of the plate. *Any* additional work constitutes a new state, without relation to the number of proofs printed. There may be one only or 500 of each state; but the removal of a single line or adding of, say, a date creates technically a further state. Even where the artist, realizing that his alterations were a mistake, returns as nearly as possible to his original, the last will still be the third state, if proofs of the two previous ones are preserved. For instance, the eighth state of Whistler's "Bridge" is only distinguishable from the first by careful examination of both, though intermediate proofs are easily recognized. These working states are known as trial-proofs, as when an addition of more than one state is published the tentative trials are ignored—only those issued receiving the titles of first, second or third *published states*, *e.g.*, Haden's "Agamemnon." Few etchings are left untouched after the first ground is removed, and it is as often necessary to cut out lines as to add them. For this a "scraper" is required. It is a tool difficult to handle and to sharpen. To remove the marks left by the scraper, snakestone is used with water, and to regain the polished surface charcoal and water and finally oil or plate-polish. Another useful etching tool is the polished steel "burnisher." With this light scratches may be rubbed out or over-heavy lines reduced. With these implements and soft rag almost anything is possible in the way of alteration. The pulling of the proof itself is one of the most fascinating of the processes which together go to the making

of an etching. And yet quite a number of etchers delegate this—the real birth of the final work—to a professional printer!

PRINTING AND PAPER

Printing.—The expense of a really good roller press is perhaps partly responsible, but a good proofing press is an essential. Small machines which have little power are worse than none at all, as their results are apt to discourage the beginner. The more delicate the line in the plate the more pressure—"pinch"—is necessary. The best modern presses are geared, and the large double-geared ones can be run with little physical exertion. The old machines were built with wooden rollers and travelling-bed, the modern entirely of iron and steel. The printing-ink is formed by grinding Frankfürt or French black powder (mixed usually with umber or burnt sienna to add warmth) with burnt linseed-oil. The burning of the oil thickens it and makes it more adhesive. Several strengths are used, which yield very different results. When mixed and well ground the ink should be sufficiently stiff not to fall quickly from the palette knife, and it is spread solidly over the surface of the heated plate by a roller or the older dabber.

The roller is made of gelatine, covered by some material to prevent adhesion when the warmth from the plate softens its composition. Stockinette is excellent for the purpose, but great care is needed to avoid any scratching edge at the seam. The roller's length should be about 3 in. and its diameter 2½ inches. The ink, after being well worked into the lines and spread evenly all over the plate, is wiped off gradually by means of pads of stiff book-muslin or Swiss-tarlatan. The hand presses firmly and equally—avoiding a scooping action—as if polishing the metal. A firm pressure forces the ink into the lines while removing it from the surface—all but a very fine film. A "clean-wiped" proof is finally polished by the base of the palm.

To soften and enrich the clean-wiped plate a piece of clinging muslin may be dragged lightly over the surface, pulling the ink a little out of the lines. This is called *retroussage,* "dragging" or "bringing up." It can also be done by going over the plate once more with the fully charged printing muslin, but this leaves a slightly granular effect upon the surface as well. Wiping is capable of great variation and the strength of oil plays an important part in the way in which the ink comes off the surface. An etching is never wiped so that no film of oil remains. A good printer will consider what colour, of ink and paper, will produce the best result; whether the plate shall be clean or only rag wiped, etc.

Paper.—Many etchers prefer old paper because the decay of its size renders it soft and pliable, and consequently more readily folded into the lines in passing between the rollers. Its colour is also more beautiful and often it is made of better material—that is, linen rags unspoilt by modern bleaching with dangerous chemicals, or adulterated with dressings.

The paper is well damped before use but should have no excess moisture on its face. This may refuse the surface film of oil on the plate and white granulations appear on the proof. Very thin oil is specially prone to do this. Before beginning to print, the edges of the plate should be examined and filed smooth, to prevent the paper being cut. When the inking and wiping has been accomplished, the warm plate is laid upon the travelling-bed of the press, a sheet of paper is taken from its damp pile, examined for hairs or dust, and placed face down upon the plate, one or two sheets of new soft blotting-paper laid over it and five or six thicknesses of printing blanket over all. The blanket is of two qualities—the two nearest the plate being fine "fronting" and the rest of coarser thicker material. When everything is in place the whole is pulled between the rollers, once only. Removing the blankets, the printing and blotting papers are peeled off the plate in one solid piece. When dried, the proof can be removed and flattened.

FURTHER METHODS

Soft-ground.—This method—the French *vernis mou*—is much less practised than it was in the early 19th century. The line somewhat resembles a chalk drawing. Its granulated texture renders it very suitable as a basis for aquatint, but its own qualities were fully exploited by that great master, Cotman. Everything depends upon the addition to the ordinary etching ground of tallow, usually an equal quantity, in hot weather less. This makes a very clinging compound, with which the plate is covered in the normal manner; but instead of being directly drawn upon, a sheet of grained paper is placed over the surface and the drawing executed upon this with a pencil, care being taken to avoid contact with the paper otherwise than with the point. When the design is complete the paper is peeled off, taking with it those portions of the ground corresponding to the lines drawn. The stronger the pressure the more ground will stick to the paper and the wider the line exposed ready to be bitten by the acid. The grain of the paper will show in the character of the bitten line. Except that stopping-out is hardly required, the biting is carried out exactly as described above. The line relies upon breadth rather than depth for variation. A smooth paper will hardly produce any result, but tissue is excellent. Tissue paper is also serviceable for re-working, as it is semi-transparent.

Aquatint.—Instead of with line aquatint deals with tone in broad masses. In most of his plates Goya, the greatest exponent of the medium, employed an etched line as guide and basis for the tonal work, but not in all. (*See* AQUATINT.)

A variant of aquatint is to form the porous ground by passing an ordinary wax ground through the press several times in contact with sand-paper; this is known as "sand-grain." Its fineness depends upon the quality of the paper and the number of passages through the rollers. Stopping-out and biting proceed exactly as before. Joseph Pennell produced some good plates in this manner.

Pen-method.—This has recently been revived in London. It was used by Gainsborough in conjunction with aquatint, and though hardly possible to employ for fine work, its quality blends better than that of the needle line with tone work. The drawing is made upon the bare plate—good results have been obtained on steel in recent times—with a pen or brush and ordinary ink or a soluble gum—gamboge and water is excellent. When dry (but not more than a day old, or it will harden), an etching ground is laid over it, not too thickly. When this is hard the plate is submerged in water for half an hour or so, whereupon the ground above the lines will come away as the ink dissolves. The lines can then be bitten in the usual manner.

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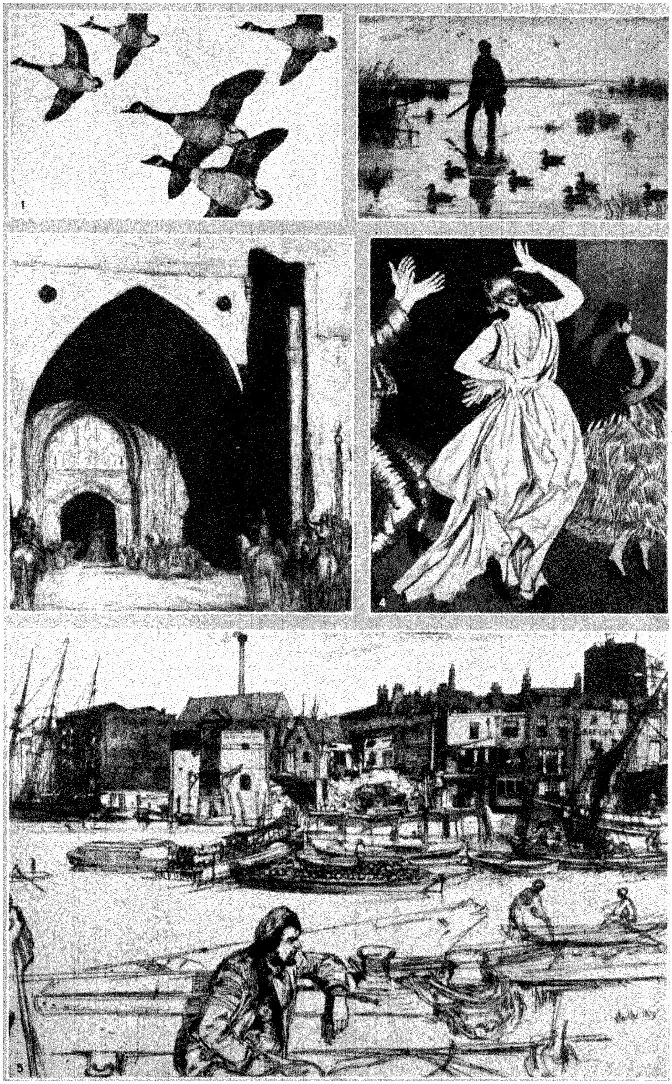
ETEOCLES: *see* OEDIPUS.

ETESIAN WIND, a local Mediterranean summer wind blowing chiefly from the north but occasionally from the west for about six weeks annually. (Gr. ἔτος, year.)

ETEX, ANTOINE (1808–1888), French sculptor, painter and architect, was born in Paris on March 20, 1808. He first exhibited in the Salon of 1833, his work including a reproduction in marble of his "Death of Hyacinthus," and the plaster cast of his "Cain and his race cursed by God." Thiers, at that time minister of public works, now commissioned him to execute the two groups of "Peace" and "War," placed at each side of the Arc de Triomphe. Among the best known of his architectural productions are the tomb of Napoleon I. in the Invalides and a monument of the revolution of 1848. He died at Chaville (Seine-et-Oise) on June 14, 1888.

See P. E. Mangeant, *Antoine Étex, peintre, sculpteur et architecte, 1808–1888* (1894).

ETHANE, a gaseous hydrocarbon, found dissolved in the oils from certain wells. Its chemical formula is C_2H_6. (*See* CHEMISTRY; *Organic: Aliphatic Division: Paraffins.*)



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19TH AND 20TH CENTURY ETCHINGS

1. Going South, by Frank W. Benson, contemporary
2. Wild Fowler, by Frank W. Benson
3. A Sultan, by Marius A. J. Bauer, contemporary
4. Spanish Dancer, No. 1, by Laura Knight, contemporary
5. Black Lion Wharf, London, by James McNeill Whistler (1834–1903); second state

ETHER (in Physics).—Whether space is a mere geometrical abstraction, or whether it has definite physical properties which can be investigated, is a question which in one form or another has often been debated. As to the parts occupied by matter, that is by a substance which appeals to the senses, there has never been any serious doubt; almost the whole of science may be said to be an investigation of the properties of matter. But from time to time attention has been directed to the intervening portions of space from which sensible matter is absent; and this also has physical properties, of which the complete investigation has hardly begun.

These physical properties do not appeal directly to the senses, and are therefore comparatively obscure; but there is now no doubt of their existence, even among those who still prefer to use the term "space." But a space endowed with physical properties is more than a geometrical abstraction, and is most conveniently thought of as a substantial reality, to which therefore some other name is appropriate. The term used is unimportant, but long ago the term ether was invented; it was adopted by Isaac Newton, and is good enough for us. The term ether therefore connotes a genuine entity filling all space, without any break or cavity anywhere, the one omnipresent physical reality, of which there is a growing tendency to perceive that everything in the material universe consists; matter itself being in all probability one of its modifications.

Many attempts have been made to state the properties of such a substance in terms of material analogies, and all these attempts have shown signs of weakness and may be said to have failed. The properties of the ether are too fundamental to be stated in terms of something else.

There have been tendencies at different times to invent ethers or effluvia with special qualities to account for specific phenomena. These attempts were long ago discarded, and are now regarded as absurd. But that space has physical properties is a definite fact of experience, provided experience is extended to include inferences and deductions and is not limited to direct sensual perception. What we perceive directly are length, breadth and height, modified here and there by a resistance or obstruction which we call matter, and combined with the element of time or duration, as exhibited and measured by the motion of matter, with speeds that can be directly apprehended.

But in addition to all that mass of common experience, the free unobstructed space is modified by the neighbourhood of matter; so that there exists everywhere a gravitational potential varying inversely with the distance from its appropriate portion of matter; the result of which is that matter tends to move from places of higher to places of lower potential, as if some force were driving the masses of matter together. Civil engineering—the erection of structures and the movement of great masses of material—is constantly concerned with this fact; and on this basis the whole of the older astronomy has been worked out in the most intricate detail.

Testimony of Optics.—The atoms of matter are not quiescent, even when a mass appears stationary, but are in a state of rapid quivering motion; and these motions are not independent of each other, but are interrelated and connected by additional and special disturbances which they communicate to the space or medium in which they occur. And about these supplementary disturbances our sense organ, the eye, has given us a mass of indirect information. These disturbances, though generated by matter, are not conveyed or transmitted by matter. They travel at a rate depending on innate properties of space; or rather, as we feel bound to say, on the physical properties of the substantial reality which fills space; thereby telling us something definite about those properties, though in a form difficult of apprehension and one which is not fully expressible in terms of any of the familiar properties of matter.

Thus the different masses of matter, even though separated by great distances, are not isolated or independent of each other. They are connected gravitationally, and they are connected optically. The energies of the earth, of which we constantly make use, are derived from the sun, and have travelled across the intervening 92,000,000 miles of empty space at a perfectly known and definite rate, with which rate matter has nothing to do. There may be uncertainty as to what exactly it is that is travelling; but the fact that it is travelling energy is certain. All that matter does is to generate this radiant energy at one end and absorb it at the other. (*See* Radiation Rays; Physics.)

Concerning the processes of generation and absorption a good deal is now known. Moreover not only is the speed of travel of the transmitted disturbance known, but also the fact that it is a periodic disturbance, expressible mathematically in exact analogy with a wave equation. Wherefore the disturbance may be spoken of without further hypothesis as ether "waves," the generic name for which is "radiation," a small range of this radiation being visible light.

Radiation is generated by some cataclysm or collision or other violent and sudden disturbance in the atoms of matter. When radiation encounters matter (unless it be merely reflected or passed on) it can throw the multitude of atoms into the confused motion we call "heat," and produce other remarkable and chemical effects. Thus an ether is necessary for the purpose of transmitting what is called gravitational force between one piece of matter and another, and for the still more important and universal purpose of transmitting waves of radiation between one piece of matter and another, however distant they be.

Electric and Magnetic Properties.—In addition to those two functions, other properties have been discovered, notably the properties called electric and magnetic. Atoms of matter are electrically constituted, and accordingly tend to attract each other with a force which is the source of chemical affinity; with the result that molecules and other aggregates are formed, of which the structure is studied in the science of chemistry. Moreover the molecules themselves attract each other by a residual affinity, giving the familiar shape of crystals and other solids, the particles of which are held together in regular packing across ultra-microscopic intervals by what is called cohesion, for which likewise the ether must be held responsible. For, as Newton forcefully said in other words, it is absurd to imagine one piece of matter acting mechanically on another at a distance, whether that distance be large or small, without some intervening mechanism or connecting link. The continuous medium which fills space, therefore, is not only the vehicle of gravitation and light, but is also the instrument for cohesion and chemical affinity and for electric and magnetic attractions and repulsions. It must also be the vehicle for every kind of mechanical force, and for the elastic connection between particles of matter, which are never in real contact with each other.

The intimate structure of the ether may ultimately be expressible and partially understood in terms of the phenomena of electricity and magnetism: for electric and magnetic influences are transmitted perfectly through vacuum, that is, across space empty of matter. They represent primarily properties of the ether, though they are only made manifest to our senses by means of matter. It was in terms of electricity and magnetism that Clerk Maxwell was able to explain the phenomenon of light. A close study of electro-magnetism, that is, of the interaction between electric and magnetic disturbances, showed that they must combine into a wave equation, the waves being transmitted at a rate calculable from purely electric and magnetic considerations. This velocity turned out to be the velocity of light; and so in 1865 the true theory of light was born.

Not that it is anything like complete. We know too little of the electric and magnetic properties of the ether to be able to picture exactly what is happening. What we do know is that light is an electro-magnetic phenomenon, and that it is entirely dependent on the properties of the ether. The ether involves or possesses properties expressible by two fundamental constants; one of which regulates the force of attraction between two electrified bodies, and the other the force of attraction between two magnets. Neither constant by itself is as yet known. But the value of the constants multiplied together is known; it was discovered by Clerk Maxwell, and is the reciprocal of the square of the velocity of light. In other words, the combination of the

electric and magnetic properties of the ether enables it to transmit waves at a rate equal to the inverse geometric mean of its two constants.

So far we have been dealing with things which have been known for some time. But the subject is so fundamental and important that a recapitulation in other terms seemed advisable. It now remains to deal with the later progress which has been made in investigating the properties of this extraordinary non-material but physical substance. Perhaps "substance" is hardly the right term, for, though exceedingly substantial in one sense, it makes no appeal to the senses and is therefore unlike any substance we know.

In the 9th Edition of the *Encyclopædia Britannica* an attempt was made to estimate the elasticity and the density of the ether, on the strength of a certain hypothesis made by Lord Kelvin. In the 11th Edition (1.292) this estimate was repeated, and it was hinted that the hypothesis might be erroneous and the values obtained exceedingly wrong. Everything tends to confirm that conclusion. Strictly speaking the very terms elasticity and density, which are terms applicable to matter, may be inapplicable to the ether without re-definition; if used they must be understood in a formal sense. The properties of the ether are not likely to be expressible in terms of matter; but, as we have no better clue, we must proceed by analogy, and we may apologetically speak of the elasticity and density of the ether as representing things which, if it were matter, would be called by those names. What these terms really express we have not yet fathomed; but if, as is now regarded as very probable, atomic matter is a structure in ether, there is every reason for saying that the ether must in some sense be far denser than any known material substance. The only alternative contention—and it is an important one—is that the density which displays itself as inertia may be due to the organisation responsible for the very existence of matter, and that the unorganised general body of ether does not possess the attribute of inertia. The densest known matter, or matter of highest inertia, is found in some of the stars; the barely visible companion of Sirius having been found, on converging grounds of evidence, to be more than 1,000 times as dense as lead. Unless the above alternative contention turns out true, the density of ether must exceed even that startling amount; indeed there are sound arguments for regarding it as a million times denser. The fundamental substance is not likely to be filmy and unsubstantial.

Recent discoveries have represented the atom of matter as composed of minute electric charges, which fill hardly any of the space inside the atom, so that it is as porous as a solar system. (*See* ATOM.) The great bulk of an atom is occupied only by a few electrons; so that it is by no means impenetrable to particles, which if they fly through it at sufficient speed, may escape being entangled and absorbed. Matter therefore is comparatively a gossamer structure, subsisting in a very substantial medium. An estimate of the substantiality of the medium can be made from its magnetic energies, and it comes out almost incredibly large. If it is right to express it in terms of material properties (which is doubtful) its inertia comes out as of the order of 1,000 tons per cubic millimetre. While as to the elasticity, that is still more enormous, since it is equal to the density multiplied by the square of the velocity of light.

These values are barely conceivable, being so much higher than anything of which we have sensual experience. But still they should be capable of being measured and expressed; so the ether is a physical substance, with properties which can in time be ascertained; and if the estimate above given of the source of the vast energies involved is wrong (as it is sure to be inadequately and incompletely worded) subsequent investigation can correct it. Meanwhile we may assume that there is some truth underlying these modes of expression, a truth which we cannot at present formulate any better.

The constants embodying the physical properties of the ether though so huge are not infinite: its properties are finite but very simple and perfect. It is perfectly transparent, it dissipates no energy; otherwise the stars and the spiral nebulae could not be seen at their gigantic distances across space. There is no friction between matter and ether, otherwise a portion of matter isolated from the rest would cool down, and the planets would not continue forever in their courses unperturbed. The ether has nothing of what we call in matter viscosity or fluid friction. There is no real heat in the ether, nor any sound. Nothing but one simple type of propagation by waves goes on in free space, and that with a definite unchangeable velocity which is known as the velocity of light, the one fundamental and so to say absolute velocity in the universe.

Possible Structure.—The question arises as to what that velocity can be due to. The most probable surmise or guess at present is that the ether is a perfectly incompressible continuous fluid, in a state of fine-grained vortex motion, circulating with that same enormous speed. For it has been partly, though as yet incompletely, shown that such a vortex fluid would transmit waves of the same general nature as light waves—*i.e.*, periodic disturbances across the line of propagation—and would transmit them at a rate of the same order of magnitude as the vortex or circulation speed. There remains indeed a question of stability to be safeguarded, but in these days of quanta (*see* QUANTUM THEORY) stability considerations are apt to be deferred. Thus it appears possible that some day an extended hydrodynamics of a perfect fluid will explain all the physical properties of the material universe. *See* Lord Kelvin, "The Vortex Theory of Ether," *Phil. Mag.* (1887) and *Math. and Phys. Papers*, vol. iv. and passim; also G. F. FitzGerald, *Proc. Roy. Dub. Soc.* (1899), or *Collected Papers*, pp. 154, 238, 472.

This notion of a structure due to vortex circulation in a perfect fluid may be regarded by some as too material an idea, and it may have to be discarded; but it is the nearest approach that can be suggested to a pictorial image of the etheric constitution. Certainly no *structureless* fluid could transmit actual radiation. And certainly the ether is continuous and without viscosity or any dissipation of energy, and so in many respects is like an ideal fluid. More than that we cannot say, except speculatively, about its constitution.

Ether and Matter.—Meanwhile we must assume that the ether has a substantiality and a wave-conveying structure beyond our present clear imaginings, with parts of it modified in an unknown way into electrons and protons; that of these the atoms of matter are built up; and that the whole of material activity consists in the interactions of these minute electric charges, connected as they are by their lines of force and by radiation.

These electric charges, and the aggregates which they have built up are subject to what we experience or recognise as locomotion. The ether itself is stationary. Whether it is really infinite in extent, or whether, though boundless like the surface of a sphere, it is nevertheless finite, are questions which we cannot at present answer. There is no doubt that it extends beyond the farthest visible stellar object, and for all practical purposes is infinite. There is very little doubt that matter is not an alien substance, but is essentially composed of it, being built up of the electrons and protons whose constitution has not yet been ascertained, but which must somehow be constituted of ether, perhaps in some sense analogous to that in which a knot in a piece of string is constructed of string, or a vortex in air is composed of air, or the fibre of a muscle is still essentially flesh.

Einstein's Theory.—The theory of Relativity (*see* RELATIVITY) has led some people—not many of the leaders of thought—to doubt if the ether can really exist. It may be useful therefore to explain in what way the equations connected with that theory are to be understood physically. Newton expressed the laws binding the planets and suns together in terms of a hypothetical force acting between them, the same kind of force as we experience when a weight is supported above the earth; which force may therefore be taken as a fact of experience. But though the force is a fact, it is not explained: any expression in terms of action at a distance is necessarily incomplete.

Einstein was led by considerations of relativity to formulate a law of gravitation, not in terms of force or of action at a distance, but in terms of something in space, that is, in the ether, which results in a tendency of bodies to approach each other. It

might be called a warp in space, or it might be called by other names: the names do not matter. The thing that has to be expressed is that the presence of matter modifies its whole neighbourhood, causing a gravitational potential or virtual stress. And, until we know more about its intimate nature, the action of this modification is best expressed in terms of a differential equation which seeks to formulate abstractly, without physical hypothesis, the essence of what is really happening. None of the arguments which necessitate the existence of a medium are affected, but no name for it need be used, nor need the idea of a medium be introduced, for mathematical purposes. Mathematicians are quite able to work with abstract equations about quantities without physical implications or conceptions, as long as they remain purely mathematicians. They can reduce even geometry to arithmetic.

In a complete expression for the enlarged geometric "interval" between two points, the element of time must be introduced as well as the element of space, because they may be moving points. In other words geometry must be enlarged into kinematics, in order to express activities. The interval or line element between two neighbouring points may be expressed in polar co-ordinates r, θ, φ thus: $ds^2 = -dr^2 - (rd\theta)^2 - (r\sin\theta d\varphi)^2 + c^2dt^2$, a mode of expression devised by Minkowski, an enthusiast for this kind of four-dimensional treatment, where the fundamental etheric velocity c is introduced as a coefficient able to turn time into imaginary space, $icdt$. The emphasis on c, as an absolute geometric constant, is perhaps the most remarkable part of the Einstein-Minkowski conception, as a preparation for the building erected upon it.

But Einstein took a further step, introducing the gravitation potential as something which would modify the motions of matter, and introduced it not only into the element of time (as Newton might have done if he had used that notation) but into the element of radial distance also; so that if the points are in the field of a mass of matter m the Minkowski equation is:—

$$ds^2 = -\gamma^{-1}(dr)^2 - (rd\theta)^2 - (r\sin\theta d\varphi)^2 + \gamma c^2 dt^2$$

where $\gamma = 1 - 2P/c^2$, P being the gravitation potential at the place considered; which, if caused by a mass at a distance r, is $P = {}^{km}/_{r}$, with k as the Newtonian gravitation constant.

Here the coefficient γ occurs twice. If it occurred in the t term only it would be a mode of stating Newton's theory of astronomy, in differential instead of integral fashion; but this γ occurs in the r term also, as a result of the isotropy of the fourfold medium contemplated in this gravitational theory. This equation when elaborated gives, strangely enough, the outstanding progression of the perihelion of Mercury, and it also gives the double deflection for a ray of light passing near the Sun (doubled because the co-efficient γ occurs twice), which has since been confirmed quantitatively by observation of stars near an eclipsed sun. It likewise gives the shift of the spectral lines emanating from any sufficiently massive body, which has now been confirmed beyond the reach of reasonable controversy by observations on light coming from the companion of Sirius, which Eddington has astonishingly proved to be by far the most compact and densest material body at present known to science, so that it is characterized by an excessively high gravitational potential.

The beauty of these results is overwhelming; but the idea that any mathematical scheme is more than a powerful method of exploration, and that a universe can be thus constructed in which physical explanations can be dispensed with, involves too simple and anthropomorphic a view of nature. The things calculated, and the things observed, however brilliantly accordant, cannot exhaust reality; an explanation is bound to be sought, and ultimately attained, in terms of the partially recognised but largely unexplored properties of the entity which fills space.

Locomotion of Matter.—The locomotion of matter is perhaps the commonest fact of experience, and it seems strange that it should be in need of explanation. But since an atom of matter is composed of electric charges, the locomotion of those charges has to be considered more in detail. An electric charge in motion constitutes an electric current, and the path of every electric current is surrounded by rings of magnetic force. This magnetic field confers inertia or momentum upon the moving charge; so that mechanical impulse is necessary to start it moving; and also to stop the motion. If not stopped it will continue to move uniformly in a straight line until it encounters some deflecting or retarding agency.

But though locomotion can thus be stated and worked out electromagnetically, that cannot be regarded as an ultimate explanation of so familiar and apparently simple a thing. Moving matter is known to have kinetic energy; and the familiar expression $\frac{1}{2}mv^2$ is the type of its measure. But when we come to analyse this expression there are difficulties about it, which hardly need elaborate theory to bring out and emphasise. For when we try to specify the velocity of a body, in order to calculate its energy, we find it difficult to say what that velocity really is: we can only specify it with reference to something else, commonly with reference to the earth. But the earth itself is moving. Hence $\frac{1}{2}mv^2$ does not give the absolute energy, but only the energy relative to the earth or other frame of reference, as Newton implicitly recognised. What the velocity of a body is in space we have no means at present of ascertaining, having no universal standard of reference; and accordingly the usual expressions, though practically useful, are by no means ultimately satisfactory. Nor can a statement in terms of electromagnetism be considered as ultimate.

The fact is that locomotion does not seem to be a property of the ether; it appears to be affected by one speed and one speed only, namely, what we may imagine to be the speed of its internal circulation and are familiar with as the velocity of light. Yet a modified particle of ether, like an electron, can move from one place to another. The analogy of a loose knot slipping along a string may be helpful.

An electron even at rest has intrinsic energy, *viz.*, its electrostatic energy of constitution, which can be expressed in various ways, and which, when expressed in terms of mass and speed, is m_0c^2, m_0 being its inertia at rest. Its static energy is thus expressible as equivalent to that of a particle of certain mass m_0 or $2m_0$, moving with the speed c, the speed of light. To assist ideas, it might be thought of as a spinning motion; at any rate not locomotion.

When the particle is moved, the natural idea would be that this velocity c is increased, or that some addition is made to it. But according to the doctrine of relativity that is impossible: the velocity c is constant. The thing that changes is not c, but m. And the energy of a moving body is m_1c^2, where m_1 is greater than m_0. As the speed of motion increases, m_1 increases too; until at high speeds it grows fast, and, as the speed of light is approached, tends to become infinite. The factor, or ratio between m_1 and m_0, is $c/\sqrt{(c^2-v^2)}$. So when an identified portion of ether is in locomotion, it is not the fundamental speed that is changed, but the amount of modified ether, or modification of ether associated with that identified moving portion. And what we observe as the kinetic energy of a body is really $(m_1 - m_0)c^2$ or c^2dm. This is what we have hitherto recognized and called $\frac{1}{2}mv^2$, an expression which is only relative, and moreover is not exactly applicable to great velocities, such as we encounter in vacuum tubes and in radioactivity generally.

Short Summary of Present Knowledge.—To sum up our present position in more compact form, in order to put on record what may perhaps excite the interest or else the derision of posterity:—Assuming the Ether to be in some sense a substance, that is real and substantial, a genuine entity and not the mere emptiness which it superficially appears to be, the things that are known about it are these:—

(1) It is absolutely transparent and undispersive. In other words it quenches no light but transmits it undiminished in total intensity, though diluted by spreading, to and from the greatest distances known in astronomy. Moreover it transmits every kind of radiation at the same pace, whatever the wave-length, except in so far as it is interfered with by electricity or matter.

(2) It is absolutely devoid of viscosity. In other words it allows the motion of matter through it without any friction; it dissipates no energy and generates no heat. A serious attempt

made at Liverpool (University College) from 1890 to 1897 to detect a mechanical grip or cling between ether and rapidly moving matter, failed (as was more than half expected) to find any convective effect, even when the moving matter was strongly electrified or magnetised. (*Phil. Trans. Roy. Soc.*, 1893 and 1897.)

(3) Ether is the sole vehicle of radiation, that is of transverse disturbances periodic in space and time travelling at a definite and immense speed without any obvious destination, but it neither emits nor absorbs them. In other words it generates neither heat nor light; but it can receive these forms of energy from matter, and can convey and deliver them to other matter at a distance. Our sensory instrument, the eye, has long familiarised mankind with various practical aspects of this wonderful phenomenon.

(4) An electric field is another form of energy existing in the ether. For this we have no sense organ, and therefore know less about it, but its lines of force appear to be of the nature of strain. And probably the ether is the seat of all strain or potential energy. An electric field (like radiation) can only be originated by matter: its lines of force never terminate in ether, but they pass through ether along their whole extent. Insulating matter only modifies the lines, but conductors stop them.

(5) Another etheric form of energy is a magnetic field, which is certainly different from an electric field though somewhat similar. Magnetic lines of force are closed curves, and seem more intimately connected with the ether than with matter. But they interact with matter, and have thus displayed their existence by consequent attractions and repulsions.

(6) Electric and magnetic fields interact also with each other in free space, and thereby constitute radiation, in accordance with the Poynting formula that the flux of energy at every place is their vector product.

(7) Chemical affinity between atoms of matter is undoubtedly due to electric or magnetic attraction or both. And cohesion may be attributed to a residual chemical affinity between molecules. Thus the ether is indirectly responsible as a vehicle for all physical and chemical activity, and no one who believes in the ether has any doubt that it is responsible also for whatever is represented by the word "gravitation." What other functions this universal medium may be found to possess, and whether life and mind can be in any way associated with those functions, must be left to posterity to find out. Our serious surmise is that they are so associated, in a primary sense, and are temporarily manifested by secondary association with matter.

Steps Toward Further Knowledge.—Beyond definite knowledge, other guesses and working hypotheses have been made concerning the ether on the assumption that its properties can be partially expressed in terms of more or less familiar ideas. The property of inertia, so fundamentally possessed by matter, is doubtfully applicable to the ether. Even if matter turns out to be really modified ether, as many are beginning to expect, it is a question whether inertia arises as a result of the modification, or whether it is a property of the primitive substance which, by the materialisation, is individualised, localised and made manifest. If inertia can rightly be predicated of the ether itself, its value per unit bulk must be enormously greater than is exhibited by any kind of matter; for matter by its very constitution is certainly excessively porous, consisting as it does of minute particles far apart from each other in proportion to their size, whereas the ether must be as continuous as space itself. A molecular structure for the ether is not to be thought of, for its whole value as an explanation of facts depends on its continuity: separate particles with interspaces are appropriate to matter, but the whole problem of action at a distance would remain unsolved unless the particles are united into a coherent whole by something which has no gaps, and is responsible for cohesion, elastic rigidity and other properties of solids.

The fundamental units of measurement, the centimetre, gramme and second, have direct relation to matter, and it is doubtful if they are applicable to the continuous ether at all. If they are, then there are grounds for maintaining that the inertia of unit volume of ether is represented by a number of the order 10^{12}; while, since it certainly transmits the polarisable and therefore transverse vibration of light, it must on that view have a quasi-rigidity comparable to the number 10^{33}.

This elastic quasi-rigidity can be attributed to a continuous perfect fluid provided, and only provided, it is in an excessively rapid and fine-grained state of vortex motion; and Lord Kelvin showed that such a rotational or turbulent fluid could transmit transverse waves at a speed of the same order as the circulation velocity. This velocity c is now regarded as one of the unalterable constants of nature: it is the one definite measurement which has been made concerning the ether of space, and of itself is sufficient to show that space empty of matter is endowed with finite and measurable physical properties. We can measure the speed of light by aid of matter, because matter generates, absorbs, reflects, and otherwise interferes with it: we observe electricity and magnetism and every other manifestation of the ether by aid of matter; but unfortunately all the properties of ether itself, apart from matter, have hitherto proved completely elusive. None of our apparatus grips or gives us a foothold; so that some physicists claim that pragmatically the ether is a gratuitous hypothesis and need not really exist. It is quite true that physical calculations and discoveries can proceed without explicit reference to the ether, but when we come to philosophise and try to formulate the facts physically, it is clear that space must be endowed with physical properties and is therefore entitled to something more than a merely geometrical name. These properties are equally real inside matter, and radiation is everywhere conveyed by space: transparent material does not really convey light, it only allows the passage and reduces the speed.

So much for a transparent body, which must be an insulator because the electrons are tightly attached and not free to move. On the other hand, when the electronic constituents of matter are loose, not anchored to something heavier than themselves, the substance becomes a metallic conductor, and as such must be mainly opaque. A conducting film, or rarefied electric region, if it can transmit radiation at all can only do so in a peculiar manner. In an electrified region waves do not travel as in free space. Different wave lengths begin to be treated differently, for their speed is a function of wave length. An expression for their speed in that case is

$$v=\sqrt{(c^2+b^2\lambda^2)}$$

where b^2 is proportional to the electrical concentration. It turns out that b is the smallest frequency which such waves can have under the given conditions. Strangely enough the energy of the radiation is apt to lag a little behind these curious waves, for it travels at a speed called the group velocity c^2/v; and this may be slow when b^2 is big. The amount of energy is proportional to the frequency of vibration.

Interaction of Ether and Matter.—A part of space occupied by matter or electrical particles transmits radiation in a peculiar way. Treated in a statistical or average fashion, matter in which electric constituents are firmly attached to the atoms—so that it insulates when solid, and conducts chemically when liquid—has a refractive index μ which reduces the apparent velocity of light to c/μ; a simple consequence of wave theory which Foucault definitely verified; though the full explanation of such a reduced velocity is not simple. Maxwell's view of the dielectric constant, or specific inductive capacity of insulators, is that it must be nearly the same as μ^2. Transparent matter thus seems to load or increase the effective density of the ether by the amount μ^2-1, so that what is sometimes spoken of as bound ether—the portion appearing to cling to matter and move with it—is in such a substance $\frac{\mu^2-1}{\mu^2}$ of the whole: as Fresnel surmised and Fizeau experimentally verified by a successful experiment on the speed of light in moving water.

It must be admitted that this is only a superficial or tentative way of regarding the still partially unexplained reaction between matter and ether; for it must be understood that statistical or average forms of statement are never completely and finally satisfactory; they fill a gap in our knowledge for the time being,

and are true as far as they go. The Lorentz transformation, used by Relativists, arrives at the same result without philosophising about it or explaining it.

Question of Reversibility.—Every star is emitting energy at the expense of its own material, so that matter is gradually turning into radiation and passing into an unlocalised form in the ether. It may be said that, without the restriction of the quantum, whereby only whole units of energy can be radiated, all the energy of matter would pass into the ether and become radiation. A good deal does. The question naturally arises whether this process is reversible or not; *i.e.*, whether radiation can under any condition generate, in return, the fundamental ingredients of which matter is composed. This discovery has not yet been made. What we know of is that the jump of an electron generates radiation, of a frequency proportional to the energy of the jump; and that this same radiation, whenever absorbed, can cause another electron elsewhere to jump with the same energy. Hence the idea looks hopeful that a reversible process may be involved generally, in the interchange of energy between ether and matter, not only in this ordinary electronic laboratory case, but in the more violent clashes in the stars, where matter appears to be destroyed. May it not perhaps in some distant region be reconstituted, with a consequent great gain of gravitational potential energy, so as to render the cosmos permanent, and reduce the useful law of dissipation of energy to comparative insignificance?

Concluding Remarks.—We have seen that when we try to look at even so apparently simple a thing as locomotion, absolutely, we have to admit that varying speed means varying amounts of ether-modification in the identified portion of matter we are attending to; for we can only express absolute energy in terms of an ether constant c, which at first sight would appear to have nothing to do with it. The same constant enters into the composition of velocities. It is as if the normal constitutional etheric circulation trended or drifted in one direction, so as to constitute perceptible or available energy, much as the energy of a river or a gale of wind is a directed fraction of random molecular motions.

The same idea may be expressed magnetically by calling attention to the magnetic field surrounding a moving charge. At high speeds the magnetic field is strong; more substance is involved in it: and the additional spin (if that is the right term, for magnetism is usually thought of as a kind of spin) accounts for the additional energy. Why it should appeal to us as locomotion, and what the real meaning of locomotion is, are not so clear. This is only an illustration of the difficulty we experience when we come to probe the simplest thing to its depths. We have grown accustomed to certain aspects of the universe given us by our senses, but we do not fundamentally understand them. And when we come to probe the meaning of things deeply enough, we find ourselves up against difficulties of conception, toward the elucidation of which our senses give hardly any aid. What we are used to is mechanical movement; but the effort to explain things ultimately in that way is not easy, and may turn out to be not possible.

Meanwhile we take refuge in expressing these things in terms of electricity and magnetism; which is a step toward an explanation, and is useful in bringing out the difficulties which underlie every ultimate and absolute statement. The attempted absolute expression for static electric energy, mc^2, with the inertia m as the only variable, is a legitimate mathematical expression of actual facts. But the real meaning of c is, at present, a hypothesis: and what the real meaning of m is, must be regarded as still less known. Both these factors must have reference to the ether, and until we know more about the constitution of the ether we must be content to remain in a condition of provisional ignorance. We are led to regard the material universe as a substantial reality in various stages or varieties of internal activity. We may try to think of this activity as akin to a fine-grained vortex circulation in a continuous, incompressible, perfect fluid: beyond that we cannot at present go; nor are we clear about the exact meaning of these terms when applied to a medium of unknown constitution. When we understand the real and ultimate nature of electricity and magnetism we may hope to proceed further. Till then we must be content with proximate explanations and await the gradual illumination of further experience.

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(O. J. L.)

ETHER, in chemistry, any member of a certain class of substances (of which the well known anaesthetic, di-ethyl ether, commonly called "ether" or "aether," is one) composed of carbon, hydrogen and oxygen, and having the general formula, R·O·R′, where R·R′ = alkyl or aryl groups (*see* CHEMISTRY: *Organic*).

The term ether formerly included the esters (*q.v.*) of organic acids, such as acetic ether, now termed ethyl acetate. The true ethers are formed by elimination of one molecule of water from two molecules of the alcohols; the two hydrocarbon radicals are similar in *simple* ethers, and dissimilar in *mixed* ethers. They may be prepared by the action of concentrated sulphuric acid on the alcohols; alkyl sulphuric acids are first formed, and yield ethers on being heated with alcohols. The process is rendered continuous by running an alcohol slowly into the heated reaction mixture of alcohol and sulphuric acid. Benzenesulphonic acid has been used in place of sulphuric acid (F. Krafft, 1893). A. W. Williamson explained the mechanism of this action in 1850; in 1851 and 1852 he prepared di-ethyl ether (*v.* below) by the action of sodium ethoxide on ethyl iodide, and showed that all ethers possess the structural formula given above. They may also be prepared by heating the alkyl halides with silver oxide. Phosphorus pentachloride or halogen hydrides convert them into alkyl chlorides. With chlorine they yield substitution products.

Di-methyl ether, $(CH_3)_2O$, first obtained by J. B. Dumas and E. Péligot, 1835, is best prepared by heating methyl alcohol and sulphuric acid to 140° C and leading the evolved gas into sulphuric acid. The sulphuric acid solution is then allowed to drop slowly into an equal volume of water, when the methyl ether is liberated (E. Erlenmeyer and A. Kriechbaumer, 1874). It is a pleasant-smelling inflammable gas, condensing to a liquid which boils at −23·6° C. It is somewhat soluble in water and readily soluble in alcohol and concentrated sulphuric acid. It combines with hydrogen chloride to form a compound $(CH_3)_2O{\cdot}HCl$. *Methyl ethyl ether,* $CH_3{\cdot}O{\cdot}C_2H_5$, prepared from methyl iodide and sodium ethoxide, or from ethyl iodide and sodium methoxide, is a liquid boiling at 10·8° C. The homologous ethers are also liquids, with boiling points rising with increase of carbon content.

Di-ethyl ether, $(C_2H_5)_2O$, the *ether* of pharmacy is a colourless, volatile, highly inflammable liquid, of specific gravity 0·736 at 0°, boiling-point 35° C, and freezing-point −117·4° C, with a powerful characteristic odour, and a hot sweetish taste; it is soluble in ten parts of water, and in all proportions in alcohol; it dissolves bromine, iodine, and, in small quantities, sulphur and phosphorus, also the volatile oils, most fatty and resinous substances, guncotton, caoutchouc and certain vegetable alkaloids. A mixture of the vapour with oxygen or air is violently explosive. The making of ether by the action of sulphuric acid on alcohol was known in about the 13th century; and later Basil Valentine and Valerius Cordus described its preparation and properties. The name ether appears to have been applied to the drug only since the times of Frobenius, who in 1730 termed it *spiritus aethereus* or *vini vitriolatus*. It was considered to be a sulphur compound, hence its name sulphuric ether; this idea was proved to be erroneous by Valentine Rose in about 1800. Ether is manufactured by the distillation of 5 parts of 90% alcohol with 9 parts of concentrated sulphuric acid at a temperature of 140°–145° C, a constant stream of alcohol being caused to flow into the mixture during the operation. The distillate is purified by treatment with lime and calcium chloride, and subsequent distillation.

The presence of so small a quantity as 1% of alcohol may be detected in ether by the colour imparted to it by aniline violet; if water or acetic acid be present, the ether must first be shaken

with anhydrous potassium carbonate. Chromic acid oxidizes ether to acetic acid and ozone oxidizes it to ethyl peroxide. Ethyl peroxide also forms spontaneously in ether under many conditions of storage. This action is inhibited by certain metals, notably copper. In contact with hydrogen iodide at 0° C, it forms ethyl iodide, and with water and a little sulphuric acid at 180° C, it yields alcohol. It forms crystalline compounds with bromine and with many metallic salts.

Ether may be transported in iron drums, glass bottles and tin cans. Its principal use is in the manufacture of smokeless powder, organic synthesis as a solvent in analytical chemistry and for medicinal purposes. (*See* below.) No flames or sparking electrical equipment may be used in connection with the industrial application of ether.

Medicinal Uses.—(*See* ANAESTHESIA.) Applied externally, ether evaporates rapidly, producing such intense cold as to cause marked local anaesthesia. It is best applied as a fine spray, but ethyl chloride (*q.v.*) is generally found more efficient and produces less subsequent discomfort. Ether aids the absorption of fats and may be used with cod liver oil when the latter is administered by the skin. Ether, when subcutaneously injected, is perhaps the most rapid and powerful cardiac stimulant known, and is often employed for this purpose in cases of syncope under anaesthesia. Taken internally, ether acts in many respects similarly to alcohol and chloroform, but its stimulant action on the heart is much more marked owing to its rapid diffusion.

Chronic Poisoning.—A little more than a teaspoonful will produce a condition of inebriation, but the dose must soon be increased. The principal symptoms of chronic ether-drinking are a weakening of the activity of the special senses, and notably sight and hearing, a lowering of the intelligence and a partial paralysis of motion. The whole moral tone of the addict is lowered and he neglects his personal appearance. The effect is similar to chronic alcoholism in an advanced stage but the deterioration is more rapid and more marked.

ETHER, MUSIC FROM THE: *see* MUSIC FROM ELECTRIC OSCILLATIONS.

ETHEREGE, SIR GEORGE (*c.* 1635–1691), English dramatist and poet, was probably born about 1634–35, but practically nothing is known of his life except for a short period. Knowledge of his ancestry and early history is only derived from some chancery papers in the record office, from which it is gathered that his grandfather lived at Maidenhead and that he spelled his name as it is here spelled. He may have been educated at Cambridge, have studied law at one of the inns of court, and have lived some part of his early life abroad. In 1664 he was living in London, apparently quite unknown, when his first comedy, *Love in a Tub,* was produced at the Duke's theatre. This play marks the beginning of the specifically restoration comedy. It is partly in rhymed heroic verse, but the comedy scenes, with their play of wit, and their introduction of the "war of the sexes" theme, strike a new note in the history of the English drama. With the production of this play, Etherege leaped into fame. Thereafter he was one of the outstanding figures in the circle of Sedley and Rochester, and soon became an almost legendary type of the beau and wit of the day. More than 20 years after he had left London for ever the *Spectator,* to indicate the position Sir Roger de Coverley had held in his youth, said that he had often supped with Rochester and Etherege.

Three years of elegant idleness followed, before his next play, *She would if she could,* was produced at the Duke's house in 1677. "Lord!" says Pepys, "how full the house and how silly the play." He goes on to say that the actors were "out of humour," which may be partly explained by the nature of the play, which hovers rather indecisively between the formal comedy of the four lovers, and the farcical scenes where Jolly and Cockwood appear, which are more in the spirit of the Johnsonian comedy of humours. About this time he had an affair with the famous actress Mrs. Barry; she bore him a daughter who died in her youth. In 1668 he went to Constantinople as secretary to Sir Daniel Harvey, the English ambassador there. He returned to London in 1671, but published nothing but some occasional poems, drawing a rebuke for his laziness even from Rochester. At last in 1676 his last comedy, *The Man of the Mode,* appeared at the Duke's house. It was a great success, unlike the previous one, which appears to have fallen a trifle flat. But "Gentle George's" life was beginning to tell. A supreme picture of the life of the day, so much so that it set the fashion of "original-hunting" from which we have never escaped, it is yet a little less high-spirited and a little more savage than its predecessors. After this he continued his life as a man-about-town, and was involved with Rochester in the Epsom brawl which led to the death of Downes. Somewhere about 1679–80 he was married and knighted. The gossip of the day, our only authority, takes two forms; one that he married a fortune and so got a knighthood, the other that he was forced to purchase a knighthood to secure a fortune.

In 1685 he was appointed ambassador at Ratisbon, and his letters are preserved, so that at last he ceases to be a legend and becomes a living person for us. It is these letters that let us see the justice of his nicknames "Gentle George" and "Easy Etherege"; the essence of his letters is tolerance and good manners. It was not good form to make a fuss about anything, particularly your work. But this paraded idleness, which became affectation in his successors, is natural to him; his own nature is a summary of the ideal of the period. The only thing that roused him was the bad manners of the local burghers to a visiting actress in whom he was interested. That, as one might expect, he would not stand, and he raised all sorts of trouble until he got his apology. Exactly when he died we do not know, but it seems to have been in Paris, probably in 1691.

Etherege deserves to hold a more distinguished place in English literature than has generally been allotted to him. In a dull and heavy age, he inaugurated a period of genuine wit and sprightliness. He invented the comedy of intrigue, and led the way for the masterpieces of Congreve and Sheridan. Before his time the manner of Ben Jonson had prevailed in comedy, and traditional "humours" and typical eccentricities, instead of real characters, had crowded the comic stage. Etherege paints with a light, faint hand, but it is from nature, and his portraits of fops and beaux are simply unexcelled. No one knows better than he how to present a gay young gentleman, a Dorimant, "an unconfinable rover after amorous adventures." His genius is as light as thistle-down; he is frivolous, without force of conviction, without principle; but his wit is very sparkling, and his style pure and singularly picturesque. No one approaches Etherege in delicate touches of dress, furniture and scene; Sir Fopling, for example, "He was yesterday at the play, with a pair of gloves up to his elbow, and a periwig more exactly curled than a lady's head newly dressed for a ball"; he makes the fine airs of London gentlemen and ladies live before our eyes even more vividly than Congreve does; but he has less insight and less energy than Congreve. Had he been poor or ambitious, he might have been to England almost what Molière was to France, but he was a rich man living at his ease, and he disdained to excel in literature. Etherege was "a fair, slender, genteel man, but spoiled his countenance with drinking." His contemporaries all agree in acknowledging that he was the soul of affability and sprightly good-nature.

The life of Etherege was first given in detail by Edmund Gosse in *Seventeenth Century Studies* (1883). His works were edited by A. W. Verity, in 1888, and by H. F. B. Brett-Smith (Percy Reprints, no. 6, Oxford, 1927); *see* B. Dobrée, *Restoration Comedy* (Oxford, 1924). (E. G.)

ETHICAL MOVEMENT, THE. The object of the Ethical Movement is to emphasize the moral factor in all the relations of life in such a way that morality may be regarded as the fundamental and abiding part of religion, and therefore the true basis for religious union; for the noblest religious beliefs of all civilized peoples, when traced to their source, are found to be inferences from the facts of moral life.

Never before has there been an attempt to found a religious organization in which all can unite, and yet, such is not only a possibility, but a necessity, if progress in the moral life is to be realized.

Foundation of the Movement.—The ethical movement was initiated in the United States in 1876 by Felix Adler, Ph.D. of

Columbia University, a young Jew then being trained as a Rabbi. As a young man while completing his studies in Berlin, he was impressed by the sublimity of the works of Immanuel Kant, with whose philosophy he at that time identified himself. He was also influenced by his reading of the *Die Arbeiterfrage* of Friedrich Albert Lange. In a glow of enthusiasm his first action on returning to America consisted, as he says "in founding among men of my own or nearly my own age a little society, which we ambitiously called a Union for the Higher Life, based upon three tacit assumptions:—sex purity, the principle of devoting the surplus of one's income beyond that required for one's own genuine needs to the elevation of the working classes, and, finally, continued intellectual development."

Ethical Philosophy of Life.—Dr. Adler later broke with the Hebrew Religion, although friends urged him to maintain outward conformity in order to adapt the truth of the old faith to modern conditions. But he was too honest for this, and felt, moreover, that what was of real value in Hebrew or in any other religion needed to be "re-stated and fitted into a larger synthesis." He compared religious growth to the growth of a tree and said "to expect that development should continue along Hebrew or Christian lines was like expecting that a tree would develop along one of its branches. There is a limit beyond which the extension of a branch cannot go. Then growth must show itself in putting forth a new branch."

The first actual Ethical Society was inaugurated in New York on May 15, 1876, and the bulk of it, in the words of Dr. Adler, "consisted of what would be called average people, especially of fathers and mothers who felt the need both for themselves and their children of something to take the place of the consecrating influence of the old religions." This desire for a consecrating influence expressed itself in the initiation of very simple Sunday services, which were without prayer or ritual and were preceded by beautiful music to induce a suitable atmosphere, the most important feature being the address. Dr. Adler's ideals as to the qualifications necessary for an ethical speaker are so high that he expressly declares:—"that he shall give his whole life to the problems of ethical living, having no professional or business interests in competition with his dedication to these problems. . . . The platform of an Ethical Society is itself the altar, the address must be the fire that burns thereon."

Societies in America.—The Society founded in 1876 prospered, and has distinguished itself by organizing a school where pupils are educated from the kindergarten to the university stage; a large number of free places are open to children of requisite ability, irrespective of race or colour.

There are now six Ethical Societies in America, viz.—The New York Society for Ethical Culture, Chicago Ethical Society, Philadelphia Society for Ethical Culture, St. Louis Ethical Society, Brooklyn Society for Ethical Culture, and the Boston Ethical Society. These are federated into the American Ethical Union, whose object is "To assert the supreme importance of the ethical factor in all relations of life, personal, social, national and international, apart from any theological or metaphysical considerations."

British Ethical Societies.—The New York Society for Ethical Culture is regarded as the parent of the British Societies. The effort has not met with the same popular success in Great Britain as in America, where religious thought appears to have been far less hampered by unfavourable social conditions and traditional influences than has there been the case. The first English Ethical Society may be said to have been founded in 1888, when Dr. Stanton Coit became minister of the South Place Religious Society after the resignation of Moncure Daniel Conway. Dr. Coit had been attached to Dr. Adler's Society in New York and his aim was to reproduce in England the main features of the American ethical culture movement, with such modifications as were needed by the circumstances and traditions of the older country. At his suggestion the Society was called the South Place Ethical Society. In 1892 Dr. Coit retired from South Place and later in the year became Lecturer and Organizer for the newly-formed West London Ethical Society.

In 1895 the then existing North, South, East and West London Societies took steps to become federated, the Union of Ethical Societies being formed in 1896 and finally incorporated as the Ethical Union in 1928. Its main object is:—"To promote by all lawful means the study of ethical principles; to advocate a religion of human fellowship and service, based upon the principle that the supreme aim of religion is the love of goodness, and that moral ideas and the moral life are independent of beliefs as to the ultimate nature of things and a life after death; and, by purely human and natural means, to help men to love, know, and do the right in all relations of life."

The English ethical movement has included amongst its supporters and sympathizers Professors Leslie Stephen, J. H. Muirhead, Bernard Bosanquet, and Alexander and J. S. Mackenzie, as well as other distinguished moral philosophers and prominent men of science and letters, some of whom have been presidents of the Union. The Secular Education League was founded in 1907 as the result of a public conference convened by the Union in 1906. It regards religion as a personal and private matter which all should be free to pursue in a private capacity. In 1911 the Union assisted in promoting the first Universal Races Congress in London; it attracted world-wide attention and 17 Governments were officially represented.

A series of conferences of modern religious thinkers were convened by the Union in 1920, 1921 and 1923, at which Professors Gilbert Murray, J. B. Bury and L. T. Hobhouse presided. Distinguished speakers, representing many diversities of faith, attended to address the meetings.

Summer Schools for the consideration of vital social and moral problems were arranged in 1926, 1927 and 1928, experts being invited to speak on the subjects under discussion. A constant propaganda has been sustained by the English Ethical Union. It has produced, either directly or in association with publishers, many pamphlets, leaflets and books in advocacy of the principles of the Movement.

The English Ethical Societies are as follows:—The Ethical Church, Bayswater, the Forest Group of the Ethical Movement, Hampstead Ethical Institute, South London Ethical Society, South Place Ethical Society, Wimbledon Ethical Society, The Women's Group of the Ethical Movement, and The Young People's Group of the Ethical Movement. They are akin both in thought and method to the Ethical Societies in America, with whom a close relationship is maintained.

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ETHICS is the systematic study of the ultimate problems of human conduct (from Greek ἦθος, character, or ἔθος, custom); also called *Moral Philosophy* (from Lat. *mores*, customs).

The Scope of Ethics.—Human conduct may be studied in many different ways. It may be observed and described in a purely external manner, in the way in which the behaviour of lower animals is sometimes studied; and this is the way in which behaviourism (*q.v.*) deals with human conduct. It may be studied in relation to the mental processes which precede or accompany it; this is the way in which psychology and common sense usually deal with it. It may be studied in relation to physical and social environment, as is done to some extent in biology, anthropology and sociology. The results of these and similar studies are important for ethics. But the problem of ethics is essentially different. Unlike the above-mentioned studies, it is not concerned mainly with bare facts but with values, with estimates. This is usually expressed by saying that ethics is not a positive science but a *normative science*—it is not primarily occupied with the actual character of human conduct but with its ideal, not so much with what human conduct is as with what it ought to be. It should be noted, however, that even ideas of what human conduct ought to be may be studied in a positive or natural-history spirit. They are so studied to some extent in sociology

(*q.v.*) and comparative ethics (*q.v.*), in which moral ideas as well as customs are correlated with other cultural conditions. In ethics proper the standpoint taken is, as far as is humanly possible, that of an ideal humanity capable of rising above the common limitations of time and place. To maintain such a point of view is no easy matter, even for philosophers, whose special business it is to rise above the prejudices of the multitude. And Nietzsche has complained, not without some justice, that the moral philosophers of Christendom have attempted little, if anything, more than a rational systematization of Christian preaching (the practice of Christendom would baffle any such attempt at rational systematization). Many moral philosophers, indeed, have stated explicitly that the business of ethics merely consists in clearing up current moral conceptions and unfolding the ultimate presuppositions involved in them, and that it is not its function to discover new moral ideas. It may be remarked that even the ethics of Aristotle attempted no more, although he was not bound by anything like this authority, and the traditions of the Christian Church. It is only occasionally in the history of ethics that Sophists or Sceptics impugn the validity of traditional moral ideas, or that a Spinoza or a Nietzsche ventures to proclaim new ideals of conduct. The present article, however, is not concerned with the history of ethics (*q.v.*) but with the main problems of ethics. These problems turn chiefly on the following conceptions: (1) the highest good of human conduct, or its ultimate ideal aim, which may serve as the ultimate standard of right conduct; (2) the origin or source of our knowledge of the highest good or of right and wrong; (3) the sanctions of moral conduct; (4) the motives which prompt right conduct. Another problem discussed by moral philosophers is that of the freedom of the will; but as this is dealt with under FREE-WILL it will not be considered in the present article.

THE HIGHEST GOOD

The oldest, and in some ways the most important, ethical problem is that relating to the supreme good or ultimate end of human conduct. Many human activities are admittedly directed to ends or purposes that are not regarded as possessing value in themselves, but as means to ulterior ends which confer on them a derivative value. One may do strenuous physical exercises or take long walks merely in order to keep physically fit; one may play chess or solve cross-word puzzles in order to exercise and improve one's intelligence, or in order to divert one's thoughts from cares and worries; one may try hard to make money in order to provide for one's dependents, or in order to carry out some other philanthropic scheme. But even these ulterior aims may not be valued as final ends; one may be prepared to sacrifice them to some higher end. The individual may at a supreme crisis be willing to sacrifice himself and his family to some great cause such as honour, or justice, or patriotism, or humanity. Yet some end or aim there must be (so it is commonly assumed) which is ultimate and not subordinate to anything else. Such an ultimate end, whatever it may be, is usually called the *summum bonum*, or highest good. It is an old ethical tradition that there is such a highest good; and that this highest good is *happiness*. (The view that happiness is the *summum bonum* is known as *Eudaemonism*.) There are, however, very different conceptions about the nature and claims of happiness as the ultimate end of human conduct. Moreover, other ultimate ends have been formulated, such as *perfectionism*, or *duty* for duty's sake, and, in intimate connection with this, the *good will* as the highest good. All these conceptions must be briefly considered.

Happiness As the Highest Good.—The popular moral maxims of all times and climes testify to the widespread belief that in the last resort what man really seeks is happiness, and that all his other pursuits are directed (though sometimes mistakenly) to this end. Popular moralizing for the most part either points out the right means to happiness or utters a warning against the wrong means. Hence the prudential character of popular ethics. Psychologically the assumption that happiness is what men always seek either directly or indirectly is open to serious criticism. Generally speaking, happiness is the consequence of the attainment of some desired end, the satisfaction of some felt need. It is not usually either the actual end or object desired, or even the conscious purpose for which something else is sought. For the most part it is only people devoid of interest in things, and so deprived of the satisfaction of realizing, or at least advancing some cause or other, who voice a longing for happiness, or their grievance against its elusiveness. But even if this objection be waived as something calling for a more careful reformulation of the eudaemonistic *summum bonum* rather than for its rejection, the question naturally arises as to *whose* happiness is to be sought. To this question three different answers are possible, and have actually been given. It may be held that each individual should seek his own happiness. This theory is known as *Egoistic Eudaemonism.* On the other hand it has been maintained that the end to be pursued is the happiness of mankind as a whole or at least of the community of which the individual concerned is a member. This theory is known as *Utilitarianism.* A third answer that has been suggested, though not very seriously, is that the individual should always pursue the happiness of others, not his own happiness. This theory is known as *Altruism* or *Altruistic Eudaemonism.* These views will now be considered in turn.

Egoistic Eudaemonism.—In its crudest form this theory identifies happiness with physical pleasures. (A theory which identifies happiness with physical pleasure or sensuous enjoyment is called *Hedonism.*) In its maturer form egoistic eudaemonism (indeed every form of eudaemonism) attaches a higher value to pleasures of the mind (that is, pleasures derived from the pursuit of knowledge, art, etc.) than to those of the body; and in its highest form, egoistic eudaemonism identifies individual happiness with that which results from the fullest development of a highly artistic or spiritual personality. By a curious paradox egoistic eudaemonism is apt to become ascetic in character when it takes on a religious complexion. The individual is then so bent on securing his salvation at all costs that he eschews all ordinary pleasures, and sacrifices worldly happiness on the altar of an other-worldly blessedness.

Universalistic Eudaemonism or Utilitarianism formulates as the highest good the happiness of the community, not merely that of the agent himself. According to egoistic eudaemonism the agent is only interested in others in so far as they are of service to him in some way or other. According to utilitarianism, on the other hand, the agent should not claim any privileges for himself—no individual must count as more than one, and the happiness to be aimed at is the greatest happiness of the greatest number. There are obvious difficulties in such a theory. Even if it were true, as Bentham believed, that pleasures differ only quantitatively, not qualitatively, that pushpin and poetry afford the same kind of pleasure, even so it would be difficult to choose, on the utilitarian principle, when the same quantity of happiness might be afforded to alternative groups of people. Why prefer the happiness of A, B, C to that of X, Y, Z? But, as J. S. Mill admitted, pleasures are not of the same kind. Moreover they cannot be reduced to a common denominator. This difficulty is inherent in every form of eudaemonism. But in so far as it is real, it is impossible to construct a calculus of pleasures such as is indispensable to utilitarianism. Still the practical difficulties of the doctrine must not be exaggerated. The problems of life and conduct are vastly more complicated than the problems of arithmetic, whatever ideal one may set himself. And utilitarianism, whatever its shortcomings may be, proved itself an effective instrument in the march of social democracy—and that was the main point with its founders.

Altruistic Eudaemonism or Altruism, when the term is not used as synonymous with utilitarianism, demands the pursuit of the happiness of others at the expense of one's own. It is a more positive formulation of the familiar doctrine of self-sacrifice. Every ideal of life involves an element of self-repression, and self-denial is one of the conditions of self-fulfilment. But the pure altruism with which we are here concerned can hardly be considered seriously. If the happiness of the agent himself has no value, how can the happiness of others be of value? If it be urged that self-devotion to others, in so far as it is reciprocal,

is a sure way of securing the happiness of everybody, then it is only utilitarianism in a disguised form, and expressed in a manner which recalls the famous island, the inhabitants of which maintained themselves by doing each other's washing. The doctrine of altruism and self-sacrifice is only too intimately associated with incompetent state-craft. Those who lack sufficient wisdom and insight so to work the social and political machine as to enrich the life of the citizens usually head for the kind of disaster which necessitates the sacrifice of the lives of the citizens in order to save the machine and the mechanics.

Perfection As the Highest Good.—Perfectionism is the theory which maintains that the highest good of human conduct is the fullest development of all the capacities of man in so far as these can co-exist in an harmonious whole. This may be expressed in yet another way. Man, like everything else, has certain latent potentialities. Different things have different kinds of potentialities, according to which we array them in a certain order of merit. Living plants have more potentialities than inert matter, animals are superior to plants, and man to animals. The precise limits of human potentialities cannot, of course, be determined in advance. But the high attainments of gifted individuals serve as milestones on the path of human progress, and encourage the imaginative construction of ideals of human life and character. Such ideals become standards of perfection, and the attainment of such perfection, or at least the earnest endeavour to attain it as far as in us lies, is what the theory of perfectionism regards as the highest good of human conduct.

Egoistic, Universalistic and Altruistic Perfectionism.—The question as to *whose* perfection is to be aimed at by the moral agent is clearly answerable, at least theoretically, in the same three ways as the corresponding question relating to eudaemonism or happiness. The perfection sought might be that of the individual agent, or of mankind (or at least the community) as a whole, or of people other than the agent himself. We should thus get egoistic, universalistic and altruistic perfectionism corresponding to the three forms of eudaemonism. But the universalistic form is the only one worth serious consideration. Even in the case of eudaemonism it may be urged that the universalistic form is the only tenable one, inasmuch as ideal happiness on the part of any individual is inconceivable in a *milieu* of unhappiness. But the contention is much stronger in relation to perfectionism. An individual may grow towards perfection in virtue of his struggle against imperfection and evil. But it is more than doubtful whether the attainment, the realization of perfection, is conceivable except in a perfect society. That is why the upholders of perfectionism sometimes postulate, as the metaphysical basis of their moral philosophy, the existence of a society of spirits as an essential part of the cosmic order. Actually, it is true, one may meet with a supreme egoist, such as Goethe is alleged to have been, who is so absorbed in his own development as to "pass by" all else. It is also not unusual to find very imperfect people trying to exercise a "moral influence" on others without attempting to heal themselves. Ethically, however, such cases are of little or no significance.

Perfectionism and Eudaemonism are not entirely opposed to each other. In fact, they have certain features in common. In the first place, perfectionism may be said to embrace eudaemonism to some extent inasmuch as perfectionists usually maintain, and, from a psychological point of view, rightly maintain, that whatever contributes to human perfection is generally also conducive to human happiness, while that which retards human development also brings unhappiness. Again, eudaemonism and perfectionism tend to estimate moral conduct by its results. According to eudaemonism, conduct is good or right if it promotes happiness; it is bad or wrong if it leads to unhappiness. According to perfectionism, conduct is good or right if it promotes the development of human potentialities; it is bad or wrong if it hinders it. Apart from such results, it would appear that human conduct as such could not be described as good or bad, as right or wrong. Lastly, the highest good, which, of course, is also the standard of conduct, as conceived by both eudaemonists and perfectionists, is such that it would be pursued quite spontaneously without the sense of "obligation" or "duty" frequently associated with right conduct. Hence the tendency of both eudaemonist and perfectionist ethics to become mainly descriptive. In the case of eudaemonist ethics this tendency is seen clearly in so-called psychological hedonism, which takes its stand on the alleged fact that men actually do pursue pleasure as the ultimate good. In the case of perfectionist ethics this same tendency is clearly observable in the ethics of Spinoza, which aimed "neither to revile nor to deride but to understand" human conduct. One consequence of this is what may be described as the predominantly intellectual character of eudaemonist and even more so of perfectionist ethics.

Duty As the Highest Good.—In contrast with both eudaemonism and perfectionism, which make the moral worth of conduct depend on its results, an attempt has been made, notably by Kant, to associate moral value with the immediate springs of conduct. This attempt is inspired to a great extent by what may be crudely described as a sense of constraint that is frequently associated with moral behaviour, and which is regarded by upholders of this view as of the very essence of right conduct. Right or good conduct, in other words, must be judged by the sense of duty which prompts it, not by the consequences which result from it. There is, according to this view, a "categorical imperative," an unconditional law of duty, which demands obedience, whatever the consequences may be, and implicit obedience to this categorical imperative is the highest and only ultimate good. "Nothing in the world," says Kant, "is good except the good will." In order to make his theory plausible, and save it from the chaos of the Babel of voices in which the categorical imperative finds utterance in different cases (when it finds utterance at all), Kant had to postulate a metaphysical moral order, on the one hand, and to empty the categorical imperative of all definite content, on the other hand. All that the categorical imperative bids us, according to Kant, is this: "act only on that principle which thou canst at the same time will to become a universal law." Apparently the essence of evil consists in treating one's own case as exceptional. *Nomism* (as this theory might be called) savours perhaps too much of the Prussian drill-sergeant's love of the uniform and of obedience to be greatly in favour with an age that has a touching faith in freedom and democracy. Moreover, there are certain psychological considerations which seem to shake the very basis of the nomistic theory of duty for duty's sake. There are some people who have never heard the categorical imperative even in the modest form of a still, small voice. Some of those who have heard it are prone to identify it with a familiar and usual form of constraint that heredity, education and social environment are apt to make habitual in most mortals. Lastly, sentiment itself has a way of powerfully prompting various kinds of action in relation to its objects; and most people, probably all, for one reason or another, or even for no reason at all, possess, or are possessed by, sentiments for various objects, whose impelling promptings may easily be mistaken for the commands of the categorical imperative. Of course, there is a stage in the education of everybody when discipline and the inculcation of a sense of duty may be not only valuable but necessary. In moral *philosophy*, however, as distinguished from moral pedagogy, one is concerned with the mature, reflective person; and the moral ideal is that of a race of people who are so mastered by high ideals that they do their duty and know it not, rather than of a race of well-drilled creatures of habit.

THE KNOWLEDGE OF GOOD AND EVIL

How do we know what is good or evil, right or wrong? The principal answers to this question are rather mixed, combining more or less different epistemological points of view. But if their predominant element be considered, then three main answers may be distinguished, namely, the *empirical*, the *rational* and the *intuitionist*.

Empiricism.—This stresses chiefly the actual experience of mankind. Ancient and modern appeals to the *consensus gentium* (the general agreement of mankind) are a case in point. Another case is that of the modern biological answer as formulated, say,

by Spencer, according to whom our moral judgments, however self-evident they may appear to us, are really the result of certain habits which have been acquired by mankind in the course of evolution as they learned by experience to adapt themselves to their environment. In so far as moral habits and moral ideas are different among different peoples, the empiricist would endeavour to obtain a general standard of right conduct by a careful comparison and sifting of the relevant facts. As this task is full of difficulties, empiricist ethics rather tends towards relativism or the denial of a really universal objective moral standard.

Rationalism or a Priorism.—This stresses the sufficiency of reason to determine what is good or evil, right or wrong, more or less independently of actual experience (i.e., *a priori*). To some extent Kant may be regarded as an ethical rationalist, though it is perhaps better to class him as an intuitionist. A much older example of ethical rationalism of a rather different type is the theory of Socrates that all virtue is knowledge. Plato and Aristotle, Spinoza and Hegel may also be classed among ethical rationalists. Even Kant, however, found it impossible to put any content into the categorical imperative, or to formulate anything very definite as the discovery of reason. To judge from what mostly happens in the practical affairs of daily life it would appear that our everyday moral judgments are prompted by something too vague to be dignified by the names of empirical method or of method of reason. Owing to its vagueness it is usually described (as such vague experiences commonly are described) as a *feeling*, or some kind of feeling. This description is probably intended to stress the character of *immediacy* (as distinguished from discursiveness) rather than its *affective* character. The theory of *intuitionism* tries to do justice to the apparent immediacy of moral judgment without deriving it from feeling as such. It must be remembered, however, that some moral philosophers have held that moral judgment is essentially a matter of feeling, like the aesthetic appreciation of beauty.

Intuitionism in ethics, then, is the theory that man has an immediate apprehension of moral value as such. Some intuitionists maintain that what is intuited is the ultimate moral law (say, Kant's categorical imperative). Others hold that we intuit the moral character of certain general types of conduct or of motives. Yet others are of the opinion that what is intuited is the moral value of each separate act or feeling either absolutely or at least relatively to some other act or feeling. But intuitionists differ among themselves not only with regard to the object of intuition but also with regard to the intrinsic psychological character of the intuitive process itself. Some describe it as a kind of perception, and speak of a "moral sense" analogous to other kinds of sense-perception. Others regard it as a function of reason. (Such intuitionism is hardly distinguishable from rationalism; hence the above remark about Kant.) Others again, as already noted, conceive it to be a kind of feeling, similar to that of aesthetic appreciation.

In some ways intuitionist ethics, like empirical ethics, rather tends towards ethical relativism. If his intuition is the final tribunal of moral judgment for each individual, it is clearly possible for different individuals to judge differently. Kant, it is true, held that "an erring conscience is a chimera." But in order to make this view plausible he had to invent an elaborate metaphysical substructure. Pope was probably nearer the truth when he suggested that "our consciences are like our watches. None go just alike, yet each believes his own."

THE SANCTION OF MORALITY

It has already been remarked above that moral conduct is commonly associated with a sense of duty to do certain things and to abstain from certain others. The question then naturally arises concerning the authority of this sense of duty to command or to prohibit actions as the case may be. This is the problem of the *Sanction of Morality.* The problem does not arise for some ethical theories. At least, it is not equally urgent for all of them. For eudaemonists and perfectionists, *e.g.*, the highest good is something so intrinsically alluring that the question of a moral sanction, if it is raised at all, can be adequately answered by saying that the *summum bonum* is its own sanction, its own authority. The problem is most urgent in those cases in which morality is regarded as something imposed upon man by some outside authority. At first sight, this would appear to be the case with Kant's categorical imperative. Kant, however, insisted on the autonomy of conscience. He regarded the moral law as *self-imposed* by the rational will of man who, *qua* a person, identifies himself with the moral law, which thus carries its own sanction with it. Kant's view, however, requires the metaphysics of a moral world-order valid for all rational beings, and such a metaphysics is remote from the thought of the ordinary moral person. Generally speaking, most people who are moral lean on some outside authority as their moral sanction. The three most important sanctions of the type with which we are here concerned are the *religious, political* and *social sanctions.*

The *religious sanction* is operative when morality is based on the authority of God or of the Church. (Strictly speaking, what is called the authority of God is always the authority of some church which claims to speak in His name.) In this case moral imperatives are looked upon as the commands of God, these imperatives being sometimes regarded as purely arbitrary. According to this view, if God had chosen to command what He has prohibited, or to prohibit what He has commanded, then what is now right would have been wrong, and what is now wrong would have been right. Nothing is either good or bad but God makes it so. For those who accept such a sanction there can be no ethics, no rational or philosophical account of morality, for all is arbitrary.

The *political sanction* is operative when the state is regarded as the authority that is empowered to decide what the citizen ought to do or avoid. The acceptance of this sanction tends to efface the distinction between legality and morality. It is also, as a rule, intimately connected with a eudaemonistic (generally utilitarian) ethical theory, for the aim of the state (except it be theocratic, like Geneva in the days of Calvin) is really to promote the temporal happiness of its citizens.

The *social sanction* is that exercised by society or one's social environment, in a less formal and less explicit manner than is done by the State as a political organization. There are social customs and traditions which carry much weight though not embodied in laws or regulations of the legislative body.

It is, of course, possible for all the above-mentioned sanctions to carry authority for the same person. In a theocratic state it would perhaps be so inevitably.

Any theory of morality which treats it as resting on its own authority is called *autonomous;* theories which base morality on any authority outside itself are usually called *heteronomous.* Strictly speaking, of course, it is the morality or the moral law, not the theory of morality, that is either autonomous or heteronomous.

THE MOTIVE OF MORAL CONDUCT

The problem of the sanction of morality is intimately connected with that of the *motive* of moral conduct; in fact they are two aspects of one theme. Sanctions are chiefly of practical importance in so far as they furnish motives. The natural inclinations of man are not, as a rule, strictly moral. Hence the sense of constraint, of external pressure, so frequently associated with the performance of duty. The question thus arises inevitably as to how man comes to conform to moral dictates in spite of his natural inclinations. This is the problem of *motives,* meaning by motives whatever induces one to adopt a certain course of action. The answers to this problem are various, and are intimately connected with differences in the views adopted in relation to some of the other ethical problems already considered. Egoistic eudaemonists naturally incline to say that the chief motives of moral conduct are the hope of obtaining some happiness and the fear of pain or misery. And to some extent this view is really implicit also in all ethical theories that formulate external sanctions of morality. The religious sanction is apt to build upon the personal hope of heaven and the personal fear of hell; though there is such a thing as a love of God that is entirely free from such

considerations. The political sanction may easily be identified with the fear of the police and punishment on the one hand, and the hope of political advancement on the other. Similarly, the social sanction may often assume the form of a fear of social ostracism of one kind or another, and the hope of finding favour with one's fellows who may advance one's ambitions. Of course, this need not be so; no doubt there are some who love their country or their community without any ulterior considerations. From the point of view of utilitarianism the political and social sanctions may provide the bases of quite satisfactory moral motives. Similarly, with universalistic perfectionism.

It is quite different with nomism, the theory of duty for duty's sake. In its rigorous form it approves no motive except that of respect for the moral law. Personal fear and hope it would condemn as selfish motives; and actions prompted by political or social motives it would characterize as "legal" but not as moral. This severe attitude of Kant was ridiculed by the poet, Schiller, who was otherwise a devoted admirer of the philosophy of Kant. And, most remarkable of all, Kant himself could not escape entirely the natural desire of man for happiness, on which he actually based the postulates of the existence of God and of the immortality of man, so that those who do their duty for duty's sake may yet reap their reward, at least hereafter in a better world.

Note.—The preceding account of ethics only gives a sketch of the main ethical problems and their solutions. The article, ETHICS, HISTORY OF, gives the historical setting of the problems and their solutions, and discusses them more fully. The adequate study of these problems, however, requires also some insight into the whole philosophical system of each moral philosopher, such as will be found in the articles under the names of the leading moral philosophers.

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ETHICS, HISTORY OF. The following historical sketch traces the main lines of development of ethical theory. Fuller details will be found in separate articles devoted to special subjects. The most important thinkers whose names occur in this historical outline have separate biographical articles devoted to them.

GREEK AND GRAECO-ROMAN ETHICS

The Pre-Socratic Philosophers.—The ethical speculation of Greece, and therefore of Europe, had no abrupt and absolute beginning. The naïve and fragmentary precepts of conduct, which are everywhere the earliest manifestation of nascent moral reflection, are a noteworthy element in the gnomic poetry of the 7th and 6th centuries B.C. Their importance is shown by the traditional enumeration of the Seven Sages of the 6th century, and their influence on ethical thought is attested by the references of Plato and Aristotle. But from these unscientific utterances to a philosophy of morals was a long process. In the practical wisdom of Thales (*q.v.*), one of the seven, we cannot discern any systematic theory of morality. In the case of Pythagoras, conspicuous among pre-Socratic philosophers as the founder not merely of a school, but of an order bound by a common rule of life, there is a closer connection between moral and metaphysical speculation. The doctrine of the Pythagoreans that the essence of justice (conceived as equal retribution) was a square number, indicates a serious attempt to extend to the region of conduct their mathematical view of the universe; and the same may be said of their classification of good with unity, straightness and the like, and of evil with the opposite qualities. Still, the enunciation of the moral precepts of Pythagoras appears to have been dogmatic, or even prophetic, rather than philosophic, and to have been accepted by his disciples with an unphilosophic reverence as the *ipse dixit* of the master. Hence, whatever influence the Pythagorean blending of ethical and mathematical notions may have had on Plato, and, through him, on later thought, we cannot regard the school as having really forestalled the Socratic enquiry after a completely reasoned theory of conduct. The ethical element in the "dark" philosophizing of Heraclitus (*c.* 530–470 B.C.), though it anticipates Stoicism in its conceptions of a law of the universe, to which the wise man will carefully conform, and a divine harmony, in the recognition of which he will find his truest satisfaction, is more profound, but even less systematic. It is only when we come to Democritus, a contemporary of Socrates, that we find anything which we can call an ethical system. The fragments that remain of the moral treatises of Democritus are sufficient, perhaps, to convince us that the turn of Greek philosophy in the direction of conduct, which was actually due to Socrates, would have taken place without him, though in a less decided manner; but when we compare the Democritean ethics with the post-Socratic system to which it has most affinity, Epicureanism, we find that it exhibits a very rudimentary apprehension of the formal conditions which moral teaching must fulfil before it can be treated as scientific.

The truth is that no system of ethics could be constructed until attention had been directed to the vagueness and inconsistency of the common moral opinions of mankind. For this purpose was needed the concentration of a philosophic intellect of the first order on the problems of practice. In Socrates first we find the required combination of a paramount interest in conduct and an ardent desire for knowledge.

Socrates.—Though Socrates was the first to arrive at a proper conception of the problems of conduct, the general idea did not originate with him. The natural reaction against the metaphysical and ethical dogmatism of the early thinkers had reached its climax in the Sophists (*q.v.*). Gorgias and Protagoras are only representatives of what was really a universal tendency to abandon dogmatic theory and take refuge in practical matters, and especially, as was natural in the Greek city-state, in the civic relations of the citizen. The education given by the Sophists aimed at no general theory of life, but professed to expound the art of getting on in the world and of managing public affairs. In their eulogy of the virtues of the citizen, they pointed out the prudential character of justice and the like as a means of obtaining pleasure and avoiding pain. The Greek conception of society was such that the life of the free-born citizen consisted mainly of his public function, and, therefore, the pseudo-ethical disquisitions of the Sophists satisfied the requirements of the age. None thought of ἀρετή (virtue or excellence) as a unique quality possessed of an intrinsic value, but as the virtue of the citizen, just as good flute-playing was the virtue of the flute-player. We see here, as in other activities of the age, a determination to acquire technical knowledge, and to apply it directly to the practical issue. The Sophists had studied these matters superficially indeed but with thoroughness as far as they went, and it is not remarkable that they should have taken the methods which were successful in rhetoric, and applied them to the "science and art" of civic virtues. Plato's *Protagoras* claims, not unjustly, that in teaching virtue they simply did systematically what every one else was doing at haphazard. But in the true sense of the word, they had no ethical system at all, nor did they contribute save by contrast to ethical speculation. Into this arena of hazy popular common sense Socrates brought a new critical spirit, showing that these popular lecturers, in spite of their fertile eloquence, could not defend their fundamental assumptions, nor even give rational definitions of what they professed to explain. Not only were they thus "ignorant," but they were also inconsistent. Thus, by the aid of his famous "dialectic," Socrates arrived first at the negative result that the professed teachers were as ignorant as he himself claimed to be.

Socrates, first in the history of thought, propounds a positive law of conduct. Virtue is knowledge. This principle involved the paradox that no man, knowing good, would do evil. But it was a

paradox derived from his unanswerable truisms, "Every one wishes for his own good, and would get it if he could," and "No one would deny that justice and virtue generally are goods, and of all goods the best." But this good is not, for Socrates, duty as distinct from interest. The force of the paradox depends upon a blending of duty and interest in the single notion of good. This it is which forms the kernel of the positive thought of Socrates according to Xenophon. He could give no satisfactory account of Good in the abstract, and evaded all questions on this point by saying that he knew "no good that was not good *for something in particular*," but that good is consistent with itself. For himself he prized above all things the wisdom that is virtue, and in the task of producing it he endured the hardest penury, maintaining that such life was richer in enjoyment than a life of luxury.

The historically important characteristics of his moral philosophy, if we take his teaching and character together, may be summarized as follows: (1) an ardent enquiry for knowledge nowhere to be found, but which, if found, would perfect human conduct; (2) a demand meanwhile that men should act as far as possible on some consistent theory; (3) a provisional adhesion to the commonly received view of good, and a perpetual readiness to maintain the harmony of its different elements, and demonstrate the superiority of virtue by an appeal to the standard of self-interest; (4) personal firmness in carrying out consistently such practical convictions as he had attained. It is only when we keep all these points in view that we can understand how from Socratic conversation came all Greek ethical thought.

The Socratic Schools.—Four distinct philosophical schools trace their immediate origin to the circle that gathered round Socrates—the Megarian, the Platonic, the Cynic and the Cyrenaic. The impress of the master is manifest on all, in spite of the wide differences that divide them; they all agree in holding the most important possession of man to be wisdom or knowledge, and the most important knowledge to be knowledge of Good. Here, however, the agreement ends. The more philosophic part of the circle, forming a group in which Euclid of Megara (*see* MEGARIAN SCHOOL) seems at first to have taken the lead, regarded this Good as the object of a still unfulfilled quest, and were led to identify it with the hidden secret of the universe, and thus to pass from ethics to metaphysics. Others again, who were more impressed with the positive and practical side of the master's teaching, made the quest a much simpler affair. They took the Good as already known, and held philosophy to consist in the steady application of this knowledge to conduct. Among these were Antisthenes the Cynic and Aristippus of Cyrene. It is by their recognition of the duty of living consistently by theory instead of mere impulse or custom, their sense of the new value given to life through this rationalization, and their effort to maintain the easy, calm, unwavering firmness of the Socratic temper, that we recognize both Antisthenes and Aristippus as "Socratic men," in spite of the completeness with which they divided their master's positive doctrine into systems diametrically opposed.

Aristippus (*see* CYRENAICS) argued that, if all that is beautiful or admirable in conduct has this quality as being useful, *i.e.*, productive of some further good; this good must be pleasure. Bodily pleasures and pains Aristippus held to be the keenest, though he admitted the existence of purely mental pleasures, such as joy in the prosperity of one's native land. He fully recognized that his good was capable of being realized only in successive parts, and gave even exaggerated emphasis to the rule of seeking the pleasure of the moment, and not troubling oneself about a dubious future. It was in the calm, resolute, skilful culling of such pleasures as circumstances afforded from moment to moment, undisturbed by passion, prejudices or superstition, that he conceived the quality of wisdom to be exhibited. Among the prejudices from which the wise man was free he included all regard to customary morality beyond what was due to the actual penalties attached to its violation; though he held, with Socrates, that these penalties actually render conformity reasonable. Thus early appeared the most thoroughgoing exposition of hedonism.

Far otherwise was the Socratic spirit understood by Antisthenes and the Cynics (*q.v.*). They equally held that no speculative research was needed for the discovery of good and virtue, and maintained that the Socratic wisdom was exhibited, not in the skilful pursuit, but in the rational disregard of pleasure—in the clear apprehension of the intrinsic worthlessness of this and most other objects of men's ordinary desires and aims. Pleasure, indeed, Antisthenes declared evil. He did not overlook the need of supplementing merely intellectual insight by "Socratic force of soul"; but it seemed to him that, by insight and self-mastery combined, an absolute spiritual independence might be attained which left nothing wanting for perfect well-being (*see* DIOGENES). For, regarding poverty, painful toil, disrepute, and such evils as men dread most, these, he argued, were positively useful as means of progress in spiritual freedom and virtue. There is, however, in the Cynic notion of wisdom, no positive criterion beyond the mere negation of irrational desires and prejudices. We saw that Socrates, while not claiming to have found the abstract theory of good or wise conduct, practically understood by it the faithful performance of customary duties. The Cynics more boldly discarded both pleasure and mere custom as alike irrational; but in so doing they left the freed reason with no definite aim but its own freedom. It is absurd, as Plato urged, to say that knowledge is the good, and then when asked "knowledge of what?" to have no positive reply but "of the good"; but the Cynics do not seem to have made any serious effort to escape from this absurdity.

Plato.—The ethics of Plato cannot properly be treated as a finished result, but rather as a continual movement from the position of Socrates towards the more complete, articulate system of Aristotle; except that there are ascetic and mystical suggestions in some parts of Plato's teaching which find no counterpart in Aristotle, and in fact disappear from Greek philosophy soon after Plato's death until they are revived and fantastically developed in Neopythagoreanism and Neoplatonism. The first stage at which we can distinguish Plato's ethical view from that of Socrates is presented in the *Protagoras*, where he makes a serious, though tentative effort to define the object of that knowledge which he with his master regards as the essence of all virtue. Such knowledge, he here maintains, is really mensuration of pleasures and pains, whereby the wise man avoids those mistaken under-estimates of future feelings in comparison with present which we commonly call "yielding to fear or desire." This hedonism has perplexed Plato's readers needlessly, inasmuch as hedonism is the most obvious corollary of the Socratic doctrine that the different common notions of good—the beautiful, the pleasant and the useful—were to be interpreted by each other. By Plato, however, this conclusion could have been held only before he had accomplished the movement of thought by which he carried the Socratic method beyond the range of human conduct and developed it into a metaphysical system.

This movement may be expressed thus. "If we know," said Socrates, "what justice is, we can give an account or definition of it"; true knowledge must be knowledge of the general fact, common to all the individual cases to which we apply our general notion. But this must be no less true of other objects of thought; the same relation of general notions to particular examples extends through the whole physical universe; we can think of it only by means of such notions. True knowledge then must be general knowledge, relating not to individuals primarily, but to the general facts or qualities which individuals exemplify; in fact, our notion of an individual, when examined, is found to be an aggregate of such general qualities. But, again, the object of true knowledge must be what really exists; hence the reality of the universe must lie in general facts or relations.

Plato's philosophy is now concerned with the whole universe of being; yet the ultimate object of his philosophic contemplation is still "the good," now conceived as the ultimate ground of all being and knowledge. How comes this about?

Perhaps we may best explain this by recurring to the original application of the Socratic method to human affairs. Since all rational activity is for some end, the different arts or functions of human industry are naturally defined by a statement of their ends or uses; and similarly, in giving an account of the different artists and functionaries, we necessarily state their end, "what

they are good for." In a society well ordered on Socratic principles, every human being would be put to some use; the essence of his life would consist in doing what he was good for. But again, it is easy to extend this view throughout the whole region of organized life; an eye that does not attain its end by seeing is without the essence of an eye. In short, we may say of all organs and instruments that they are what we think them in proportion as they fulfil their function and attain their end. If, then, we conceive the whole universe organically, as a complex arrangement of means to ends, we shall understand how Plato might hold that all things really *were*, or "realized their idea," in proportion as they accomplished the special end for which they were adapted.

Plato, therefore, took this vast stride of thought, and identified the ultimate notions of ethics and ontology. We have now to see what attitude he will adopt towards the practical enquiries from which he started. What will now be his view of wisdom, virtue, pleasure and their relation to human well-being?

The answer to this question is somewhat complicated. In the first place we have to observe that philosophy has now passed definitely from the market-place into the lecture-room. The quest of Socrates was for the true art of conduct for a man living a practical life among his fellows. But if the objects of abstract thought constitute the real world, of which this world of individual things is but a shadow, it is plain that the highest, most real life must lie in the former region and not in the latter. It is in contemplating the abstract reality which concrete things obscurely exhibit, the type or ideal which they imperfectly imitate, that the true life of the mind in man must consist; and as man is most truly man in proportion as he is mind, the desire of one's own good, which Plato, following Socrates, held to be permanent and essential in every living thing, becomes in its highest form the philosophic yearning for knowledge. This yearning, he held, springs from a sense of want of something formerly possessed, of which there remains a latent memory in the soul, strong in proportion to its philosophic capacity; hence it is that in learning any abstract truth by scientific demonstration we merely bring into clear consciousness hidden memories of a state in which the soul looked upon Reality and Good face to face, before the lapse that imprisoned her in an alien body and mingled her true nature with fleshly feelings and impulses. We thus reach the paradox that the true art of living is really an "art of dying" as far as possible to mere sense, in order more fully to exist in intimate union with absolute goodness and beauty. On the other hand, since the philosopher must still live and act in the concrete sensible world, the Socratic identification of wisdom and virtue is fully maintained by Plato. Only he who apprehends good in the abstract can imitate it in such transient and imperfect good as may be realized in human life; and it is impossible that, having this knowledge, he should not act on it, whether in private or public affairs. Thus, in the true philosopher, we shall necessarily find the practically good man, and also the perfect statesman, if only conditions allow him a sphere for exercising his statesmanship.

The characteristics of this practical goodness in Plato's matured thought correspond to the fundamental conceptions in his view of the universe. The soul of man, in its good or normal condition, must be ordered and harmonized under the guidance of reason. The question then arises, "Wherein does this order or harmony precisely consist?" In explaining how Plato was led to answer this question, it will be well to notice that, while faithfully maintaining the Socratic doctrine that the highest virtue was inseparable from knowledge of the good, he had come to recognize an inferior kind of virtue, possessed by men who were not philosophers. It is plain that if the good that is to be known is the ultimate ground of the whole of things, it is attainable only by a select and carefully trained few. Yet we can hardly restrict all virtue to these alone. What account, then, was to be given of ordinary "civic" bravery, temperance and justice? It seemed clear that men who did their duty, resisting the seductions of fear and desire, must have right opinions, if not knowledge, as to the good and evil in human life; but whence comes this right "opinion"? Partly, Plato said, it comes by the nature and "divine allotment," but for its adequate development "custom and practice" are required. Hence the importance of education and discipline for civic virtue; and even for future philosophers such moral culture, in which physical and aesthetic training must co-operate, is indispensable; no merely intellectual preparation will suffice. His point is that perfect knowledge cannot be implanted in a soul that has not gone through a course of preparation. What, then, is this preparation? A distinct step in psychological analysis was taken when Plato recognized that its effect was to produce the "harmony" above mentioned among different parts of the soul, by subordinating the impulsive elements to reason. These non-rational elements he further distinguished as appetitive and spirited—the practical separateness of which from each other and from reason he held to be established by our inner experience.

On this triple division of the soul he founded a systematic view of the four kinds of goodness recognized by the common moral consciousness of Greece, and in later times known as the Cardinal Virtues (*q.v*). Of these the two most fundamental were wisdom—in its highest form philosophy—and that harmonious and regulated activity of all the elements of the soul which Plato regards as the essence of uprightness in social relations. The import of this term is essentially social; and we can explain Plato's use of it only by reference to the analogy which he drew between the individual man and the community. In a rightly ordered polity social and individual well-being alike would depend on that harmonious action of diverse elements, each performing its proper function, which in its social application is more naturally termed Justice. We see, moreover, how in Plato's view the fundamental virtues, Wisdom and Justice, are mutually involved. Wisdom will necessarily maintain orderly activity, and this latter consists in regulation by wisdom, while the two more special virtues of Courage and Temperance are only different sides or aspects of this wisely regulated action of the complex soul.

Such, then, are the forms in which essential good seemed to manifest itself in human life. It remains to ask whether the statement of these gives a complete account of human well-being, or whether pleasure also is to be included. On this point Plato's view seems to have gone through several oscillations. After apparently maintaining (*Protagoras*) that pleasure is *the* good, he passes first to deny it (*Phaedo, Gorgias*) to be a good at all. This view, however, was too violent a divergence from Socratism for Plato to remain in it. That pleasure is not the real absolute good, was no ground for not including it in the good of concrete human life; and after all only vulgar pleasures were indissolubly linked to the pains of want. Accordingly, in the *Republic* he has no objection to trying the question of the intrinsic superiority of virtuous life by the standard of pleasure, and argues that the good man alone enjoys real pleasure, while the sensualist spends his life in oscillating between painful want and the merely neutral state of painlessness, which he mistakes for positive pleasure. Still more emphatically is it declared in the *Laws* that when we are "discoursing to men, not to gods," we must show that the life which we praise as best and noblest is also that in which there is the greatest excess of pleasure over pain. But though in the *Philebus* a place is allowed to pleasures of colour, form and sound, of intellectual exercise, and even to the "necessary" satisfaction of appetite, it is only a subordinate one. At the same time Plato avoids the exaggeration of denying all positive quality of pleasure even to the coarser sensual gratifications; they are undoubtedly cases of that "replenishment" or "restoration" to its "natural state" of a bodily organ, in which he defines pleasure to consist (see *Timaeus*, pp. 64, 65); he merely maintains that the common estimate of them is to a large extent illusory, or a false appearance of pleasure is produced by contrast with the antecedent or concomitant painful condition of the organ. In the *Philebus*, however, the antithesis of knowledge and pleasure is again sharpened, and a desire to depreciate even good pleasures is more strongly shown; still even here pleasure is recognized as a constituent of that philosophic life which is the highest human good, while in the *Laws*, where the subject is more popularly treated, it is admitted that we cannot convince man the just life is best unless we can also prove it the pleasantest.

Aristotle.—When a student passes from Plato to Aristotle, he is so forcibly impressed by the contrast between the habits of mind of the two authors, and the literary manners of the two philosophers, that it is easy to understand how their systems have come to be popularly conceived as diametrically opposed to each other; and the uncompromising polemic which Aristotle, both in his ethical and in his metaphysical treatises, directs against Plato and the platonists, has tended strongly to confirm this view. Yet a closer inspection shows us that when a later president of the Academy (Antiochus of Ascalon) repudiated the scepticism which for 200 years had been accepted as the traditional Platonic doctrine, he had good grounds for claiming Plato and Aristotle as consentient authorities for the ethical position which he took up. For though Aristotle's divergence from Plato is very conspicuous when we consider either his general conception of the subject of ethics, or the details of his system of virtues, still his agreement with his master is almost complete as regards the main outline of his theory of human good; the difference between the two practically vanishes when we view them in relation to the later controversy between Stoics and Epicureans. Even on the cardinal point on which Aristotle entered into direct controversy with Plato, the definite disagreement between the two is less than at first appears; the objections of the disciple hit that part of the master's system that was rather imagined than thought; the main positive result of Platonic speculation only gains in distinctness by the application of Aristotelian analysis.

The substantial good of the universe, in Aristotle's view, is the pure activity of universal abstract thought, at once subject and object, which, itself changeless and eternal, is the final cause and first source of the whole process of change in the concrete world. And both he and Plato hold that a similar activity of pure speculative intellect is that in which the philosopher will seek to exist, though he must, being a man, concern himself with the affairs of ordinary human life, a region in which his highest good will be attained by realizing perfect moral excellence. Both accept the paradox in the qualified sense that no one can deliberately act contrary to what appears to him good, and that perfect virtue is inseparably bound up with perfect wisdom or moral insight. Both, however, recognize that this actuality of moral insight is not a function of the intellect only, but depends rather on careful training in good habits applied to minds of good natural dispositions, though the doctrine has no doubt a more definite and prominent place in Aristotle's system. The disciple certainly takes a step in advance by stating definitely, as an essential characteristic of virtuous action, that it is chosen for its own sake, for the beauty of virtue alone; but herein he merely formulates the conviction that his master inspires. Nor, finally, does Aristotle's account of the relation of pleasure to human well-being (although he has to combat the extreme anti-hedonism to which the Platonic school under Speusippus had been led) differ materially from the outcome of Plato's thought on this point, as the later dialogues present it to us. Pleasure, in Aristotle's view, is not the primary constituent of well-being, but rather an inseparable accident of it. He no doubt criticizes Plato's account of the nature of pleasure, arguing that we cannot properly conceive pleasure either as a "process" or as "replenishment." But this does not interfere with the general ethical agreement between the two and the doctrine that vicious pleasures are not true or real pleasures is so characteristically Platonic that we are almost surprised to find it in Aristotle.

Aristotle, discarding the transcendentalism of Plato, naturally retained from Plato's teaching the original Socratic method of induction from and verification by common opinion. Indeed, the windings of his exposition are best understood if we consider his literary manner as a kind of Socratic dialogue formalized and reduced to a monologue. He first leads us by an induction to the fundamental notion of ultimate end or good for man. All men, in acting, aim at some result, either for its own sake or as a means to some further end; but obviously not everything can be sought merely as a means; there must be some ultimate end. In fact men commonly recognize such an end, and agree to call it well-being. But they take very different views of its nature; how shall we find the true view? We observe that men are classified according to their functions; all kinds of man, and indeed all organs of man, have their special functions, and are judged as functionaries and organs according as they perform their functions well or ill. May we not then infer that man, as man, has his proper function, and that the well-being or "doing-well" that all seek really lies in fulfilling well the proper function of man—that is, in living well that life of the rational soul which is man's distinctive attribute?

The most important element, then, of well-being or good life for ordinary men Aristotle holds to consist in well-doing as determined by the notions of the different moral excellences. Ethical truth, in his view, is to be attained by careful comparison of particular moral opinions, just as physical truth is to be obtained by induction from particular physical observations. On account of the conflict of opinion in ethics we cannot hope to obtain certainty upon all questions; still reflection will lead us to discard some of the conflicting views and find a reconciliation for others, and will furnish, on the whole, a practically sufficient residuum of moral truth. This adhesion to common sense, though it involves a sacrifice of both depth and completeness in Aristotle's system, gives at the same time an historical interest which renders it deserving of special attention as an analysis of the current Greek ideal of "fair and good life" (καλοκἀγαθία). His virtues are not arranged on any clear philosophic plan; the list shows no serious attempt to consider human life exhaustively, and exhibit the standard of excellence appropriate to its different departments or aspects. He seems to have taken as a starting-point Plato's four cardinal virtues. The two comprehensive notions of Wisdom and Justice (δικαιοσύνη) he treats separately. As regards both, his analysis leads him to diverge considerably from Plato. As we saw, his distinction between practical and speculative Wisdom belongs to the deepest of his disagreement with his master; and in the case of δικαιοσύνη again he distinguishes the wider use of the term to express Law-observance, which (he says) coincides with the social side of virtue generally, and its narrower use for the virtue that "aims at a kind of equality," whether (1) in the distribution of wealth, honour, etc., or (2) in commercial exchange, or (3) in the reparation of wrong done. Then, in arranging the other special virtues, he begins with courage and temperance, which (after Plato) he considers as the excellences of the "irrational element" of the soul. Next follow two pairs of excellences, concerned respectively with wealth and honour: (1) liberality and magnificence, of which the latter is exhibited in greater matters of expenditure, and (2) laudable ambition and highmindedness similarly related to honour. Then comes gentleness—the virtue regulative of anger; and the list is concluded by the excellences of social intercourse, friendliness, truthfulness and decorous wit.

On the whole, there is probably no treatise so masterly as Aristotle's *Ethics*, and containing so much close and valid thought, that yet leaves on the reader's mind so strong an impression of dispersive and incomplete work. It is only by dwelling on these defects that we can understand the small amount of influence that his system exercised during the five centuries after his death, as compared with the effect which it has had, directly or indirectly, in shaping the thought of modern Europe. Partly, no doubt, the limited influence of his disciples, the Peripatetics (*q.v.*), is to be attributed to that exaltation of the purely speculative life which distinguished the Aristotelian ethics from other later systems, and which was too alien from the common moral consciousness to find much acceptance in an age in which the ethical aims of philosophy had again become paramount. Partly, again, the analytical distinctness of Aristotle's manner brings into special prominence the difficulties that attend the Socratic effort to reconcile the ideal aspirations of men with the principles on which their practical reasonings are commonly conducted. The conflict between these two elements of Common Sense was too profound to be compromised; and the moral consciousness of mankind demanded a more trenchant partisanship than Aristotle's. Its demands were met by the Stoic school, which separated the moral from the worldly view of life, with an absoluteness and definiteness that caught the imagination; which regarded practical goodness as the highest manifestation of its ideal of wisdom; and which bound the common notions of duty into an apparently coherent system,

by a formula that comprehended the whole of human life, and exhibited its relation to the ordered process of the universe. The intellectual descent of its ethical doctrines is principally to be traced to Socrates through the Cynics, though an important element in them seems attributable to the school that inherited the "Academy" of Plato. Both Stoic and Cynic maintained, in its sharpest form, the fundamental tenet that the practical knowledge which is virtue, with the condition of soul that is inseparable from it, is alone to be accounted good. The Stoics seem generally to have regarded the eccentricities of Cynicism as an emphatic manner of expressing the essential antithesis between philosophy and the world; and though not necessary or even normal, might be advantageously adopted under certain circumstances.

Stoicism.—Wherein, then, consists this knowledge or wisdom that makes free and perfect? Both Cynics and Stoics (*q.v.*) agreed that the most important part of it was the knowledge that the sole good of man lay in this knowledge or wisdom itself. It must be understood that by wisdom they meant wisdom realized in act; indeed, they did not conceive the existence of wisdom as separable from such realization. We may observe, too, that the Stoics rejected the divergence which we have seen gradually taking place in Platonic-Aristotelian thought from the position of Socrates, "that no one aims at what he knows to be bad." The stress that their psychology laid on the essential unity of the rational self that is the source of voluntary action prevented them from accepting Plato's analysis of the soul into a regulative element and elements needing regulation. They held that what we call passion is a morbid condition of the rational soul, involving erroneous judgment as to what is to be sought or shunned. From such passionate errors the truly wise man will of course be free. He will be conscious indeed of physical appetite; but he will not be misled into supposing that its object is really a good; he cannot, therefore, hope for the attainment of this object or fear to miss it, as these states involve the conception of it as a good. Similarly, though like other men he will be subject to bodily pain, this will not cause him mental grief or disquiet, as his worst agonies will not disturb his clear conviction that it is really indifferent to his true reasonable self.

That this impassive sage was a being not to be found among living men the later Stoics at least were fully aware. They faintly suggested that one or two mortal heroes of old time might have realized the ideal, but they admitted that all other philosophers, even, were merely in a state of progress towards it. This admission did not in the least diminish the rigour of their demand for absolute loyalty to the exclusive claims of wisdom. The assurance of its own unique value that such wisdom involved they held to be an abiding possession for those who had attained it; and without this assurance no act could be truly wise or virtuous. Whatever was not of knowledge was of sin; and the distinction between right and wrong being absolute and not admitting of degrees, all sins were equally sinful; whoever broke the least commandment was guilty of the whole law. Similarly, all wisdom was somehow involved in any one of the manifestations of wisdom, commonly distinguished as particular virtues; though whether these virtues were specifically distinct, or only the same knowledge in different relations, the Stoics do not seem to have agreed.

Aristotle had already been led to attempt a refutation of the Socratic identification of virtue with knowledge; but his attempt had only shown the profound difficulty of attacking the paradox, so long as it was admitted that no one could of deliberate purpose act contrary to what seemed to him best. Now, Aristotle's divergence from Socrates had not led him so far as to deny this; while for the Stoics who had receded to the original Socratic position, the difficulty was still more patent. This theory of virtue led them into two dilemmas. Firstly, if virtue is knowledge, does it follow that vice is involuntary? If not, it must be that ignorance is voluntary. This alternative is the less dangerous to morality, and as such the Stoics chose it. But they were not yet at the end of their perplexities; for while they were thus driven to an extreme extension of the range of human volition, their view of the physical universe involved an equally thorough-going determinism. How could the vicious man be responsible if his vice were strictly predetermined? The Stoics answered that the error which was the essence of vice was so far voluntary that it could be avoided if men chose to exercise their reason. No doubt it depended on the innate force and firmness of a man's soul whether his reason was effectually exercised; but moral responsibility was saved if the vicious act proceeded from the man himself and not from any external cause.

With all this we have not ascertained the positive practical content of this wisdom. How are we to emerge from the barren circle of affirming (1) that wisdom is the sole good and unwisdom the sole evil, and (2) that wisdom is the knowledge of good and evil; and attain some method for determining the particulars of good conduct? The Cynics made no attempt to solve this difficulty; they were content to mean by virtue what any plain man meant by it, except in so far as their sense of independence led them to reject certain received precepts and prejudices. The Stoics, on the other hand, not only worked out a detailed system of duties—or, as they termed them, "things meet and fit" for all occasions of life; they were further especially concerned to comprehend them under a general formula. They found this by bringing out the positive significance of the notion of Nature, which the Cynic had used chiefly in a negative way, as an antithesis to the "conventions" from which his knowledge had made him free. Even in this negative use of the notion it is necessarily implied that whatever active tendencies in man are found to be "natural"—that is, independent of and uncorrupted by social customs and conventions—will properly take effect in outward acts, but the adoption of "conformity to nature" as a general positive rule for outward conduct seems to have been due to the influence on Zeno of Academic teaching. Whence, however, can this authority belong to the natural, unless nature be itself an expression or embodiment of divine law and wisdom? The conception of the world, as organized and filled by divine thought, was common, in some form, to all the philosophies that looked back to Socrates as their founder. This pantheistic doctrine harmonized thoroughly with the Stoic view of human good; but being unable to conceive substance idealistically, they (with considerable aid from the system of Heraclitus) supplied a materialistic side to their pantheism—conceiving divine thought as an attribute of the purest and most primary of material substances, a subtle fiery aether. This theological view of the physical universe had a double effect on the ethics of the Stoic. In the first place it gave to his cardinal conviction of the all-sufficiency of wisdom for human well-being a root of cosmical fact and an atmosphere of religious and social emotion. The exercise of wisdom was now viewed as the pure life of that particle of divine substance which was in very truth the "god within him"; the reason whose supremacy he maintained was the reason of Zeus, and of all gods and reasonable men, no less than his own; it might even be said that he was "as useful to Zeus as Zeus to him." But again, the same conception served to harmonize the higher and the lower elements of human life. For even in the physical or non-rational man, as originally constituted, we may see clear indications of the divine design, which it belongs to his rational will to carry into conscious execution; indeed, in the first stage of human life, before reason is fully developed, uncorrupted natural impulse effects what is afterwards the work of reason. Thus the formula of "living according to nature," in its application to man as the "rational animal," may be understood both as directing that reason is to govern and as indicating how that government is to be practically exercised. In man, as in every other animal, from the moment of birth natural impulse prompts to the maintenance of his physical frame; then, when reason has been developed and has recognized itself as its own sole good, these "primary ends of nature" and whatever promotes these still constitute the outward objects at which reason is to aim; there is a certain value in them, in proportion to which they are "preferred" (προηγμένα) and their opposites "rejected"; indeed it is only in the due and consistent exercise of such choice that wisdom can find its practical manifestation. In this way all or most of the things commonly judged to be "goods"—health, strength, wealth, fame, etc.—are brought within the sphere of the sage's choice, though his real good is solely in the wisdom of the

choice, and not in the thing chosen.

The doctrine of conformity to Nature as the rule of conduct was not peculiar to Stoicism. It is found in the theories of Speusippus, Xenocrates and also to some extent in those of the Peripatetics. The peculiarity of the Stoics lay in their refusing to use the terms "good and evil" in connection with "things indifferent," and in pointing out that philosophers, though independent of these things, must yet deal with them in practical life.

So far we have considered the "nature" of the individual man as apart from his social relations; but the sphere of virtue, as commonly conceived, lies chiefly in these, and this was fully recognized in the Stoic account of duties; indeed, in their exposition of the "natural" basis of justice, the evidence that man was born not for himself but for mankind is the most important part of their work in the region of practical morality. Here, however, we especially notice the double significance of "natural," as applied to (1) what actually exists everywhere or for the most part, and (2) what would exist if the original plan of man's life were fully carried out; and we find that the Stoics have not clearly harmonized the two elements of the notion. That man was "naturally" a social animal Aristotle had already taught; that all rational beings, in the unity of the reason that is common to all, form naturally one community with a common law was (as we saw) an immediate inference from the Stoic conception of the universe as a whole. That the members of this "city of Zeus" should observe their contracts, abstain from mutual harm, combine to protect each other from injury, were obvious points of natural law; while again, it was clearly necessary to the preservation of human society that its members should form sexual unions, produce children and bestow care on their rearing and training. But beyond this nature did not seem to go in determining the relations of the sexes; accordingly, we find that community of wives was a feature of Zeno's ideal commonwealth, just as it was of Plato's; while, again, the strict theory of the school recognized no government or laws as true or binding except those of the sage; he alone is the true ruler, the true king. So far, the Stoic "nature" seems in danger of being as revolutionary as Rousseau's. Practically, however, this revolutionary aspect of the notion was kept for the most part in the background; the rational law of an ideal community was not distinguished from the positive ordinances and customs of actual society; and the "natural" ties that actually bound each man to family, kinsmen, fatherland, and to unwise humanity generally, supplied the outline on which the external manifestation of justice was delineated. It was a fundamental maxim that the sage was to take part in public life; and it does not appear that his political action was to be regulated by any other principles than those commonly accepted in his community. Similarly, in the view taken by the Stoics of the duties of social decorum, and in their attitude to the popular religion, we find a fluctuating compromise between the disposition to repudiate what is conventional, and the disposition to revere what is established, each tendency expressing the principle of "conforming to nature."

Epicureanism.—Among the primary ends of nature, in which wisdom recognized a certain preferability, the Stoics included freedom from bodily pain; but they refused, even in this outer court of wisdom, to find a place for pleasure. They held that the latter was not an object of uncorrupted natural impulse, but an "aftergrowth." They thus endeavoured to resist Epicureanism even on the ground where the latter seems *primâ facie* strongest; in its appeal, namely, to the natural pleasure-seeking of all living things. Nor did they merely mean by pleasure the gratification of bodily appetite; we find, *e.g.*, Chrysippus urging, as a decisive argument against Aristotle, that pure speculation was "a kind of amusement; that is, pleasure." Even the "joy and gladness" that accompany the exercise of virtue seem to have been regarded by them as merely an inseparable accident, not the essential constituent of well-being. It is only by a later modification of Stoicism that cheerfulness or peace of mind is taken as the real ultimate end, to which the exercise of virtue is merely a means. At the same time it is probable that the serene joys of virtue and the griefiessness which the sage was conceived to maintain amid the worst tortures, formed the main attractions of Stoicism for ordinary minds. In this sense it may be fairly said that Stoics and Epicureans made rival offers to mankind of the same kind of happiness; and the philosophical peculiarities of either system may be traced to the desire of being undisturbed by the changes and chances of life. The Stoic claims on this head were the loftiest; as the well-being of their sage was independent, not only of external things and bodily conditions, but of time itself; it was fully realized in a single exercise of wisdom and could not be increased by duration. This paradox is violent, but it is quite in harmony with the spirit of Stoicism; and we are more startled to find that the Epicurean sage, no less than the Stoic, is to be happy even on the rack; that his happiness, too, is unimpaired by being restricted in duration, when his mind has apprehended the natural limits of life; that, in short, Epicurus makes no less strenuous efforts than Zeno to eliminate imperfection from the conditions of human existence. This characteristic, however, is the key to the chief differences between Epicureanism and the more naïve hedonism of Aristippus. The latter system gave the simplest and most obvious answer to the enquiry after ultimate good for man; but besides being liable, when developed consistently, to offend the common moral consciousness, it conspicuously failed to provide the "completeness" and "security" which, as Aristotle says, "one divines to belong to man's true Good." Philosophy, in the Greek view, should be the art as well as the science of good life; and hedonistic philosophy would seem a bungling and uncertain art of pleasure. Hence later thinkers of the Cyrenaic school felt themselves compelled to change their fundamental notion; thus Theodorus defined the good as "gladness" depending on wisdom, as distinct from mere pleasure, while Hegesias proclaimed that happiness was unattainable, and that the chief function of wisdom was to render life painless by producing indifference to all things that give pleasure. But by such changes their system lost the support that it had had in the pleasure-seeking tendencies of ordinary men. It was clear that if philosophic hedonism was to be established on a broad and firm basis, it must in its notion of good combine what the plain man naturally sought with what philosophy could plausibly offer. Such a combination was effected, with some little violence, by Epicurus, whose system with all its defects showed a remarkable power of standing the test of time, as it attracted the unqualified adhesion of generation after generation of disciples for a period of some six centuries.

In the fundamental principle of his philosophy Epicurus is not original. Aristippus (*cf.* also Plato in the *Protagoras* and *Eudoxus*) had already maintained that pleasure is the sole ultimate good, and pain the sole evil; that no pleasure is to be rejected except for its painful consequences, and no pain to be chosen except as a means to greater pleasure; that the stringency of all laws and customs depends solely on the legal and social penalties attached to their violation; that, in short, all virtuous conduct and all speculative activity are empty and useless, except as contributing to the pleasantness of the agent's life. And Epicurus assures us that he means by pleasure what plain men mean by it; and that if the gratifications of appetite and sense are discarded, the notion is emptied of significance. The originality of Epicurus lay in his theory that the highest point of pleasure is attained by the mere removal of pain or disturbance, after which pleasure admits of variation only and not of augmentation; that therefore the utmost gratification of which the body is capable may be provided by the simplest means, and that "natural wealth" is no more than any man can earn. When further he teaches that the attainment of happiness depends almost entirely upon insight and right calculation, fortune having very little to do with it; that the pleasures and pains of the mind are far more important than those of the body, owing to the accumulation of feeling caused by memory and anticipation; and that an indispensable condition of mental happiness lies in relieving the mind of all superstitions, which can be effected only by a thorough knowledge of the physical universe —he introduces an ample area for the exercise of the philosophic intellect. So again, in the stress that he lays on the misery which the most secret wrong-doing must necessarily cause from the perpetual fear of discovery, and in his exuberant exultation of the value of disinterested friendship, he shows a sincere, though not

completely successful effort to avoid the offence that consistent egoistic hedonism is apt to give to ordinary human feeling. As regards friendship, Epicurus was a man of peculiarly unexclusive sympathies. The genial fellowship of the philosophic community that he collected in his garden remained a striking feature in the traditions of his school; and certainly the ideal which Stoics and Epicureans equally cherished of a brotherhood of sages was most easily realized on the Epicurean plan of withdrawing from political and dialectical conflict to simple living and serene leisure, in imitation of the gods apart from the fortuitous concourse of the world. No doubt it was rather the practical than the theoretical side of Epicureanism which gave it so strong a hold.

Later Schools.—The two systems that have just been described were those that most prominently attracted the attention of the ancient world, so far as it was directed to ethics, from their almost simultaneous origin to the end of the 2nd century A.D., when Stoicism almost vanishes from our view. But side by side with them the schools of Plato and Aristotle still maintained a continuity of tradition, and a more or less vigorous life; and philosophy, as a recognized element of Graeco-Roman culture, was understood to be divided among these four branches. The internal history, however, of the four schools was very different. We find no development worthy of notice in the Aristotelian ethics (*see* PERIPATETICS). The Epicureans, again, almost deserve to be called a sect rather than a school. On the other hand, the changes in Stoicism are very noteworthy; and it is the more easy to trace them, as the only original writings of this school which we possess are those of the later Roman Stoics. These changes may be attributed partly to the natural inner development of the system, partly to the reaction of the Roman mind on the essentially Greek doctrine which it received—a reaction all the more inevitable from the very affinity between the Stoic sage and the ancient Roman ideal of manliness. It was natural that the earlier Stoics should be chiefly occupied with delineating the inner and outer characteristics of ideal wisdom and virtue, and that the gap between the ideal sage and the actual philosopher, though never ignored, should yet be somewhat overlooked. But when the question, "What is man's good?" had been answered by an exposition of perfect wisdom, the practical question, "How may a man emerge from the folly of the world, and get on the way towards wisdom?" naturally attracted attention; and the preponderance of moral over scientific interest, which was characteristic of the Roman mind, gave this question especial prominence. The sense of the gap between theory and fact gives to the religious element of Stoicism a new force; the soul, conscious of its weakness, leans on the thought of God, and in the philosopher's attitude towards external events, pious resignation preponderates over self-poised indifference; the old self-reliance of the reason, looking down on man's natural life as a mere field for its exercise, makes room for a positive aversion to the flesh as an alien element imprisoning the spirit; the body has come to be a "corpse which the soul sustains" (Epictetus) and life a "sojourn in a strange land" (Marcus Aurelius); in short, the ethical idealism of Zeno has begun to borrow from the metaphysical idealism of Plato.

In no one of these schools was the outward coherence of tradition so much strained by inner changes as it was in Plato's. The alterations, however, in the metaphysical position of the Academics had little effect on their ethical teaching, as, even during the period of Scepticism, they appear to have presented as probable the same general view of human good which Antiochus afterwards dogmatically announced as a revival of the common doctrine of Plato and Aristotle. And during the period of a century and a half between Antiochus and Plutarch, we may suppose the school to have maintained the old controversy with Stoicism on much the same ground, accepting the formula of "life according to nature," but demanding that the "good" of man should refer to his nature as a whole, the good of his rational part being the chief element, and always preferable in case of conflict, but yet not absolutely his sole good. In Plutarch, however, we see the same tendencies of change that we have noticed in later Stoicism. The conception of a normal harmony between the higher and lower elements of human life has begun to be disturbed, and the side of Plato's teaching that deals with the inevitable imperfections of the world of concrete experience becomes again prominent. For example, we find Plutarch amplifying the suggestion in Plato's latest treatise (the *Laws*) that this imperfection is due to a bad world-soul that strives against the good—a suggestion which is alien to the general tenor of Plato's doctrine, and had consequently been unnoticed during the intervening centuries. We observe, again, the value that Plutarch attaches, not merely to the sustainment and consolation of rational religion, but to the supernatural communications vouchsafed by the divinity to certain human beings in dreams, through oracles, or by special warnings, like those of the genius of Socrates. For these flashes of intuition, he holds, the soul should be prepared by tranquil repose and the subjugation of sensuality.

Neo-Platonism.—The system of Plotinus (A.D. 205–270) is a striking development of that element of Platonism which has had most fascination for the mediaeval and even for the modern mind, but which had almost vanished out of sight in the controversies of the post-Aristotelian schools. At the same time the differences are the more noteworthy from the reverent adhesion which the Neoplatonists always maintain to Plato. Plato identified good with the real essence of things; with that in them which is definitely conceivable and knowable. It belongs to this view to regard the imperfection of things as devoid of real being, and so incapable of being definitely thought or known; accordingly, we find that Plato has no technical term for that in the concrete sensible world which hinders it from perfectly expressing the abstract ideal world, and which in Aristotle's system is distinguished as absolutely formless matter (ὕλη). And so, when we pass from the ontology to the ethics of Platonism, we find that, though the highest life is only to be realized by turning away from concrete human affairs and their material environment, still the sensible world is not yet an object of positive moral aversion; it is rather something which the philosopher is seriously concerned to make as harmonious, good and beautiful as possible. But in Neoplatonism the inferiority of the condition in which the embodied human soul finds itself is more intensely and painfully felt; hence an express recognition of formless matter as the "first evil," from which is derived the "second evil," body (σῶμα), to whose influence all the evil in the soul's existence is due. Accordingly the ethics of Plotinus represent, we may say, the moral idealism of the Stoics cut loose from nature. The only good of man is the pure existence of the soul, which in itself, apart from the contagion of the body, is perfectly free from error or defect; if only it can be restored to the untrammeled activity of its original being, nothing external, nothing bodily, can positively impair its perfect welfare. It is only the lowest form of virtue—the "civic" virtue of Plato's *Republic*—that is employed in regulating those animal impulses whose presence in the soul is due to its mixture with the body; higher or philosophic wisdom, temperance, courage and justice are essentially purifications from this contagion; until finally the highest mode of goodness is reached, in which the soul has no community with the body, and is entirely turned towards reason. It should be observed that Plotinus himself is still too Platonic to hold that the absolute mortification of natural bodily appetites is required for purifying the soul; but this ascetic inference was drawn to the fullest extent by his disciple Porphyry.

There is, however, a yet higher point to be reached in the upward ascent of the Neoplatonist from matter; and here the divergence of Plotinus from Platonic idealism is none the less striking, because it is a *bona fide* result of reverent reflection on Plato's teaching. The cardinal assumption of Plato's metaphysic is, that the real is definitely thinkable and knowable in proportion as it is real; so that the farther the mind advances in abstraction from sensible particulars and apprehension of real being, the more definite and clear its thought becomes. Plotinus, however, urges that, as all thought involves difference or duality of some kind, it cannot be the primary fact in the universe, what we call God. He must be an essential unity prior to this duality, a Being wholly without difference or determination; and, accordingly, the highest mode of human existence, in which the soul apprehends this absolute, must be one in which all definite thought is transcended, and all consciousness of self lost in the absorbing ecstacy.

Porphyry tells us that his master Plotinus attained the highest state four times during the six years which he spent with him.

Neoplatonism, originally Alexandrine, is often regarded as Hellenistic rather than Hellenic, a product of the mingling of Greek with Oriental civilization. But however Oriental may have been the cast of mind that welcomed this theosophic asceticism, the forms of thought by which these views were philosophically reached are essentially Greek; and it is by a thoroughly intelligible process of natural development, in which the intensification of the moral consciousness represented by Stoicism plays an important part, that the Hellenic pursuit of knowledge culminates in a preparation for ecstacy, and the Hellenic idealization of man's natural life ends in a settled antipathy to the body and its works. At the same time we ought not to overlook the affinities between the doctrine of Plotinus and that remarkable combination of Greek and Hebrew thought which Philo Judaeus had expounded two centuries before; nor the fact that Neoplatonism was developed in conscious antagonism to the new religion which had spread from Judea, and was already threatening the conquest of the Graeco-Roman world, and also to the Gnostic systems (*see* GNOSTICISM); nor, finally, that it furnished the chief theoretical support in the last desperate struggle under Julian to retain the old worship.

MEDIAEVAL ETHICS

Christianity.—In the present article we are not concerned with the origin of the Christian religion, nor with its outward history. Nor have we to consider the special doctrines that have formed the bond of union of the Christian communities except in their ethical aspect, their bearing on the systematization of human aims and activities. This aspect, however, must necessarily be prominent in discussing Christianity, which cannot be adequately treated merely as a system of theological beliefs divinely revealed, and special observances divinely sanctioned; for it claims to regulate the whole man, in all departments of his existence. It was not till the 4th century A.D. that the first attempt was made to offer a systematic exposition of Christian morality; and nine centuries more had passed away before a genuinely philosophic intellect, trained by a full study of Aristotle, undertook to give complete scientific form to the ethical doctrine of the Catholic Church. Before, however, we take a brief survey of the progress of systematic ethics from Ambrose to Thomas Aquinas, it may be well to examine the chief features of the new moral consciousness that had spread through Graeco-Roman civilization, and was awaiting philosophic synthesis. It will be convenient to consider first the new *form* or universal characteristics of Christian morality, and afterwards to note the chief points in the *matter* or particulars of virtue which received development from the new religion.

The first point to be noticed is the new conception of morality as the positive law of a theocratic community possessing a written code imposed by divine revelation, and sanctioned by divine promises and threatenings. It is true that we find in ancient thought, from Socrates downwards, the notion of a law of God, eternal and immutable, partly expressed and partly obscured by the shifting codes and customs of actual human societies. But the sanctions of this law were vaguely and, for the most part, feebly imagined; its principles were essentially unwritten, and thus referred not to the external will of an Almighty Being who claimed unquestioning submission, but rather to the reason that gods and men shared, by the exercise of which alone they could be adequately known and defined. Hence, even if the notion of law had been more prominent than it was in ancient ethical thought, it could never have led to a juridical, as distinct from a philosophical, treatment of morality. In Christianity, on the other hand, we early find that the method of moralists determining right conduct is to a great extent analogous to that of jurisconsults interpreting a code. It is asssumed that divine commands have been implicitly given for all occasions of life, and that they are to be ascertained in particular cases by interpretation of the general rules obtained from texts of scripture, and by inference from scriptural examples. This juridical method descended naturally from the Jewish theocracy, of which Christendom was a universalization. Moral insight, in the view of the most thoughtful Jews of the age immediately preceding Christianity, was conceived as knowledge of a divine code, emanating from an authority external to human reason which had only the function of interpreting and applying its rules. This law was derived partly from Moses, partly from the utterances of the later prophets, partly from oral tradition and from the commentaries and supplementary maxims of generations of students. Christianity inherited the notion of a written divine code acknowledged as such by the "true Israel"—now potentially including the whole of mankind, or at least the chosen of all nations—on the sincere acceptance of which the Christian's share of the divine promises to Israel depended. And though the ceremonial part of the old Hebrew code was altogether rejected, and with it all the supplementary jurisprudence resting on tradition and erudite commentary, still God's law was believed to be contained in the sacred books of the Jews, supplemented by the teaching of Christ and his apostles. By the recognition of this law the Church was constituted as an ordered community, essentially distinct from the State; the distinction between the two was emphasized by the withdrawal of the early Christians from civic life, to avoid the performance of idolatrous ceremonies imposed as official expressions of loyalty, and by the persecutions which they had to endure, when the spread of an association apparently so hostile to the framework of ancient society had at length alarmed the imperial Government. Nor was the distinction obliterated by the recognition of Christianity as the State religion under Constantine.

Thus the jural form in which morality was conceived only emphasized the fundamental difference between it and the laws of the State. The ultimate sanctions of the moral code were the infinite rewards and punishments awaiting the immortal soul hereafter; but the Church early felt the necessity of withdrawing the privileges of membership from apostates and allowing them to be gradually regained only by a solemn ceremonial expressive of repentance, protracted through several years. This formal and regulated "penitence" was extended from apostasy to other grave—or, as they were subsequently called, "deadly"—sins; while for minor offences all Christians were called upon to express contrition by fasting and abstinence from ordinarily permitted pleasures, as well as verbally in public and private devotions. "Excommunication" and "penance" thus came to be temporal ecclesiastical sanctions of the moral law. As the graduation of these sanctions naturally became more minute, a correspondingly detailed classification of offences was rendered necessary, and thus a system of ecclesiastical jurisprudence was gradually produced, somewhat analogous to that of Judaism. At the same time this tendency to make prominent a scheme of external duties has always been counteracted in Christianity by the remembrance of its original antithesis to Jewish legalism. We find that this antithesis, as exaggerated by some of the Gnostic sects of the 2nd and 3rd centuries A.D., led, not merely to theoretical antinomianism, but even (if the charges of their orthodox opponents are not entirely to be discredited) to gross immorality of conduct. A similar tendency has shown itself at other periods of Church history. And though such antinomianism has always been sternly repudiated by the moral consciousness of Christendom, it has never been forgotten that "inwardness," rightness of heart or spirit, is the preeminent characteristic of Christian goodness. It must not, of course, be supposed that the need of something more than mere fulfilment of external duty was ignored even by the later Judaism. Rabbinic erudition could not forget the repression of vicious desires in the tenth commandment, the stress laid in Deuteronomy on the necessity of service to God, or the inculcation by later prophets of humility and faith. "The real and only Pharisee," says the Talmud, "is he who does the will of his Father because he loves Him." But it remains true that the contrast with the "righteousness of the scribes and pharisees" has always served to mark the requirement of "inwardness" as a distinctive feature of the Christian code—an inwardness not merely negative, tending to the repression of vicious desires as well as vicious acts, but also involving a positive rectitude of the inner state of the soul.

In this aspect Christianity invites comparison with Stoicism, and indeed with pagan ethical philosophy generally, if we except the hedonistic schools. Rightness of purpose, preference of virtue

for its own sake, suppression of vicious desires, were made essential points by the Aristotelians, who attached the most importance to outward circumstances in their view of virtue, no less than by the Stoics, to whom all outward things were indifferent. The fundamental differences between pagan and Christian ethics depend not on any difference in the value set on rightness of heart, but on different views of the essential form or conditions of this inward rightness. In neither case is it presented purely and simply as moral rectitude. By the pagan philosophers it was always conceived under the form of Knowledge or Wisdom, it being inconceivable to all the schools sprung from Socrates that a man could truly know his own good and yet deliberately choose anything else. This knowledge, as Aristotle held, might be permanently precluded by vicious habits, or temporarily obliterated by passion, but if present in the mind it must produce rightness of purpose. Or even if it were held with some of the Stoics that true wisdom was out of the reach of the best men actually living, it none the less remained the ideal condition of perfect human life. By Christian teachers, on the other hand, the inner springs of good conduct were generally conceived as Faith and Love. Of these notions the former has a somewhat complex ethical import; it seems to blend several elements differently prominent in different minds. Its simplest and commonest meaning is that emphasized in the contrast of "faith" with "sight"; where it signifies belief in the invisible divine order represented by the Church, in the actuality of the law, the threats, the promises of God, in spite of all the influences in man's natural life that tend to obscure this belief. Out of this contrast there ultimately grew an essentially different opposition between faith and knowledge or reason, according to which the theological basis of ethics was contrasted with the philosophical; the theologians maintaining sometimes that the divine law is essentially arbitrary, the expression of will, not reason; more frequently that its reasonableness is inscrutable, and that actual human reason should confine itself to examining the credentials of God's messengers, and not the message itself. But in early Christianity this latter antithesis was as yet undeveloped; faith means simply force in clinging to moral and religious conviction, whatever their rational grounds may be; this force, in the Christian consciousness, being inseparably bound up with personal loyalty and trust towards Christ, the leader in the battle with evil, the ruler of the kingdom to be realized. So far, however, there is no ethical difference between Christian faith and that of Judaism, or its later imitation, Mohammedanism.

A more distinctively Christian, and a more deeply moral significance is given to the notion in the antithesis of "faith" and "works." Here faith means more than loyal acceptance of the divine law and reverent trust in the lawgiver; it implies a consciousness, at once continually present and continually transcended, of the radical imperfection of all human obedience to the law, and at the same time of the irremissible condemnation which this imperfection entails. The Stoic doctrine of the worthlessness of ordinary human virtue, and the stern paradox that all offenders are equally, in so far as all are absolutely, guilty, find their counterparts in Christianity; but the latter overcomes its practical exclusiveness through faith. This faith, again, may be conceived in two modes, essentially distinct though usually combined. In one view it gives the believer strength to attain, by God's supernatural aid or "grace," a goodness of which he is naturally incapable; in the other view it gives him an assurance that, though he knows himself a sinner deserving of utter condemnation, a perfectly just God still regards him with favour on account of the perfect services and suffering of Christ.

But faith is rather an indispensable pre-requisite than the essential motive principle of Christian good conduct. This motive is supplied by the other central notion, love. On love depends the "fulfilling of the law," and the sole moral value of Christian duty —that is, on love to God, in the first place, which in its fullest development must spring from Christian faith; and, secondly, love to all mankind, as the objects of divine love and sharers in the humanity ennobled by the incarnation. This derivative philanthropy characterizes the spirit in which all Christian performance of social duty is to be done; loving devotion to God being the fundamental attitude of mind that is to be maintained throughout the whole of the Christian's life. But further, as regards abstinence from unlawful acts and desires prompting to them, we have to notice another form in which the inwardness of Christian morality manifests itself. The profound horror with which the Christian's conception of a suffering as well as an avenging divinity tended to make him regard all condemnable acts was tinged with a sentiment which we may describe as a ceremonial aversion moralized—the aversion, that is, to impurity. In Judaism, as in other, especially Oriental, religions, the natural dislike of material defilement has been elevated into a religious sentiment, and made to support a complicated system of quasi-sanitary abstinences and ceremonial purifications; then, as the ethical element predominated in the Jewish religion, a moral symbolism was felt to reside in the ceremonial code, and thus aversion to impurity came to be a common form of the ethico-religious sentiment. Then, when Christianity threw off the Mosaic ritual, this religious sense of purity was left with no other sphere besides morality; while, from its highly idealized character, it was peculiarly well adapted for that repression of vicious desires which Christianity claimed as its special function.

The distinctive features of Christian ethics are obedience, unworldliness, benevolence, purity and humility. They are naturally connected with the more general characteristics just stated; though many of them may also be referred directly to the example and precepts of Christ, and in several cases they are clearly due to both causes, inseparably combined.

1. We may notice, in the first place, that the conception of morality as a code which, if not in itself arbitrary, is yet to be accepted by men with unquestioning submission, tends naturally to bring into prominence the virtue of *obedience to authority*; just as the philosophic view of goodness as the realization of reason gives a special value to *self-determination* and independence.

2. Again, the opposition between the natural world and the spiritual order into which the Christian has been born anew led not merely to a contempt equal to that of the Stoic for wealth, fame, power and other objects of worldly pursuit, but also, for some time at least, to a comparative depreciation of the domestic and civic relations of the natural man. This tendency was exhibited most simply and generally in the earliest period of the Church's history. In the view of primitive Christians, ordinary human society was a world temporarily surrendered to Satanic rule, over which a swift and sudden destruction was impending; in such a world the little band who were gathered in the ark of the Church could have no part or lot. On the other hand, it was difficult practically to realize this alienation, and a keen sense of this difficulty induced the same hostility to the body as a hindrance, that we find to some extent in Plato, but more fully developed in Neoplatonism, Neopythagoreanism, and other products of the mingling of Greek with Oriental thought. This feeling is exhibited in the value set on fasting in the Christian Church from the earliest times, and in an extreme form in the self-torments of later monasticism; while both tendencies, anti-worldliness and anti-sensualism, seem to have combined in causing the preference of celibacy over marriage. Patriotism, again, and the sense of civic duty, the most elevated of all social sentiments in the Graeco-Roman civilization, tended, under Christianity, either to expand itself into universal philanthropy or to concentrate itself on the ecclesiastical community. We might further derive from the general spirit of Christian unworldliness that repudiation of the secular modes of conflict, even in a righteous cause, which substituted a passive patience and endurance for the old pagan virtue of courage. Here, however, we clearly trace the influence of Christ's express prohibition of violent resistance to violence, and his inculcation, by example and precept, of a love that was to conquer even natural resentment. An extreme result of this influence is shown in Tertullian's view, that no Christian could properly hold the office of a secular magistrate in which he would have to doom to death, chains, imprisonment; but even more sober writers, such as Ambrose, extend Christian passivity so far as to preclude self-defence even against a murderous assault. The common sense of Christendom gradually shook off these extravagances; but the reluctance

to shed blood lingered long, and was hardly extinguished even by the growing horror of heresy. We have a curious relic of this in later times when the heretic was doomed to the stake that he might be punished in some manner "short of bloodshed."

3. It is, however, in the impulse given to practical beneficence in all its forms, by the exaltation of love as the root of all virtues, that the most important influence of Christianity on the particulars of civilized morality is to be found; although the exact amount of this influence is here somewhat difficult to ascertain, since it merely carries farther a development traceable in the history of pagan morality. This development appears when we compare the different post-Socratic systems of ethics. In Plato's exposition of the different virtues there is no mention whatever of benevolence, although his writings show a keen sense of the importance of friendship as an element of philosophic life, especially of the intense personal affection naturally arising between master and disciple. Aristotle goes somewhat further in recognizing the moral value of friendship; and though he considers that in its highest form it can be realized only by the fellowship of the wise and good, he yet extends the notion so as to include the domestic affections, and takes notice of the importance of mutual kindness in binding together all human societies. Still in his formal statement of the different virtues, positive beneficence is discernible only under the notion of "liberality." Cicero, on the other hand, in his paraphrase of a Stoic treatise on external duties (*De officiis*), ranks the rendering of positive services to other men as a chief department of social duty; and the Stoics generally recognized the universal fellowship and natural mutual claims of human beings as such. Indeed, this recognition in later Stoicism is sometimes expressed with so much warmth of feeling as to be hardly distinguishable from Christian philanthropy. Nor was this regard for humanity merely a doctrine of the school. Partly through the influence of Stoic and other Greek philosophy, partly from the natural expansion of human sympathies, the legislation of the empire, during the first three centuries, shows a steady development in the direction of natural justice and humanity; and some similar progress may be traced in the general tone of moral opinion. Still the utmost point that this development reached fell considerably short of the standard of Christian charity. Without dwelling on the immense impetus given to the practice of social duty generally by the religion that made beneficence a form of divine service, and identified "piety" with "pity," we have to put down as definite changes introduced by Christianity—(1) the severe condemnation and final suppression of the practice of exposing infants; (2) effective abhorrence of the barbarism of gladiatorial combats; (3) immediate moral mitigation of slavery, and a strong encouragement of emancipation; (4) great extension of the eleemosynary provision made for the sick and the poor. As regards almsgiving, however—the importance of which has caused it to usurp, in modern languages, the general name of "charity"—it ought to be observed that Christianity merely universalized a duty always inculcated by Judaism.

4. The same may be said of the stricter regulation which Christianity enforced on the relations of the sexes; except so far as the prohibition of divorce is concerned, and the stress laid on "purity of heart" as contrasted with merely outward chastity.

5. Even the peculiarly Christian virtue of humility, which presents so striking a contrast to the Greek "highmindedness," was anticipated in the Rabbinic teaching. Its far greater prominence under the new dispensation may be partly referred to the express teaching and example of Christ; partly, in so far as the virtue is manifested in the renunciation of external rank and dignity, or the glory of merely secular gifts and acquirements, it is one aspect of the unworldliness which we have already noticed; while the deeper humility that represses the claim of personal merit even in the saint belongs to the strict self-examination, the continual sense of imperfection, the utter reliance on strength not his own, which characterize the inner moral life of the Christian.

We have, however, yet to notice the enlargement of the sphere of ethics due to its close connection with theology; for while this added religious force and sanction to ordinary moral obligations, it equally tended to impart a moral aspect to religious belief and worship. "Duty to God" had not been altogether unrecognized by pagan moralists; but the rather dubious relations of even the more orthodox philosophy to the established polytheism had generally prevented them from laying much stress upon it. Again the emphasis laid on inwardness in Christian ethics caused orthodoxy or correctness of religious belief to be regarded as essential to goodness, and heresy as the most fatal of vices, corrupting as it did the very springs of Christian life. To the philosophers (with the single exception of Plato), however, convinced as they were that the multitude must necessarily miss true well-being through their folly and ignorance, it could never occur to guard against these evils by any other method than that of providing philosophic instruction for the few; whereas the Christian clergy, whose function it was to offer truth and eternal life to all mankind, naturally regarded theological misbelief as insidious preventible contagion. Indeed, their sense of its deadliness was so keen that, when they were at length able to control the secular administration, they rapidly overcame their aversion to bloodshed, and initiated that long series of religious persecutions to which we find no parallel in the pre-Christian civilization of Europe.

Lastly, we must observe that, in proportion as the legal conception of morality as a code of which the violation deserves supernatural punishment predominated over the philosophic view of ethics as the method for attaining natural felicity, the question of man's freedom of will to obey the law necessarily became prominent. At the same time it cannot be broadly said that Christianity took a decisive side in the metaphysical controversy on free-will and necessity; since, just as in Greek philosophy the need of maintaining freedom as the ground of responsibility clashes with the conviction that no one deliberately chooses his own harm, so in Christian ethics it clashes with the attribution of all true human virtue to supernatural grace, as well as with the belief in divine foreknowledge. All we can say is that in the development of Christian thought the conflict of conceptions was far more profoundly felt, and far more serious efforts were made to evade or transcend it.

In the preceding account of Christian morality, it has been already indicated that the characteristics delineated did not all exhibit themselves simultaneously to the same extent, or with perfect uniformity throughout the Church. Changes in the external condition of Christianity, the different degrees of civilization in the societies of which it was the dominant religion, and the natural process of internal development, continually brought different features into prominence; while again, the important antagonisms of opinion within Christendom frequently involved ethical issues —even in the Eastern Church—until in the 4th century it began to be absorbed in the labour of a dogmatic construction. Thus, for example, the anti-secular tendencies of the new creed, to which Tertullian (160–220) gave violent and rigid expression, were exaggerated in the Montanist heresy which he ultimately joined; on the other hand, Clement of Alexandria, in opposition to the general tone of his age, maintained the value of pagan philosophy for the development of Christian faith into true knowledge (Gnosis), and the value of the natural development of man through marriage for the normal perfecting of the Christian life. So again, there is a marked difference between the writers before Augustine and those that succeeded him in all that concerns the internal conditions of Christian morality. By Justin and other apologists the need of redemption, faith, grace is indeed recognized, but the theological system depending on these notions is not sufficiently developed to come into even apparent antagonism with the freedom of the will. Christianity is for the most part conceived as essentially a proclamation through the Divine Word, to immortal beings gifted with free choice, of the true code of conduct sanctioned by eternal rewards and punishments. This legalism contrasts strikingly with the efforts of pagan philosophy to exhibit virtue as its own reward; and the contrast is triumphantly pointed out by more than one early Christian writer. It is plain, however, that on this view it was impossible to maintain a difference in kind between Christian and pagan morality; the philosopher's conformity to the rules of chastity and beneficence was indistinguishable from the saint's. But when this

inference was developed in the teaching of Pelagius, it was repudiated as heretical by the Church, under the powerful leadership of Augustine (354–430); and the doctrine of man's incapacity to obey God's law by his unaided moral energy was pressed to a point at which it was difficult to reconcile it with the freedom of the will. Augustine attempted to Christianize the Platonic list of virtues. This was probably due to the influence of his master, Ambrose, in whose *De officiis ministrarum* is found the first attempt to systematize Christian duties on a Platonic plan.

Under the influence of Ambrose and Augustine, the four cardinal virtues furnished a basis on which the systematic ethical theories of subsequent theologians were built. With them the triad of Christian graces, Faith, Hope and Love, and the seven gifts of the Spirit (Isa. xi. 2) were often combined. In antithesis to this list, an enumeration of the "deadly sins" obtained currency. These were at first commonly reckoned as eight; but a preference for mystical numbers characteristic of mediaeval theologians finally reduced them to seven. The statement of them is variously given—Pride, Avarice, Anger, Gluttony, Unchastity, are found in all the lists; the remaining two (or three) are variously selected from among Envy, Vainglory, and the rather singular sins Gloominess (*tristitia*) and Languid Indifference (*acidia* or *acedia*, from Gr. ἀκηδία). These latter notions show plainly, what indeed might be inferred from a study of the list as a whole, that it represents the moral experience of the monastic life, which for some centuries was more and more unquestioningly regarded as in a peculiar sense "religious." It should be observed that the (also Augustinian) distinction between "deadly" and "venial" sins had a technical reference to the quasi-jural administration of ecclesiastical discipline, which grew gradually more organized as the spiritual power of the Church established itself amid the ruins of the Western empire, and slowly developed into the theocracy that almost dominated Europe during the latter part of the middle ages. "Deadly" sins were those for which formal ecclesiastical penance was held to be necessary, in order to save the sinner from eternal damnation; for "venial" sins he might obtain forgiveness, through prayer, almsgiving and the observance of the regular fasts. This ecclesiastical jurisprudence, and indeed the general relation of the church to the ruder races with which it had to deal, necessarily tended to encourage a somewhat external view of morality.

Aquinas.—Scholastic ethics, like scholastic philosophy, attained its completest result in the teaching of Thomas Aquinas, whose moral philosophy is Aristotelianism with a Neoplatonic tinge, supplemented by a view of Christian dogma derived from Augustine. All action or movement of all things irrational as well as rational is directed towards some end or good—that is, really and ultimately towards God himself, the ground and first cause of all being, and unmoved principle of all movement. This universal though unconscious striving after God, since he is essentially intelligible, exhibits itself in its highest form in rational beings as a desire for knowledge of him; such knowledge, however, is beyond all ordinary exercise of reason, and may be only partially revealed to man here below. Thus the *summum bonum* for man is objectively God, subjectively the happiness to be derived from loving vision of His perfections; although there is a lower kind of happiness to be realized here below in a normal human existence of virtue and friendship, with mind and body sound and whole and properly trained for the needs of life. The higher happiness is given to man by free grace of God; but it is given to those only whose heart is right, and as a reward of virtuous actions. In his *Summa theologiae* Aquinas gave a detailed account of particular duties. This was frequently drawn upon when the quasi-legal treatment of morality came again into prominence as the philosophic interest of Scholasticism faded in the 14th and 15th centuries. One result of this movement was the development of casuistry (*q.v.*).

Humanism.—In the 17th century, however, the interest of this quasi-legal treatment of morality gradually faded; and the ethical studies of educated minds were occupied with the attempt, renewed after so many centuries, to find an independent philosophical basis for the moral code. The renewal of this attempt was only indirectly due to the Reformation; it is rather to be connected with the more extreme reaction from the mediaeval religion which was partly caused by, partly expressed in, that enthusiastic study of the remains of old pagan culture that spread from Italy over Europe in the 15th and 16th centuries. To this "humanism" the Reformation seemed at first more hostile than the Roman hierarchy; indeed, the extent to which this latter had allowed itself to become paganized by the Renaissance was one of the points that especially roused the Reformers' indignation. Not the less important is the indirect stimulus given by the Reformation towards the development of a moral philosophy independent alike of Catholic and Protestant assumptions. Scholasticism, while reviving philosophy as a handmaid to theology, had metamorphosed its method into one resembling that of its mistress; thus shackling the renascent intellectual activity which it stimulated by the double bondage to Aristotle and to the Church. When the Reformation shook the traditional authority in one department, the blow was necessarily felt in the other. Not 20 years after Luther's defiance of the pope, the startling thesis "that all that Aristotle taught was false" was prosperously maintained by the youthful Ramus before the university of Paris; and almost contemporaneously the group of remarkable thinkers in Italy who heralded the dawn of modern physical science—Cardanus, Telesio, Patrizzi, Campanella, Bruno—began to propound their Aristotelian theories of the constitution of the physical universe. It was to be foreseen that a similar assertion of independence would make itself heard in ethics also; and, indeed, amid the clash of dogmatic convictions, and the variations of private judgment, it was natural to seek for an ethical method that might claim universal acceptance from all sects.

MODERN ETHICS

Hugo Grotius.—The need of such independent principles was most strongly felt in the region of man's civil and political relations, especially the mutual relations of communities. Accordingly we find that modern ethical controversy began in a discussion of the law of nature. Albericus Gentilis (1557–1611) and Hugo Grotius (1583–1645) were the first to give a systematic account. Natural law, according to Grotius and other writers of the age, is that part of divine law which follows from the essential nature of man, who is distinguished from animals by his "appetite" for tranquil association with his fellows, and his tendency to act on general principles. It is therefore as unalterable, even by God himself, as the truths of mathematics, although its effect may be overruled in any particular case by an express command of God; hence it is cognizable *a priori*, from the abstract consideration of human nature, though its existence may be known *a posteriori* also from its universal acceptance in human societies. The conception, as we have seen, was taken from the later Roman jurists; by them, however, the law of nature was conceived as something that underlay existing law, and was to be looked for through it, though it might ultimately supersede it, and in the meanwhile represented an ideal standard, by which improvements in legislation were to be guided. Still the language of the jurists in some passages (cf. *Inst. of Justinian*, ii. 1, 2) clearly implied a period of human history in which men were governed by natural law alone, prior to the institution of civil society. Thus there had become current the conception of a "state of nature" in which individuals or single families lived side by side—under none other than those "natural" laws which prohibited mutual injury and interference in the free use of the goods of the earth common to all, and upheld parental authority, fidelity of wives, and the observance of compacts freely made. This conception Grotius took, and gave it additional force and solidity by using the principles of this natural law for the determination of international rights and duties, it being obvious that independent nations, in their corporate capacities, were still in that "state of nature" in their mutual relations. It was not, of course, assumed that these laws were universally obeyed; indeed, one point with which Grotius is especially concerned is the natural right of private war, arising out of the violation of more primary rights. Still a general observance was involved in the idea of a natural law as a "dictate

of right reason indicating the agreement or disagreement of an act with man's rational and social nature"; and we may observe that it was especially necessary to assume such a general observance in the case of contracts, since it was by an "express or tacit pact" that the right of property (as distinct from the mere right to non-interference during use) was held by him to have been instituted. A similar "fundamental pact" had long been generally regarded as the normal origin of legitimate sovereignty.

The ideas above expressed were not peculiar to Grotius; in particular the doctrine of the "fundamental pact" as the jural basis of government had long been maintained, especially in England, where the constitution historically established readily suggested such a compact. At the same time the rapid and remarkable success of Grotius's treatise (*De jure belli et pacis*) brought his view of Natural Right into prominence, and suggested such questions as—"What is man's ultimate reason for obeying these laws? Wherein exactly does this their agreement with his rational and social nature consist? How far, and in what sense, is his nature really social?"

English Ethics: Hobbes.—It was the answer which Hobbes (1588–1679) gave to these fundamental questions that supplied the starting-point for independent ethical philosophy in England. The nature of this answer was determined by the psychological views to which Hobbes had been led, possibly to some extent under the influence of Bacon, partly perhaps through association with his younger contemporary Gassendi, who, in two treatises, published between the appearance of Hobbes's *De cive* (1642) and that of the *Leviathan* (1651), endeavoured to revive interest in Epicurus. Hobbes's psychology is in the first place materialistic; he holds, that is, that in any of the psychophysical phenomena of human nature the reality is a material process of which the mental feeling is a mere "appearance." Accordingly he regards pleasure as essentially motion "helping vital action," and pain as motion "hindering" it. There is no logical connection between this theory and the doctrine that appetite or desire has always pleasure (or the absence of pain) for its object; but a materialist, framing a system of psychology, will naturally direct his attention to the impulses arising out of bodily wants, whose obvious end is the preservation of the agent's organism; and this, together with a philosophic wish to simplify, may lead him to the conclusion that all human impulses are similarly self-regarding. This, at any rate, is Hobbes's cardinal doctrine in moral psychology, that each man's appetites or desires are naturally directed either to the preservation of his life, or to that heightening of it which he feels as pleasure. Hobbes does not distinguish instinctive from deliberate pleasure-seeking; and he confidently resolves the most apparently unselfish emotions into phases of self-regard. Pity he finds to be grief for the calamity of others, arising from imagination of the like calamity befalling oneself; what we admire with seeming disinterestedness as beautiful (*pulchrum*) is really "pleasure in promise"; when men are not immediately seeking present pleasure, they desire power as a means to future pleasure, and thus have a derivative delight in the exercise of power that prompts to what we call benevolent action. Since, then, all the voluntary actions of men tend to their own preservation or pleasure, it cannot be reasonable to aim at anything else; in fact, nature rather than reason fixes this as the end of human action; it is reason's function to show the means. Hence if we ask why it is reasonable for any individual to observe the rules of social behaviour that are commonly called moral, the answer is obvious that this is only indirectly reasonable, as a means to his own preservation or pleasure. It is not, however, in this, which is only the old Cyrenaic or Epicurean answer, that the distinctive point of Hobbism lies. It is rather in the doctrine that even this indirect reasonableness of the most fundamental moral rules is entirely conditional on their general observance, which cannot be secured apart from government. For example, it is not reasonable for me to perform my share of a contract, unless I have reason for believing that the other party will perform his; and this I cannot have, except in a society in which he will be punished for non-performance. Thus the ordinary rules of social behaviour are only hypothetically obligatory; they are actualized by the establishment of a "common power" that may "use the strength and means of all" to enforce on all the observance of rules tending to the common benefit. On the other hand, Hobbes yields to no one in maintaining the paramount importance of moral regulations. The precepts of good faith, equity, requital of benefits, forgiveness of wrong so far as security allows, the prohibition of contumely, pride, arrogance, —which may all be summed up in the formula, "Do not that to another which thou wouldest not have done to thyself" (*i.e.*, the negative of the "golden rule")—he still calls "immutable and eternal laws of nature"—meaning that, though a man is not unconditionally bound to realize them, he is, as a reasonable being, bound to desire that they should be realized. The pre-social state of man, in his view, is also pre-moral; but it is therefore utterly miserable. It is a state in which everyone has a right to everything that may conduce to his preservation; but it is therefore also a state of war—a state so wretched that it is the first dictate of rational self-love to emerge from it into social peace and order. Hence Hobbes's ideal constitution naturally comes to be unlimited despotism. Whatever the government declares to be just or unjust must be accepted as such, since to dispute its dictates would be the first step towards anarchy, the one paramount peril. It is perhaps easy to understand how, in the crisis of 1640, when the ethico-political system of Hobbes first took written shape, a peace-loving philosopher should regard the claims of individual conscience as essentially anarchical, and dangerous to social well-being; but however strong might be men's yearning for order, a view of social duty, in which the only fixed positions were selfishness everywhere and unlimited power somewhere, could not but appear offensively paradoxical.

There was, however, in his theory an originality, a force, an apparent coherence which rendered it undeniably impressive; in fact, we find that for two generations the efforts to construct morality on a philosophical basis take more or less the form of answers to Hobbes. From an ethical point of view Hobbism divides itself naturally into two parts, which by Hobbes's peculiar political doctrines are combined into a coherent whole, but are not otherwise necessarily connected. Its theoretical basis is the principle of egoism; while, for practically determining the particulars of duty it makes morality entirely dependent on positive law and institution. It thus affirmed the relativity of good and evil in a double sense; good and evil, for any individual citizen, may from one point of view be defined as the objects respectively of his desire and his aversion; from another, they may be said to be determined for him by his sovereign. It is this latter aspect of the system which is primarily attacked by the first generation of writers that replied to Hobbes. This attack, or rather the counter-exposition of orthodox doctrine, is conducted on different methods by the Cambridge moralists and by Cumberland respectively. Cumberland is content with the legal view of morality, but endeavours to establish the validity of the laws of nature by taxing them on the single supreme principle of rational regard for the "common good of all," and showing them, as so based, to be adequately supported by the divine sanction. The Cambridge school, regarding morality primarily as a body of truth rather than a code of rules, insist on its absolute character and intuitive certainty.

Cudworth, Locke, etc.—Cudworth was the most distinguished of the little group of thinkers at Cambridge in the 17th century, commonly known as the Cambridge Platonists (*q.v.*). In his treatise on *Eternal and Immutable Morality* his main aim is to maintain the "essential and eternal distinctions of good and evil" as independent of mere will, whether human or divine. These distinctions, he insists, have an objective reality, cognizable by reason no less than the relations of space or number; and he endeavours to refute Hobbism—which he treats as a "novantique philosophy," a mere revival of the relativism of Protagoras—chiefly by the following *argumentum ad hominem*. He argues that Hobbes's atomic materialism involves the conception of an objective physical world, the object not of passive sense that varies from man to man, but of the active intellect that is the same in all; there is therefore, he urges, an inconsistency in refusing to

admit a similar exercise of intellect in morals, and an objective world of right and wrong, which the mind by its normal activity clearly apprehends as such.

Cumberland's treatise *De Legibus Naturae* (1672) is in its ethical matter thoroughly modern. Cumberland is noteworthy as having been the first to lay down that "regard for the common good of all" is the supreme rule of morality or law of nature. So far he may be fairly called the precursor of later utilitarianism. His fundamental principle and supreme "Law of Nature" is thus stated: "The greatest possible benevolence of every rational agent towards all the rest constitutes the happiest state of each and all, so far as depends on their own power, and is necessarily required for their happiness; accordingly Common Good will be the Supreme Good." Locke agrees entirely with Hobbes as to the egoistic basis of rational conduct, and the interpretation of "good" and "evil" as "pleasure" and "pain," or that which is productive of pleasure and pain, yet he agrees also with Hobbes's opponents in holding ethical rules to be actually obligatory independently of political society, and capable of being scientifically constructed on principles intuitively known—though he does not regard these principles as implanted in the mind at birth. The aggregate of such rules he conceives as the law of God necessarily sanctioned by adequate rewards and punishments.

Shaftesbury.—Shaftesbury (1671–1713) tried another psychological basis for ethical construction; instead of presenting the principle of social duty as abstract reason, liable to conflict to any extent with natural self-love, he tried to exhibit the naturalness of man's social affections, and demonstrate a normal harmony between these and his self-regarding impulses. This theory had already been advanced by Cumberland and others, but Shaftesbury was the first to make it the cardinal point in his system; no one had yet definitely transferred the centre of ethical interest from the Reason, conceived as apprehending either abstract moral distinctions or laws of divine legislation, to the emotional impulses that prompt to social duty; no one had undertaken to distinguish clearly, by analysis of experience, the disinterested and self-regarding elements of our appetitive nature, or to prove inductively their perfect harmony. In his *Inquiry concerning Virtue and Merit* he begins by attacking the egoism of Hobbes, which was not necessarily excluded by the doctrine of rational intuitions of duty. This interpretation, he says, would be true only if we considered man as a wholly unrelated individual. Such a being we might doubtless call "good," if his impulses were adapted to the attainment of his own felicity. But man must be considered in relation to a larger system of which he forms a part, and so we call him "good" only when his dispositions are so balanced as to tend towards the good of this whole. This being established, the principal aim of Shaftesbury's argument is to prove that the same balance of private and social affections, which tends naturally to public good, is also conducive to the happiness of the individual in whom it exists.

But virtue, in Shaftesbury's view, is something more; it implies a recognition of moral goodness and immediate preference of it for its own sake. This immediate pleasure that we take in goodness (and displeasure in its opposite) is due to a susceptibility which he calls the "reflex" or "moral" sense, and compares with our susceptibility to beauty and deformity in external things; it furnishes both an additional direct impulse to good conduct, and an additional gratification to be taken into account in the reckoning which proves the coincidence of virtue and happiness. This doctrine of the moral sense is sometimes represented as Shaftesbury's cardinal tenet; but though characteristic and important, it is not really necessary to his main argument.

The appearance of Shaftesbury's *Characteristics* (1713) marks a turning-point in the history of English ethical thought. With the generation of moralists that followed, the consideration of abstract rational principles falls into the background, and its place is taken by introspective study of the human mind, observation of the actual play of its various impulses and sentiments. This empirical psychology had not indeed been neglected by previous writers. More, among others, had imitated Descartes in a discussion of the passions, and Locke's essay had given a still stronger impulse in the same direction; still, Shaftesbury is the first moralist who distinctly takes psychological experience as the basis of ethics. His suggestions were developed by Hutcheson into one of the most elaborate systems of moral philosophy which we possess; through Hutcheson, if not directly, they influenced Hume's speculations, and are thus connected with later utilitarianism. Moreover, the substance of Shaftesbury's main argument was adopted by Butler, though it could not pass the scrutiny of that powerful and cautious intellect without receiving important modifications and additions. On the other hand, the ethical optimism of Shaftesbury, rather broadly impressive than exactly reasoned, and connected as it was with a natural theology that implied the Christian scheme to be superfluous, challenged attack equally from orthodox divines and from cynical freethinkers. Of these latter Mandeville, the author of *The Fable of the Bees, or Private Vices Public Benefits* (1723), was a conspicuous if not a typical specimen.

Price published his *Review of the Chief Questions and Difficulties of Morals* in 1757. What Price is specially concerned to show is the existence of ultimate principles *beside* the principle of universal benevolence. Not that he repudiates the obligation either of rational benevolence or self-love; on the contrary, he takes more pains than Butler to demonstrate the reasonableness of either principle. "There is not anything," he says, "of which we have more undeniably an intuitive perception, than that it is 'right to pursue and promote happiness,' whether for ourselves or for others." Finally, Price, writing after the demonstration by Shaftesbury and Butler of the actuality of disinterested impulses in human nature, is bolder and clearer than Cudworth or Clarke in insisting that right actions are to be chosen because they are right by virtuous agents as such, even laying down that an act loses moral worth in proportion as it is done from natural inclination.

On this latter point Reid, in his *Essays on the Active Powers of the Human Mind* (1788), states a conclusion more in harmony with common sense, only maintaining that "no act can be morally good in which regard for what is right has not *some* influence."

Utilitarianism had already been taught before the time of Bentham by Gay and Paley. But Bentham's utilitarianism has a decided superiority over theirs. He considers actions solely in respect of their pleasurable and painful consequences, expected or actual; and he recognizes the need of making a systematic register of these consequences, free from the influences of common moral opinion, as expressed in the "eulogistic" and "dyslogistic" terms in ordinary use. Further, the effects that he estimates are all of a definite, palpable, empirically ascertainable quality; they are such pleasures and pains as most men feel and all can observe, so that all his political or moral inferences lie open at every point to the test of practical experience. Everyone, it would seem, can tell what value he sets on the pleasures of alimentation, sex, the senses generally, wealth, power, curiosity, sympathy, antipathy (malevolence), the goodwill of individuals or of society at large, and on the corresponding pains, as well as the pains of labour and organic disorders; and can guess the rate at which they are valued by others; therefore if it be once granted that all actions are determined by pleasures and pains, and are to be tried by the same standard, the art of legislation and private conduct is apparently placed on an empirical basis. Bentham, no doubt, seems to go beyond the limits of experience proper in recognizing "religious" pains and pleasures in his fourfold division of sanctions, side by side with the "physical," "political," and "moral" or "social"; but the truth is that he does not seriously take account of them, except in so far as religious hopes and fears are motives actually operating, which therefore admit of being observed and measured as much as any other motives. He does not himself use the will of an omnipotent and benevolent being as a means of logically connecting individual and general happiness. He thus undoubtedly simplifies his system, and avoids the doubtful inferences from nature and Scripture; but this gain is dearly purchased. For in answer to the question, How are the sanctions of the moral rules which it will most conduce to the general happiness for men to observe, shown to be always adequate in the case of all the in-

dividuals whose observance is required? he is obliged to admit that "the only interests which a man is at all times sure to find adequate motives for consulting are his own." Indeed, in many parts of his work, in the department of legislative and constitutional theory, it is rather assumed that the interests of some men will continually conflict with those of their fellows, unless we alter the balance of prudential calculation by a readjustment of penalties. But on this assumption a system of private conduct on utilitarian principles cannot be constructed until legislative and constitutional reform has been perfected. And, in fact, "private ethics," as conceived by Bentham, does not exactly expound such a system; but rather exhibits the coincidence, *so far as it extends,* between private and general happiness, in that part of each man's conduct that lies beyond the range of useful legislation. It was not his place, as a practical philanthropist, to dwell on the defects in this coincidence; and since what men generally expect from a moralist is a completely reasoned account of what they ought to do, it is not surprising that some of Bentham's disciples should have either ignored or endeavoured to supply the gap in his system. One section of the school even maintained it to be a cardinal doctrine of utilitarianism that a man always gains his own greatest happiness by promoting that of others; another section, represented by John Austin, apparently returned to Paley's position, and treated utilitarian morality as a code of divine legislation; others, with Grote, are content to abate the severity of the claims made by "general happiness" on the individual, and to consider utilitarian duty as practically limited by reciprocity; while on the opposite side an unqualified subordination of private to general happiness was advocated by J. S. Mill, who did more than any other to spread utilitarianism.

The fact is that there are several different ways in which a utilitarian system of morality may be used, without deciding whether the sanctions attached to it are always adequate. (1) It may be presented as practical guidance to all who choose "general good" as their ultimate end, whether on religious grounds, or because their conscience acts in harmony with utilitarian principles, or for any other seasons; or (2) it may be offered as a code to be obeyed only so far as the coincidence of private and general interest may in any case be judged to extend; or again (3) it may be proposed as a standard by which men may reasonably agree to praise and blame the conduct of others, even though they may not always think fit to act on it. We may regard morality as a kind of supplementary legislation, supported by public opinion, which we may expect the public, when duly enlightened, to frame in accordance with the public interest. Still, even from this point of view, which is that of the legislator or social reformer rather than the moral philosopher, our code of duty must be greatly influenced by our estimate of the degrees in which men are normally influenced by self-regard, sympathy or benevolence, and of the range within which sympathy may be expected to be generally effective. Thus, for example, the moral standard for which a utilitarian will reasonably endeavour to gain the support of public opinion must be essentially different in quality, according as he holds with Bentham that nothing but self-regard will "serve for diet," though "for a dessert benevolence is a very valuable addition"; or with J. S. Mill that disinterested public spirit should be the prominent motive in the performance of all socially useful work, and that even hygienic precepts should be inculcated, because "by squandering our health we disable ourselves from rendering services to our fellow-creatures."

Continental Ethics.—In the 17th century and late into the 18th century Continental ethics had no influence on British moralists. Hence the preceding sketch of English ethics contains no allusion to Continental moralists. English ethics was self-contained during the period, and was predominantly empirical or psychological, whereas elsewhere in Europe ethics was metaphysical. Not till the time of T. H. Greene did English ethics seriously seek a metaphysical basis, though Continenal influences came into play among English moralists long before that.

Descartes.—Descartes (1596–1650) did not write a special treatise on ethics, but he dealt with ethical problems in his correspondence and in his *Treatise on the Passions of the Soul.* His ethical views show traces of Socratic, Platonic and Stoic influences. He identifies right willing with clear thinking. If man were only a spirit or rational soul, and had not also a body, he would always think clearly and so will rightly. Evil results from the influence of the body. Thus the body gives rise to "passions," which are an obstacle to clear knowledge, and so induces man to desire what is not truly desirable. Left to itself the spirit or rational soul of man is entirely active and free and good; but under the influence of the body, and of all that affects the body from outside, man becomes partly "passive," the slave of "passions," and so evil. The thing to aim at is therefore the supremacy of the mind or will over the "passions." The "passions" (including the emotions) cannot, however, be entirely suppressed, seeing that the human soul is, as a matter of fact, mated with a body. But much may be done to secure the predominance of the higher emotions at the expense of the lower passions. Wonder, or intellectual interest, is such an emotion. By cultivating it we promote the power of clear thinking or of real knowledge, and so advance the cause of morality. (*See* DESCARTES.)

Spinoza.—Spinoza (1632–1677) was the author of the most metaphysical system of ethics. His *Ethica* seems at first to be a misnamed treatise on metaphysics. But if it is true to say that his ethics is metaphysical, it is even more true to remark that his metaphysics is ethical. For unlike Descartes, who paid but little attention to ethics, Spinoza regarded the ethical problem as the most important, and subordinated to it all other philosophical problems. For Spinoza, philosophy was a completely rational religion, enriched by elements of a higher mysticism.

To understand the moral life of man attention must be focussed on a certain self-preserving impulse (*conatus*) which constitutes the very essence of each finite individual. Human feelings and emotions are the outcome of this impulse. Now the character of this self-preservation and self-realization varies with the different stages of man's intellectual development, and moral progress keeps pace with his intellectual progress. Spinoza distinguishes three (sometimes four) ascending grades of knowledge—Opinion, Reason, Intuition. At the lowest, pre-scientific stage of opinion (or vague experience) one is guided mainly by chance associations without rational insight. At this stage the self which seeks realization is the merely individual self as affected by accidents of place and time; for it, pleasure is the sole good, pain the sole evil. Not guided by its own intellectual activity, but influenced mainly by outside factors, the mind of man is at this stage in a state of bondage. Human nature, however, tends to emancipate itself from such bondage to the senses and the external objects that lure them on. At the stage of Reason, the active and universal element in human nature asserts itself, and helps man to free himself from the domination of the particular and the sensuous. Passions lose their power when they are seen through by penetrating thought. And man frees himself from his bondage to the particular objects of his loves and his hates when he grasps their real place in the order of Nature and the universal laws which control them. As man gains insight into his own place in the whole order of things and realizes the necessity of the whole cosmic process, he banishes all fear and regret, all disappointments and resentment, and acquires peace of mind. In this way reason uplifts the mind above the unrest of passion, and fills it with the joy of acquiescence in the universal order of things. At the highest stage of intellectual development, that of Intuitive Knowledge, the mind contemplates the whole universe as a complete unity, of which all things (including human beings) are infinitely varied expressions. This attitude induces the highest spiritual activity whereby the mind identifies its essence with the Infinite Being, and is filled with the intellectual love of God.

Kant.—The English moralist with whom Kant has most affinity is Price; in fact, Kantism, in the ethical thought of modern Europe, holds a place somewhat analogous to that formerly occupied by the teaching of Price and Reid among English moralists. Kant, like Price and Reid, holds that man as a rational being is unconditionally bound to conform to a certain rule of right, or "categorical imperative" of reason. Like Price he holds that an action is not good unless done from a good motive, and that this

motive must be essentially different from natural inclination of any kind; duty, to be duty, must be done for duty's sake; and he argues, with more subtlety than Price or Reid, that though a virtuous act is no doubt pleasant to the virtuous agent, and any violation of duty painful, this moral pleasure (or pain) cannot strictly be the motive to the act, because it follows instead of preceding the recognition of our obligation to do it. With Price, again, he holds that rightness of intention and motive is not only an indispensable condition or element of the rightness of an action, but actually the sole determinant of its moral worth; but with more philosophical consistency he draws the inference that there can be no separate rational principles for determining the "material" rightness of conduct, as distinct from its "formal" rightness; and therefore that all rules of duty, so far as universally binding, must admit of being exhibited as applications of the one general principle that duty ought to be done for duty's sake. This deduction is the most original part of Kant's doctrine. The dictates of reason, he points out, must necessarily be addressed to all rational beings as such; hence, my intention cannot be right unless I am prepared to will the principle on which I act to be a universal law. He considers that this fundamental rule or imperative "act on a maxim which thou canst will to be law universal" supplies a sufficient criterion for determining particular duties in all cases. The rule excludes wrong conduct with two degrees of stringency. Some offences, such as making promises with the intention of breaking them, we cannot even conceive universalized; as soon as every one broke promises no one would care to have promises made to him. Other maxims, such as that of leaving persons in distress to shift for themselves, we can easily conceive to be universal laws, but we cannot without contradiction will them to be such; for when we are ourselves in distress we cannot help desiring that others should help us.

Another important peculiarity of Kant's doctrine is his development of the connection between duty and free-will. He holds that it is through our moral consciousness that we know that we are free; in the cognition that I ought to do what is right because it is right and not because I like it, it is implied that this purely rational volition is possible; that my action can be determined, not "mechanically," through the necessary operation of the natural stimuli of pleasurable and painful feelings, but in accordance with the laws of my true, reasonable self. The realization of reason, or of human wills so far as rational, thus presents itself as the absolute end of duty; and we get, as a new form of the fundamental practical rule, "act so as to treat humanity, in thyself or any other, as an end always, and never as a means only." We may observe, too, that the notion of freedom connects ethics with jurisprudence in a simple and striking manner. The fundamental aim of jurisprudence is to realize external freedom by removing the hindrances imposed on each one's free action through the interferences of other wills. Ethics shows how to realize internal freedom by resolutely pursuing rational ends in opposition to those of natural inclination. If we ask what precisely are the ends of reason, Kant's proposition that "all rational beings as such are ends in themselves for every rational being" hardly gives a clear answer. It might be interpreted to mean that the result to be practically sought is simply the development of the rationality of all rational beings—such as men—whom we find to be as yet imperfectly rational. But this is not Kant's view. He holds, indeed, that each man should aim at making himself the most perfect possible instrument of reason; but he expressly denies that the perfection of others can be similarly prescribed as an end to each. It is, he says, "a contradiction to regard myself as in duty bound to promote the perfection of another, . . . a contradiction to make it a duty for me to do something for another which no other but himself can do." In what practical sense, then, am I to make other rational beings my ends? Kant's answer is that what each is to aim at in the case of others is not Perfection, but Happiness, *i.e.*, to help them to attain those purely subjective ends that are determined for each not by reason, but by natural inclination. He explains also that to seek one's own happiness cannot be prescribed as a duty, because it is an end to which every man is inevitably impelled by natural inclination: but that just because each inevitably desires his own happiness, and therefore desires that others should assist him in time of need, he is bound to make the happiness of others his ethical end, since he cannot *morally* demand aid from others without accepting the obligation of aiding them in like case. The exclusion of private happiness from the ends at which it is a duty to aim contrasts strikingly with the view of Butler and Reid, that man, as a rational being, is under a "manifest obligation" to seek his own interest. The difference, however, is not really so great as it seems; since in another part of his system Kant fully recognizes the reasonableness of the individual's regard for his own happiness. Though duty, in his view, excludes regard for private happiness, the *summum bonum* is not duty alone, but happiness combined with moral worth; the demand for happiness as the reward of duty is so essentially reasonable that we must postulate a universal connection between the two as the order of the universe; indeed, the practical necessity of this is the only adequate rational ground for believing in the existence of God.

Hegel.—Before the ethics of Kant had begun to be seriously studied in England, the rapid and remarkable development of metaphysical view and method of which the three chief stages are represented by Fichte, Schelling and Hegel respectively had already taken place; and the system of the latter was occupying the most prominent position in the philosophical thought of Germany. Hegel's ethical doctrine (expounded chiefly in his *Philosophie des Rechts*, 1821) shows a close affinity, and also a striking contrast, to Kant's. He holds, with Kant, that duty or good conduct consists in the conscious realization of the free reasonable will, which is essentially the same in all rational beings. But in Kant's view the universal content of this will is only given in the formal condition of "only acting as one can desire all to act," to be subjectively applied by each rational agent to his own volition; whereas Hegel conceives the universal will as objectively presented to each man in the laws, institutions and customary morality of the community of which he is a member. Thus, in his view, not merely natural inclinations towards pleasures, or the desires for selfish happiness, require to be morally resisted; but even the prompting of the individual's conscience, the impulse to do what seems to him right, if it comes into conflict with the common sense of his community. It is true that Hegel regards the conscious effort to realize one's own conception of good as a higher stage of moral development than the mere conformity to the jural rules establishing property, maintaining contract and allotting punishment to crime, in which the universal will is first expressed; since in such conformity this will is only accomplished accidentally by the outward concurrence of individual wills, and is not essentially realized in any of them. He holds, however, that this conscientious effort is self-deceived and futile, is even the very root of moral evil, except it attains its realization in harmony with the objective social relations in which the individual finds himself placed. Of these relations the first grade is constituted by the family, the second by civil society, and the third by the State, the highest manifestation of universal reason in the sphere of practice.

Hegelianism appears as a distinct element in modern English ethical thought; but the direct influence of Hegel's system is perhaps less important than that indirectly exercised through the powerful stimulus which it has given to the study of the historical development of human thought and human society. According to Hegel, the essence of the universe is a process of thought from the abstract to the concrete; and a right understanding of this process gives the key for interpreting the evolution in time of European philosophy. So again, in his view, the history of mankind is a history of the necessary development of the free spirit through the different forms of political organization: the first being that of the Oriental monarchy, in which freedom belongs to the monarch only; the second, that of the Graeco-Roman republics, in which a select body of free citizens is sustained on a basis of slavery; while finally in the modern societies, sprung from the Teutonic invasion of the decaying Roman empire, freedom is recognized as the natural right of all members of the community. The effect of the lectures (posthumously edited) in which Hegel's "Philosophy of History" and "History of Philosophy" were expounded, has extended far beyond the limits of his special school.

RECENT ETHICS

Evolutionary Ethics.—From the latter half of the 19th century onwards ethical thought was influenced by Darwinian theories. Darwin himself seems never to have questioned (as did some of his sceptical followers) the absolute character of moral obligation. What interested him chiefly, in so far as he made a study of morality, was the development of moral conduct in its preliminary stages. He was principally concerned to show that in morality, as in other departments of human life, it was not necessary to postulate a complete and abrupt gap between human and merely animal existence but that the instincts and habits which contribute to survival in the struggle for existence among animals develop into moral qualities which have a similar value for the preservation of human and social life. Regarding the social tendency as originally itself an instinct developed out of parental or filial affection, he seems to suggest that natural selection, which was the chief cause of its development in the earlier stages, may very probably influence the transition from purely tribal and social morality into morality in its later and more complex forms. But he admits that natural selection is not necessarily the only cause, and he refrains from identifying the fully developed morality of civilized nations with the "social instinct." Moreover, he recognizes that qualities, *e.g.*, loyalty and sympathy, which may have been of great service to the tribe in its primitive struggle for existence, may become a positive hindrance to physical efficiency (leading as they do to the preservation of the unit) at a later stage. Nevertheless to check our sympathy would lead to the "deterioration of the noblest part of our nature," and the question, which is obviously of vital importance, whether we should obey the dictates of reason, which would urge us only to such conduct as is conducive to natural selection, or remain faithful to the noblest part of our nature at the expense of reason, he leaves unsolved.

Spencer.—It was in Herbert Spencer, that the advocates of evolutionary ethics found their protagonist. Spencer looked to ideas derived from the biological sciences to provide a solution of all the enigmas of morality, as of most other departments of life; and he conceived it "to be the business of moral science to deduce from the laws of life and the conditions of existence what kinds of action necessarily tend to produce happiness and what kinds to produce unhappiness." It is clear, therefore, that any moral science which is to be of value must wait until the "laws of life" and "conditions of existence" have been satisfactorily determined, presumably by biology and the allied sciences; and there are few more melancholy instances of failure in philosophy than the paucity of the actual results attained by Spencer in his lifetime in his application of the so-called laws of evolution to human conduct—a failure recognized by Spencer himself. His own contribution to ethics was vitiated at the outset by the fact that he never shook himself free from the trammels of the philosophy which his own system was intended to supersede. He began by disclaiming any affinity to Utilitarianism on the part of his own philosophy. He pointed out that the principle of the greatest happiness of the greatest number is a principle without any definite meaning, since men are nowhere unanimous in their standard of happiness, but regard the conception of happiness rather as a problem to be solved than a test to be applied. Universal happiness would require omniscience to legislate for it and the "normal" or, as some would say, "perfect" man to desire it. Further, the principle that "everybody is to count for one, nobody for more than one," is equally unsatisfactory. It may be taken to imply that the useless and the criminal should be entitled to as much happiness as the useful and the virtuous. While it gives no rule for private as distinct from public conduct, it provides no real guidance for the legislator. For neither happiness, nor the concrete means to happiness, nor finally the conditions of its realization can be distributed; and in the end "not general happiness becomes the ethical standard by which legislative action is to be guided, but universal justice." Yet the implications of this latter conclusion Spencer never fully thought out. He accepted the hedonistic psychology by which the Utilitarians sought to justify their theory while he rejected the theory itself. Good, *e.g.*, defined by him "as conduct conducive to life," is also further defined as that which is "conducive to a surplus of pleasures over pains." Happiness, again, is always regarded as consisting in feeling, ultimately in pleasant feeling, and there is no attempt to apply the same principles of criticism which he had successfully applied to the Utilitarians' "happiness" to the conception of "pleasure." And, though he maintains as against the Utilitarians the existence of certain fundamental moral intuitions which have come to be quite independent of any present conscious experience of their utility, he yet holds that they are the results of accumulated racial experiences gradually organized and inherited. Finally side by side with a theory of the nature of moral obligation thus fundamentally empirical and *a posteriori* in its outlook, he maintains in his account of justice the existence of the idea of justice as distinct from a mere sentiment, carrying with it an *a priori* belief in its existence and identical in its *a priori* and intuitive character with the ultimate criterion of Utilitarianism itself. The fact is that any close philosophical analysis of Spencer's system of ethics can only result in the discovery of a multitude of mutually conflicting theories. It is frequently impossible to discover whether he wishes by an appeal to evolutionary principles to reinforce the sanctions and emphasize the absolute character of the traditional morality which in the main he accepts without question from the current opinions about conduct of his age, or whether he wishes to discredit and disprove the validity of that morality in order to substitute by the aid of the biological sciences a new ethical code.

Nor is his attempt to construct a scientific criterion out of data derived from the biological sciences productive of satisfactory results. He is hampered by a distinction between "absolute" and "relative" ethics definitely formulated in the last two chapters of *The Data of Ethics*. Absolute ethics would deal with such laws as would regulate the conduct of ideal man in an ideal society, *i.e.*, a society where conduct has reached the stage of complete adjustment to the needs of social life. Relative ethics, on the other hand, is concerned only with such conduct as is advantageous for that society which has not yet reached the end of complete adaptation to its environment, *i.e.*, which is at present imperfect. Spencer does not tell us how to bring the two ethical systems into correlation. And the actual criteria of conduct derived from biological considerations are almost ludicrously inadequate. Conduct, *e.g.*, is said to be more moral in proportion as it exhibits a tendency on the part of the individual or society to become more "definite," "coherent" and "heterogeneous." Or, again, we should recognize as a test of the "authoritative" character of moral ideas or feelings the fact that they are complex and representative, referring to a remote rather than to a proximate good, remembering the while that "the sense of duty is transitory, and will diminish as fast as moralization increases." In fact, no acceptable scientific criterion emerges, and the outcome of Spencer's attempt to ascertain the laws of life and the conditions of existence is either a restatement of the dictates of the moral consciousness in vague and cumbrous quasi-scientific phraseology, or the substitution of the meaningless test of "survivability" as a standard of perfection for the usual and intelligible standards of "good" and "right."

Stephen.—A similar criticism might fairly be passed upon the majority of philosophers who approach ethics from the standpoint of evolution. Sir Leslie Stephen, for instance, wishes to substitute the conception of "social health" for that of universal happiness, and considers that the conditions of social health are to be discovered by an examination of the "social organism" or of "social tissue," the laws of which can be studied apart from those laws by which the individuals composing society regulate their conduct. "The social evolution means the evolution of a strong social tissue; the best type is the type implied by the strongest tissue." But on the important question as to what constitutes the strongest social tissue, or to what extent the analogy between society as at present constituted and organic life is really applicable, we are left without certain guidance. The fact is that with few exceptions evolutionary moral philosophers evade the choice between alternatives which is always presented to them. They begin, for the most part, with a belief that in ethics as in other

departments of human knowledge "the more developed must be interpreted by the less developed"—though frequently in the sequel complexity or posteriority of development is erected as a standard by means of which to judge the process of development itself. They are not content to write a *history* of moral development, applying to it the principles by which Darwinians seek to explain the development of animal life. But the search of origins frequently leads them into theories of the nature of that moral conduct whose origin they are anxious to find quite at variance with current and accepted beliefs concerning its nature. The discovery of the so-called evolution of morality out of non-moral conditions is very frequently an unconscious subterfuge by which the evolutionist hides the fact that he is making *a priori* judgments upon the value of the moral concepts held to be evolved. To accept such theories of the origin of morality would carry with it the conviction that what we took for "moral" conduct was in reality something very different, and has been so throughout its history. The legitimate inference which should follow would be the denial of the validity of those moral laws which have hitherto been regarded as absolute in character, and the substitution for all customary moral terms of an entirely new set based upon biological considerations. But it is precisely this, the only logical inference, which most evolutionary philosophers are unwilling to draw. They cannot give up their belief in customary morality. Prof. Huxley maintained, for example, that "the ethical progress of society depends not on imitating the cosmic process, still less in running away from it, but in combating it" (*Romanes Lecture*).

Nietzsche.—Perhaps the one European thinker who has carried evolutionary principles in ethics to their logical conclusion is Friedrich Nietzsche. Almost any system of morality or immorality might find some justification in Nietzsche's writings, which are extraordinarily chaotic and full of the wildest exaggerations. Yet it has been a true instinct which has led popular opinion as testified to by current literature to find in Nietzsche the most orthodox exponent of Darwinian ideas in their application to ethics. For he saw clearly that to be successful evolutionary ethics must involve the "transvaluation of all values," the "demoralization" of all ordinary current morality. He accepted frankly the glorification of brute strength, superior cunning and all the qualities necessary for success in the struggle for existence, to which the ethics of evolution necessarily tends. He proclaimed himself, before everything else, a physiologist, and looked to physiology to provide the ultimate standard for everything that has value; and though his own ethical code necessarily involves the disappearance of sympathy, love, toleration and all existing altruistic emotions, he yet in a sense finds room for them in such altruistic self-sacrifice as prepares the way for the higher man of the future. Thus, after a fashion, he is able to reconcile the conflicting claims of egoism and altruism and succeed where most apostles of evolution fail. The Christian virtues, sympathy for the weak, the suffering, etc., represent a necessary stage to be passed through in the evolution of the *Übermensch, i.e.*, the stage when the weak and suffering combine in revolt against the strong. They are to be superseded, not so much because all social virtues are to be scorned and rejected, as because in their effects, *i.e.*, in their tendency to perpetuate and prolong the existence of the weak and those who are least well equipped and endowed by nature, they are anti-social in character and inimical to the survival of the strongest and most vigorous type of humanity. Consequently Nietzsche in effect maintains the following paradoxical position: he explains the existence of altruism upon egoistical principles; he advocates the total abolition of all altruism by carrying these same egoistical principles to their logical conclusion; he nevertheless appeals to that moral instinct which makes men ready to sacrifice their own narrow personal interests to the higher good of society—an instinct profoundly altruistic in character—as the ultimate justification of the ethics he enunciates. Such a position is a *reductio ad absurdum* of the attempt to transcend the ultimate character of those intuitions and feelings which prompt men to benevolence. Thus, though incidentally there is much to be learned from Nietzsche, especially from his criticism of the ethics of pessimism, or from the strictures he passes upon the negative morality of extreme asceticism or quietism, his system inevitably provides its own refutation. For no philosophy which travesties the real course of history and distorts the moral facts is likely to commend itself to the sober judgment of mankind however brilliant be its exposition or ingenious its arguments. Finally, the conceptions of strength, power and masterfulness by which Nietzsche attempts to determine his own moral ideal, become, when examined, as relative and unsatisfactory as other criteria of moral action said to be deduced from evolutionary principles. Men desire strength or power not as ends but as means to ends beyond them; Nietzsche is most convincing when the *Übermensch* is left undefined. Imagined as ideal man, *i.e.*, as morality depicts him, he becomes intelligible; imagined as Nietzsche describes him he reels back into the beast.

It was upon this crucial difficulty, *i.e.*, the transition in the evolution of morality from the stage of purely animal and unconscious action to specifically human action—*i.e.*, action directed by self-conscious and purposive intelligence to an end conceived as good—that the polemic of T. H. Green and his followers fastened.

Metaphysical Ethics.—Green's principal objection to evolutionary moral philosophy is contained in the argument that no merely "natural" explanation of the facts of morality is conceivable. The knowing consciousness—*i.e.*, so far as conduct is concerned and moral consciousness—can never become an object of knowledge in the sense in which natural phenomena are objects of scientific knowledge. For such knowledge implies the existence of a knowing consciousness as a relating and uniting intelligence capable of distinguishing itself from the objects to which it relates. And more particularly the existence of the moral consciousness implies "the transition from mere want to consciousness of wanted object, from impulse to satisfy the want to effort for the realization of the wanted objects, implies the presence of the want to a subject which distinguishes itself from it." Consequently the facts of moral development imply with the emergence of human consciousness the appearance of something qualitatively different from the facts with which physiology, for instance, deals, imply a stratum, as it were, in development which no examination of animal tissues, no calculation of consequences with regard to the preservation of the species, can ever satisfactorily explain.

Green's loyalty to the primary facts of the moral consciousness prevented him from constructing a rationalistic system of morals based solely upon the conclusions of metaphysics, but the revival of interest in metaphysics led to a more daring criticism of ethical first principles in other writers. Bradley's *Ethical Studies* had presented with great brilliancy an idealist theory of morality not very far removed from that of Green's *Prolegomena*. But the publication of *Appearance and Reality* by the same author marked a great advance in philosophical criticism of ethical postulates, and a growing dissatisfaction with current reconciliations between moral first principles and the conclusions of metaphysics. *Appearance and Reality* was not primarily concerned with morals, yet it inevitably led to certain conclusions affecting conduct, and it was no very long time before these conclusions were elaborated in detail. A. E. Taylor's *Problem of Conduct* (1901) follows in the main Bradley's line of criticism and may therefore be regarded as representative of his school. There are two principal positions in Taylor's work: (1) a refusal to base ethics upon metaphysics, and (2) the discovery of an irreconcilable dualism in the nature of morality which takes many shapes, but may be summarized roughly as consisting in an ultimate opposition between egoism and altruism. With regard to the first of these Taylor says that his object is to show that "ethics is as independent of metaphysical speculation for its principles and methods as any of the so-called 'natural sciences'; that its real basis must be sought not in philosophical theories about the nature of the Absolute or the ultimate constitution of the Universe, but in the empirical facts of human life as they are revealed to us in our concrete everyday experience of the world and mankind, and sifted and systematized by the sciences of psychology and sociology. . . . Ethics should be regarded as a purely 'positive' or

'experimental' and not as a 'speculative' science." With regard to the second position one quotation will suffice (*op. cit.*, p. 183). "Altruism and egoism are divergent developments from the common psychological root of primitive ethical sentiment. Both developments are alike unavoidable, and each is ultimately irreconcilable with the other. Neither egoism nor altruism can be made the sole basis of moral theory without mutilation of the facts, nor can any higher category be discovered by the aid of which their rival claims may be finally adjusted."

Taylor expounds these two theories with much ingenuity, yet neither of them will carry complete conviction to his critics. It is curious to find the independence of moral philosophy upon metaphysics supported by metaphysical arguments. For it is obvious that Taylor's own dissatisfaction with current moral principles arises from an inability to believe in their ultimate rationality, *i.e.*, a belief that they are untenable from the standpoint of metaphysics. But further, it is apparent that psychology (upon which Taylor would base morality) itself involves metaphysical assumptions; its position in fact cannot be stated except as a metaphysical position. And the need which most philosophers have felt for some philosophical foundation for morality arises, not from any desire to subordinate moral insight to speculative theory, but because the moral facts themselves are inexplicable except in the light of first principles which metaphysics alone can criticize.

Taylor himself attempts to find the roots of ethics in the moral sentiments of mankind, the moral sentiments being primarily feelings or emotions, though they imply and result in judgments of approval and disapproval upon conduct. But it may be doubted whether he succeeds in clearly distinguishing ethical feelings from ethical judgments, and if they are to be treated as synonymous it seems difficult to avoid the conclusion that the implications of moral "judgment" must involve a reference to metaphysics.

Taylor's polemic against metaphysical systems of ethics is based throughout upon an alleged discrepancy and separation between the facts of moral "experience," the judgments of the moral consciousness, and theories as to the nature of these which the philosophers whom he attacks would by no means accept. There is no doubt a distinction between morality as a form of consciousness and reflection upon that morality. But such a distinction neither corresponds to, nor testifies to, the existence of a distinction between morality as "experience" and morality as "theory."

Taylor is more persuasive when he is developing his second main thesis—that of the alleged existence of an ultimate dualism in the nature of morality. His accounts of the genesis of the conceptions of obligation and responsibility as of most of the ultimate conceptions with which moral philosophy deals will be accepted or rejected to the extent to which the main contention concerning the psychological basis of ethics commends itself to the reader. But in his exposition of the fundamental contradiction involved in morality elaborated with much care and illustrative argument he appeals for the most part to facts familiar to the unphilosophical moral consciousness. He begins by finding an ultimate opposition between the instincts of self-assertion and instincts which secure the production and protection of the coming generation even in the infra-ethical world with which biology deals. He traces this opposition into the forms in which it appears in the social life of mankind, and finds "a hidden root of insincerity and hypocrisy beneath all morality," inasmuch as it is not possible to pursue any one type of ideal without some departure from singleness of purpose. And he finds all the conceptions by which men have hoped to reconcile admitted antagonisms and divergencies between moral ideals claiming to be ultimate and authoritative alike unsatisfactory. Progress is illusory; there is no satisfactory goal to which moral development inevitably tends; religion in which some take refuge when distressed by the contradictions of moral conduct itself "contains and rests upon an element of make believe."

Martineau and Sidgwick.—It would be true on the whole to assert that evolutionary systems of ethics such as those of Herbert Spencer, Leslie Stephen or S. Alexander (*Moral Order and Progress,* 1899), together with the metaphysical theories of morals of which T. H. Green and Bradley and Taylor are the chief representatives, have dominated the field of ethical speculation since 1870. Nevertheless it is only necessary to mention such a work as Martineau's *Types of Ethical Theory* to dispel the notion that the type of moral philosophy most characteristically English, *i.e.*, consisting in the patient analysis of the form and nature of the moral consciousness itself, has given way or is likely to give way to more ambitious and constructive efforts. Martineau's chief endeavour was to interpret, to vindicate, and to systematize the moral sentiments, and if the actual exhibition of what is involved, *e.g.*, in moral choice is the vindication of morality Martineau may be said to have been successful. It is with his interpretation and systematization of the moral sentiments that most of Martineau's critics have found fault. It is impossible, *e.g.*, to accept his ordered hierarchy of "springs of action" without perceiving that the real principle upon which they can be arranged in order at all must depend upon considerations of circumstances and consequences, of stations and duties, with which a strict intuitionalism such as that of Martineau would have no dealing. Similarly the notion of Conscience as a special faculty giving its pronouncements immediately and without reflection cannot be maintained in the face of modern psychological analysis and is untrue to the nature of moral judgment itself. And Martineau is curiously unsympathetic to the universal and social aspect of morality with which evolutionary and idealist moral philosophers are so largely occupied. Nevertheless there have been few moral philosophers who have set forth with clearer insight the essential nature of the moral consciousness.

Equal in importance to Martineau's work is Prof. Sidgwick's *Methods of Ethics* which appeared in 1874. The two works are alike devoted to the re-examination of the nature of the moral consciousness to the exclusion of alien branches of inquiry. In most other respects they differ. Martineau is much more in sympathy with idealism than Sidgwick, whose work consists in a restatement from a novel and independent standpoint of the Utilitarian position. Many of his most acute critics would be the first to admit how much they owe to his teaching. Chief among the more recent of these is G. E. Moore, whose book *Principia Ethica* is an important contribution to ethical thought. And although Hastings Rashdall (*The Theory of Good and Evil,* 1907) is not in agreement with Sidgwick's type of hedonistic theory, he holds a point of view similar to that of Sidgwick's Rational Utilitarianism. Rashdall's two volumes exhibit also a welcome return on the part of English thought to the proper business of the moral philosopher—the examination of the nature of moral conduct. Other works, such as L. T. Hobhouse's *Morals in Evolution* or E. A. Westermarck's *Origin and Development of the Moral Ideas,* testify to a continued interest in the history of morality and in the anthropological inquiries with which moral philosophy is closely connected.

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(H. Si.; A. Wo.)

ETHIOPIA or **AETHIOPIA** (Gr. Αἰθιοπία), the ancient name of a district of north-eastern Africa bounded on the north by Egypt and on the east by the Red Sea (for topography and later history *see* Sudan and Abyssinia). In the Homeric poems the *Aethiopes* are the furthest of mankind; the gods go to their banquets and probably the Sun sets in their country. With the growth of scientific geography, they came to be located less vaguely, and their name was employed as the equivalent of the Hebrew Cush (*q.v.*), the Kesh or Ekōsh of the Hieroglyphics, *i.e.*, a country extending from about the 24th to the 10th degree of N. lat. The etymology of the name, which to a Greek ear meant "Swarthy-faced," is unknown. In official inscriptions of the Axumite dynasty the word is used as the equivalent of Habashat (whence Abyssinia), rendered by the Greek geographers *Abaseni* and *Abissa.*

The inhabitants of Ethiopia attracted the attention of many Greek researchers. Herodotus (vii. 70) divides them into two

main groups, a straight-haired race and a woolly-haired race, dwelling respectively to the east and west, and this distinction is confirmed by the Egyptian monuments. The bulk of our information is derived from Egyptian monuments, whence it appears that, originally occupied by independent tribes, who were raided and gradually subjected by Egyptian kings (*see* E. W. Budge, *The Egyptian Sudan*, 1907, i. 505 *et seq.*), under the 18th Dynasty it became an Egyptian province, administered by a viceroy, called prince of Kesh, and paying tributes in negroes, oxen, gold, ivory, rare beads, hides and household utensils. The inhabitants frequently rebelled and were as often subdued; records of these repeated conquests were set up by the Egyptian kings in the shape of columns and temples.

Ethiopia became independent towards the 11th century B.C.; a state was founded, having for its capital Napata which in time became formidable, and in the middle of the 8th century conquered Egypt; an Egyptian campaign is recorded in the famous stele of King Pankhi. The fortunes of the Ethiopian (25th) Dynasty belong to the history of Egypt (*q.v.*). After the Ethiopian yoke had been shaken off by Egypt, about 660 B.C., Ethiopia continued independent, under kings of whom not a few are known from inscriptions. From the evidence of these it has been inferred that the sovereignty became elective; a deputation was sent to Napata, where the chief god Amen selected out of members of the royal family the person who was to succeed, and who became officially the god's son. It seems certain that the priestly caste was more influential in Ethiopia than in Egypt both before and after this period. The stele of Harsiötf contains the record of nine expeditions, in the course of which the king subdued various tribes south of Meroë. The stele of Nastasen now in the Berlin Museum, edited by H. Schäfer (Leipzig, 1901), contains information concerning the state of the Ethiopian kingdom. Shortly after his accession he was threatened with invasion by Cambyses, the Persian conqueror of Egypt, but destroyed the fleet sent by the invader up the Nile, while (as we learn from Herodotus, iii. 25) the land-force succumbed to famine (*see* CAMBYSES). The capital was removed from Napata to Meroë at a distance of 60 camel-hours to the south-east. But Napata retained its importance as the religious metropolis; thither the king went to be crowned, and there too the chief god delivered his oracles. These Ethiopian kings seem to have made no attempt to reconquer Egypt, but were often engaged in wars with the wild tribes of the Sudan. A fresh epoch was inaugurated by Ergamenes, a contemporary of Ptolemy Philadelphus, who massacred the priests at Napata, and destroyed sacerdotal influence, till then so great that the king might at the priests' order be compelled to destroy himself. Probably the sovereignty again became hereditary. Occasional notices of Ethiopia occur in Greek and Latin authors, according to which the country came to be ruled by queens named Candace. One of them was involved in war with the Romans in 24 and 23 B.C.; the land was invaded by C. Petronius, who took the fortress Premis or Ibrim, and sacked the capital (then Napata); Augustus, however, ordered the evacuation of the country without even demanding tribute. The stretch of land between Aswan (Syene) and Maharraka (Hiera Sycaminus) was, however, regarded as belonging to the Roman empire, and Roman cohorts were stationed at the latter place. Candace appears to be found as the name of a queen for whom a pyramid was built at Meroë. A great builder was Netekamane, who is represented with his queen Amanetari on temples of Egyptian style at many points up the Nile. In the Roman period the type in sculpture changed from the Egyptian. The figures are obese, especially the women, and have pronounced negro features, and the royal person is loaded with bulging gold ornaments. In the 4th century A.D. the state of Meroë was ravaged by the Abyssinians, and in the 6th century its place was taken by the Christian state of Nubia (*see* DONGOLA).

The Ethiopians appear to have derived their religion and civilization from the Egyptians. The royal inscriptions are written in the hieroglyphic character and the Egyptian language. About the time of Ergamenes, a vernacular came to be employed in inscriptions written in a special alphabet of 23 signs in parallel hieroglyphic and cursive forms. The cursive is to be read from right to left, the hieroglyphic, contrary to the Egyptian method, in the direction in which the figures face. It is clear that the forms and values of the signs are largely based on Egyptian writing; but decipherment has not been attained, nor can it be stated to what group the language should be assigned (F. Ll. Griffith in MacIver's *Areika*, 1909, and later researches).

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ETHIOPIC LITERATURE. The employment of the Geez or Ethiopic language for literary purposes appears to have begun no long time before the introduction of Christianity into Abyssinia, and its pagan period is represented by two Axumite inscriptions (published by D. H. Müller in J. T. Bent's *Sacred City of the Ethiopians*, 1893), and an inscription at Matara (published by C. C. Rossini, *Rendiconti Accad. Lincei*, 1896). As a literary language it survived its use as a vernacular, but it is unknown at what time it ceased to be the latter. In Sir W. Cornwallis Harris's *Highlands of Aethiopia* (1844) there is a list of rather more than 100 works extant in Ethiopic; subsequent research has chiefly brought to light fresh copies of the same works, but it has contributed some fresh titles. A conspectus of all the mss. known to exist in Europe (over 1,200 in number) was published by C. C. Rossini in 1899 (*Rendiconti Accad. Lincei*, ser. v. vol. viii.); of these the largest collection is that in the British Museum, but others of various sizes are to be found in the chief libraries of Europe. R. E. Littmann (in the *Zeitschrift für Assyriologie*, xv. and xvi.) describes two collections at Jerusalem, one of which contains 283 mss.; and Rossini (*Rendiconti*, 1904) a collection of 35 mss. belonging to the Catholic mission at Cheren. Other collections exist in Abyssinia, and many mss. are in private hands. In 1893 besides portions of the Bible some 40 Ethiopic books had been printed in Europe (enumerated in L. Goldschmidt's *Bibliotheca Aethiopica*), but many more have since been published.

Influence of the Bible.—Geez literature is ordinarily divided into two periods, of which the first dates from the establishment of Christianity in the 5th century, and ends somewhere in the 7th; the second from the re-establishment of the Salomonic dynasty in 1268, continuing to the present time. It consists chiefly of translations, made in the first period from Greek, in the second from Arabic. It has no authors of the first or even of the second rank. Its character as a sacred and literary language is due to its translation of the Bible, which is made to contain 81 books, 46 of the Old Testament, and 35 of the New.

The mss. of the Biblical books vary very much, and none of them can claim any great antiquity; the oldest ms. in the language is said to be one of the Octateuch (Paris Y), which claims to have been written in the time of Yekūnō Amlak; but its editor, J. Oscar Boyd, Princeton, 1909–1911, seems to throw doubt on this date. The oldest extant ms. of the four Books of Kings appears to be one in the Museo Borgiano, presented by King Amda Sion (1314) to the Virgin Mary in Jerusalem (described by N. Roupp, *Zeitschrift für Assyriologie*, vol. xvi. 296–342). An examination of ten chapters of St. Matthew by L. Hackspill (*ibid.* vol. xi.) led to the result that the Ethiopic version of the Gospels was made about A.D. 500, from a Syro-occidental text, and that this original translation is represented by Cod. Paris. Aeth. 32; whereas most mss. and all printed editions contain a text influenced by the Alexandrian Vulgate, and show traces of Arabic. Rossini (*ibid.* x. 232) has made it probable that the Abba Salāmā, whom the native tradition identifies with Frumentius, evangelist of Abyssinia, to whom the translation of the Bible was ascribed, was in reality a Metropolitan of the early 14th century, who revised the corrupt text then current. Of the ancient translation the latest book is said to be Ecclesiasticus, translated in the year 678. The New Testament has been published repeatedly (first in Rome, 1548–49; some letters about its publication were edited by I. Guidi in the *Archivio della Soc. Rom. di Storia Patria*, 1886), and C. F. A. Dillmann edited a critical text of most of the Old

Testament and Apocrypha, but did not live to complete it.

Other translations thought to belong to the first period are the *Sher'ata Makhbār*, ascribed to S. Pachomius; the *Kerilos*, a collection of homilies and tracts, beginning with Cyril of Alexandria *De recta fide;* and the *Physiologus*, a fanciful work on Natural History (edited by F. Hommel, Leipzig, 1877).

Abyssinian History.—Of the works belonging to the second period much the most important are those which deal with Abyssinian history. The earliest part of the Axum chronicle preserved is that recording the wars of Amda Sion (1314–44) against the Muslims; it is doubtful, however, whether even this exists in its original form, as some scholars think; according to its editor (J. Perruchon in the *Journ. Asiat.* for 1889) it is preserved in a recension of the time of King Zar'a Ya'kūb. Under King Lebna Dengel (1508–40) the annals of his four predecessors, Zar'a Ya'kūb, Baeda Maryam, Eskender and Na'od (1434–1508) were drawn up; those of the first two were published by J. Perruchon (Paris, 1893); in the *Journ. Asiat.* for 1894 the same scholar published a further fragment of the history of Baeda Maryam, written by the tutor to the king's children, and the history of Eskender, Amda Sion II. and Na'od as compiled in Lebna Dengel's time. The history of Lebna Dengel was published by the same scholar (*Journ. Semit.* i. 274) and Rossini (*Rendiconti*, 1894, v. p. 617); that of his successor Claudius (1540–59) by Conzelmann (Paris, 1895); that of his successor Minas (1559–63) by F. M. E. Pereira Lisbon, 1888); those of the three following kings, Sharsa Dengel, Zā Dengel, and Ya'kūb, by Rossini (*Rendiconti*, 1893). The history of the next king Sysenius (1606–32) by Abba Meherka Dengel and Tekla Shelase was edited by Pereira (Lisbon, 1892); the chronicles of Joannes I., Iyasu I. and Bakaffa (1682–1730) by I. Guidi, with a French translation (Paris, 1903–05); all are contemporary, and the names of the chroniclers of the last two kings are recorded. Besides these we have the partly fabulous chronicle of Lalibela (of uncertain date, but before the Salomonian dynasty was restored), edited by Perruchon (Paris, 1892); and a brief chronicle of Abyssinia, drawn up in the reign of Iyasu II. (1729–53), embodying materials abridged, but often unaltered, was published by R. Basset, in the *Journ. Asiat.* for 1882, and has since formed the basis for Abyssinian history.

The Ethiopic Renaissance.—The remaining literature of the second period is thought to begin somewhat earlier than these chronicles. To the time of King Yekūnō Amlāk (1268–83) the historical romance called *Kebra Nagaset* (Glory of Kings) is assigned by its editor, C. Bezold (Bavarian Academy, 1904); other scholars gave it a somewhat later date. To the time of Yagbea Sion (*ob.* 1294) belongs the *Vision of the Prophet Habakkuk in Kartasā,* as also the works of Abba Salāmā, regarded as the founder of the Ethiopic renaissance, one of whose sermons is preserved in a Cheren ms. With his name are connected the *Acts of the Passion*, the *Service for the Dead* and the translation of Philexius, *i.e.*, Philoxenus. King Zar'a Ya'kūb composed or had composed for him as many as seven books; the most important of these is the *Book of Light* (*Mashafa Berhān*), paraphrased as *Kirchenordnung*, by Dillmann, who gave an analysis of its contents (*Über die Regierung des Königs Zar'a Ya'kob*, Berl. Acad., 1884). He also organized the compilation of the *Miracles of the Virgin Mary*, one of the most popular of Ethiopic books; a magnificent edition was printed by E. W. Budge in the Meux collection (London, 1900). In the same reign the Arabic chronicle of al-Makīn was translated into Geez. Under Lebna Dengel (*ob.* 1540), besides the above-mentioned collection of chronicles, we hear of the translation from the Arabic of the history and martyrdom of St. George, the Commentary of J. Chrysostom on the Epistle to the Hebrews, and the ascetic works of J. Saba called *Aragāwi manfasāwi*. Under Claudius (1540–59) Maba Sion is said to have translated from the Arabic *The Faith of the Fathers*, a vast compilation, including the *Didascalia Apostolorum* (edited by Platt, London, 1834), and the *Creed of Jacob Baradaeus* (published by Cornill, *ZDMG.* xxx. 417–466), and to the same reign belong the *Book of Extreme Unction* (*Mashafa Kandīl*), and the religious romance *Barlaam et Joasaph* also paraphrased from the Arabic (partly edited by A. Zotenberg in *Notices et Extraits*, vol. xxviii.). The *Confession of Faith* of King Claudius has been repeatedly printed. The reign of Sharsa Dengel (*ob.* 1595) was marked by many literary monuments, such as the religious and controversial compilation called *Mazmura Chrestos*, and the translation, by a certain Salik, of the religious encyclopaedia (*Mashafa Hāwī*) of the monk Nikon; an Arab merchant from Yemen, who took on conversion the name Anbākōm (Habakkuk), translated a number of books from the Arabic. Under Ya'kūb (*ob.* 1605) the valuable chronicle of John of Nikiou was translated from Arabic (edited by A. Zotenberg with French translation in *Notices et extraits*, vol. xxiv.). Under John, about 1687, the *Spiritual Medicine* of Michael, bishop of Adtrib and Malig, was translated. The literature that is not accurately dated consists largely of liturgies, prayers and hymns; Ethiopic poetry is chiefly, if not entirely, represented by the last of these, the most popular work of the kind being an ode in praise of the Virgin, called *Weddase Maryam* (edited by K. Fries, Leipzig, 1892). Various hymn-books bear the names *Degua*, *Zemmare* and *Mawas'et* (Antiphones); there is also a biblical history in verse called *Mashafa Madbal* or *Mestira Zamān.* Homilies also exist in large numbers, both original and translated, sometimes after the Arabic fashion in rhymed prose. Hagiology is naturally an important department in Ethiopic literature. Many texts containing lives of individual saints have been issued. Such are those of Maba Sion and Gabra Chrestos, edited by Budge in the Meux collection (London, 1899); the Acts of S. Mercurius, of which a fragment was edited by Rossini (Rome, 1904); the unique ms. of the original, one of the most extensive works in the Geez language, was burned by thieves who set fire to the editor's house. The same scholar began a series of *Vitae Sanctorum antiquiorum*, while *Monumenta Aethiopiae hagiologica* and *Vitae Sanctorum indigenarum* have been edited by B. Turaiev (Leipzig and St. Petersburg, 1902, and Rome, 1905). Other lives have been edited by Pereira, Guidi, etc. Similar in historical value to these works is the *History of the Exploits of Alexander*, of which various recensions have been edited by Budge (London, 1895). *See* further ALEXANDER THE GREAT.

Law and Philosophy.—Of Law the outstanding monument is the *Fatha Nagaset* (Judgment of Kings), of which an official edition was issued by I. Guidi (Rome, 1899), with an Italian translation; it is a version probably made in the early 16th century of the Arabic code of Ibn 'Assal, of the 12th century, whose work, being meant for Christians living under Muslim rule, was not altogether suitable for an independent Christian kingdom; yet the need for such a code made it popular and authoritative in Abyssinia. The translator was not quite equal to his task, and the Brit. Mus. ms. 800 exhibits an attempt to correct it.

Science can scarcely be said to exist in Geez literature, unless a medical treatise, of which the British Museum possesses a copy, comes under this head. Philosophy is mainly represented by mystical commentaries on Scripture, such as the *Book of the Mystery of Heaven and Earth*, by Ba-Hailu Michael, probably of the 15th century, edited by Perruchon and Guidi (Paris, 1903). There is, however, a translation of the *Book of the Wise Philosophers*, made by Michael, son of Abba Michael, consisting of various aphorisms; specimens have been edited by Dillmann in his Chrestomathy, and J. Cornill (Leipzig, 1876). There is also a translation of *Secundus the Silent*, edited by Bachmann (Berlin, 1888). Far more interesting than these is the treatise of Zar'a Ya'kūb of Axum, composed in the year 1660 (edited by Littmann, 1904), which contains an effort to evolve rules of life according to nature. Epistolography is represented by the diplomatic correspondence of some of the kings with the Portuguese and Spanish courts; some documents of this sort have been edited by C. Beccari, *Documenti inediti per la storia d' Etiopia* (1903); lexicography, by the vocabulary called *Sawāsew.* The first Ethiopic book printed was the Psalter (Rome, 1513), by John Potken of Cologne, the first European who studied the language.

See Basset, *Etudes sur l'histoire de l'Ethiopie* (1882); C. C. Rossini, "Note per la storia letteraria Abissina," in *Rendiconti della R. Accad. dei Lincei* (1899); Fumagalli, *Bibliografia Etiopica* (1893); Eno Littmann, *Geschichte der äthiopischen Litteratur* (Leipzig, 1907); catalogues of various libraries, especially British Museum (Wright), Paris (Zotenberg), Oxford and Berlin (Dillmann), Frankfurt (Gold-

schmidt). Plates illustrating Ethiopic palaeography are to be found in Wright's catalogue; an account of the illustrations in Ethiopic mss. is given by Budge in his *Life of Maba Sion;* and a collection of inscriptions in the church of St. Stefano dei Mori, in Rome, by Gallina in the *Archivio della Soc. Rom. di Storia Patria* (1888).

(D. S. MA.; X.)

ETHNOGRAPHICAL AND ANTHROPOLOGICAL SOCIETIES. The *Congrès International d'Anthropologie et d'Archéologie Préhistoriques* held its first meeting at Neuchâtel in 1866; it issued its first publication, *Comptes rendus* (1866, etc.). The *Royal Anthropological Institute of Great Britain and Ireland* was founded in 1871 upon the *Ethnological Society* (1843), which published a *Journal* (1848–56) and *Transactions* (1859–69) and the *Anthropological Society* (1863), which issued *Memoirs* (1863–69) and the *Anthropological Review* (1864–70). The *Institute* brings out a *Journal* (1871), *Man,* a monthly, etc. INDIA: Bombay, *Anthrop. Soc.* (1886), *Journal.*

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ETHNOID SINUS: *see* OLFACTORY SYSTEM; EAR, NOSE AND THROAT, DISEASES OF THE.

ETHNOLOGY and **ETHNOGRAPHY,** primarily sciences which deal with man as a racial unit, and with the distribution over the earth of racial units. They include a comparative study of the physical characters of the races of mankind and also a comparative study and classification of peoples based upon cultural conditions and characteristics.

The article RACES OF MANKIND deals with the nature and distribution of the main races as now defined by anthropologists.

The word "ethnology" is used with a somewhat vague meaning for any ethnological study based on data of this general nature. "Ethnography" is conveniently restricted to the scientific mapping out of different racial regions, and exhibits the vital connection of social with geographical phenomena. (*See* ANTHROPOLOGY and the series of articles referred to therein.)

ETHYL, in chemistry, the alkyl (aliphatic hydrocarbon) radical C_2H_5. (*See* CHEMISTRY, ORGANIC: *Aliphatic Division.*) The hydride of ethyl is better known as ethane; the alcohol C_2H_5OH is the ethyl alcohol of commerce (spirit of wine) (*see* ALCOHOL); and the oxide $(C_2H_5)_2O$ is ordinary ether (*q.v.*).

Ethyl is a colloquial trade name for lead tetraethyl (*see* ORGANO-METALLIC COMPOUNDS), a liquid introduced in small amount into motor spirit in order to prevent "knocking." (*See* INTERNAL COMBUSTION ENGINES.)

ETHYL CHLORIDE, prepared from hydrogen chloride and ethyl alcohol, is a gas at room temperature but is stored and sold under pressure in glass bottles fitted with trigger-controlled spray nozzles, as a colourless, mobile liquid with a characteristic ethereal smell, and sweet, burning taste, which boils at 12·5° C and has the formula C_2H_5Cl. The vapour burns with a green flame. Chloryl and kelene are trade names. Anestile is a mixture of ethyl and methyl chlorides. Somnoform is composed of the two chlorides with ethyl bromide.

Uses.—It is used (*a*) as a local anaesthetic for small incisions, tooth extractions and needle punctures, by spraying it on the surface of the skin or mucous membrane in a fine stream with particular care that the end of the spray stream is focused upon the point to be frozen. Its rapid evaporation causes local freezing (−35° C can be obtained).

(*b*) As a general anaesthetic, it is usually given in doses of 3–5 cu.cm. in a closed inhaler. As regards safety it is probably intermediate between nitrous oxide and ether. Short administrations produce an anaesthesia similar in type to that of nitrous oxide with an equally rapid loss of consciousness, a quick recovery and slight after-effects.

Ethyl chloride like chloroform as a general anaesthetic has its popularity chiefly in Europe. On the whole it seems to be more dangerous than ether and nitrous oxide but less so than chloroform. It does not produce the muscular relaxation effected by chloroform, which is desirable especially in protracted operations. Moreover, it is inflammable. Ethyl chloride has been recommended for anaesthesia of short duration in the belief that it was less dangerous than and as satisfactory as nitrous oxide.

Longer administrations approximate more to the ether type of anaesthesia, ethyl chloride being, like chloroform and ether and unlike gas, a lipoid solvent. Its effect on the circulatory and respiratory systems is slightly stimulating, causing flushing of the face, acceleration of the pulse rate by 10–20 beats per minute, and a rise in systolic blood pressure of 10 to 20 millimetres, together with deeper and more rapid breathing. (*See* ANAESTHESIA.)

(*c*) It is also used in mechanical refrigeration (*see* REFRIGERATION AND ICE MAKING) in place of ammonia or sulphur dioxide, because of its relatively low pressure and non-toxic qualities.

ETHYLENE, also known as olefiant gas or ethene, is found in coal gas and is the first representative, C_2H_4, or $H_2C{:}CH_2$, of the series of olefine hydrocarbons. It is a colourless gas of somewhat sweetish taste, slightly soluble in water, but more so in alcohol and ether. It can be liquefied at −1·1° C, under a pressure of 42½ atmos. It solidifies at −181° C and melts at −169° C; it boils at −105° C (L. P. Cailletet), or −102° to −103° C (K. Olszewski). Its critical temperature is 13° C. It is usually prepared by heating a mixture of ethyl alcohol and sulphuric acid. G. S. Newth (1901) obtained a purer product by dropping

ethyl alcohol into syrupy phosphoric acid (sp. gr. 1·75) warmed to 200° C, subsequently raising the temperature to 220° C. A variant of this process is employed in the manufacture of ethylene when alcohol vapour is passed at 300° C over charcoal impregnated with phosphoric acid. It is also manufactured by passing alcohol vapour over heated alumina at 360° C. Scientific interest attaches to its preparation from (1) ethyl bromide and alcoholic potash; (2) the electrolysis of a concentrated solution of potassium succinate.

Ethylene burns with a bright luminous flame (*see* FLAME), and forms a very explosive mixture with oxygen. On heating it decomposes, giving, among other products, carbon, methane and acetylene (M. Berthelot, 1866). Being an unsaturated hydrocarbon, it is capable of forming addition products, *e.g.*, it combines with hydrogen in the presence of platinum black or heated nickel to form ethane, with chlorine and bromine to yield the corresponding ethylene dihalides, with sulphuric acid at 160–170° C to form ethyl sulphuric acid, $C_2H_5 \cdot HSO_4$, and with aqueous hypochlorous acid to form glycol chlorhydrin, $Cl \cdot CH_2 \cdot CH_2OH$. It combines with sulphur trioxide and with halogen hydrides. Dilute potassium permanganate solution oxidizes it to ethylene glycol, $HO \cdot CH_2 \cdot CH_2 \cdot OH$, whilst fuming nitric acid converts it into oxalic acid. Several compounds of ethylene and metallic chlorides are known; with ferric chloride and platinous chloride in hydrochloric acid it gives $C_2H_4 \cdot FeCl_3 \cdot 2H_2O$ and $C_2H_4 \cdot PtCl_2$ respectively. When inhaled ethylene is a general anaesthetic (Luckhardt and Carter, 1923). It is given with 7–12% of oxygen, but caution is necessary because this mixture of gases is explosive. To deepen the ethylene anaesthesia, ether may be added.

ÉTIENNE, CHARLES GUILLAUME (1778–1845), French dramatist and miscellaneous writer, was born near Saint Dizier, Haute-Marne, on Jan. 5, 1778. He wrote for the Paris theatres for 20 years from 1799 onwards, but he is remembered chiefly as the author of *Les Deux Gendres*, represented at the Théâtre Français on Aug. 11, 1810, which brought its author a seat in the Academy, and an accusation of plagiarism from a play in the imperial library, entitled *Conaxa, ou les gendres dupés*. The bitterness of the attacks made on him was no doubt in part due to his position as editor-in-chief of the official *Journal de l'Empire*. The patriotic opera *L'Oriflamme* and his lyric masterpiece *Joconde* date from 1814. As secretary to Maret, duc de Bassano, Etienne had accompanied Napoleon throughout his campaigns in Italy, Germany, Austria and Poland. During these journeys he produced one of his best pieces, *Brueys et Palaprat* (1807). During the Restoration Étienne was an active member of the Opposition.

His *Oeuvres* (6 vols., 1846–53) contain a notice of the author by L. Thiessé.

ETIQUETTE, a term for ceremonial usage, the rules of behaviour observed in society, more particularly the formal rules of ceremony to be observed at court functions, etc.; the procedure, especially with regard to precedence and promotions in an organized body or society. Professions, such as the law or medicine, observe a code of etiquette, which the members must respect as protecting the dignity of the profession and preventing injury to its members. (*See* BUSINESS CODES.) The O.Fr. *estiquette* or *estiquet* meant a label, or "ticket," a meaning retained by the mod. Fr. *étiquette*. The ultimate origin is Teutonic, from *sticken*, to post up, stick, affix. For a summary guide to the various forms of social address, *see* FORMS OF ADDRESS.

ETNA, a borough of Allegheny county, Pa., U.S.A., 2m. N. of Pittsburgh, on the west bank of the Allegheny river. It is served by the Baltimore and Ohio, the Etna and Montrose and the Pennsylvania railways. The population was 6,341 in 1920, and was estimated locally at 7,509 in 1928. It is an important manufacturing suburb of Pittsburgh, producing iron, steel, brass, enamelled ware and various other commodities. The borough (at first called Steuart's Town) was incorporated in 1869. Its industrial history dates from 1820, when a small factory was built to make scythes and sickles. Natural gas was piped in from Butler county to serve as fuel for the early iron mills.

ETNA, an active volcano on the east coast of Sicily (Gr. Αἴτνη, from αἴθω, burn; Lat. *Aetna*), the summit of which is 18 m. N. by W. of Catana. Its height was ascertained to be 10,758 ft. in 1900, having decreased from 10,870 ft. in 1861. It is the highest volcano in Europe and the highest mountain in southern Italy. Its base is elliptical (31 m. by 19 m.) and covers 460 sq.m. The Torre del Filosofo, a building of Roman date, is only 1,188 ft. from the summit. In shape it is a truncated cone, with the great rift of the Valle del Bove, a huge sterile abyss 3 m. wide, on its east side. This latter is the original crater, the volcanic axis having shifted to the present summit crater. There are some 200 subsidiary cones, some of them over 3,000 ft. high, which have risen on lateral fissures that converge toward the central crater. The mountain is built up of three superimposed parts which correspond to three distinct zones of vegetation. The lowest "regione coltivata" extends up to 3,000 ft., has a gentle gradient, and is a great belt of volcanic products. It is densely populated and of luxuriant fertility (vine, olive, fruit, vegetables, corn, etc.), and often yields five harvests a year. On it are the towns Catana, Nicolosi and Acireale. The middle zone "regione boscosa" has a gradient of 1 in 5 and is no longer rich in oak plantations as at one time but now grows abundant pine, genista broom, chestnut, beech and ferns. The highest and central zone "regione deserta" is a desolate region of lava flows and volcanic ash, almost destitute of vegetation. There is a narrow zone of sub-Alpine shrubs, but no true Alpine flora. In the last 2,000 ft. five phanerogamous species only are to be found, the first three of which are peculiar to the mountain: *Senecio Etnensis, Anthemis Etnensis, Robertsia taraxacoides, Tanacetum vulgare* and *Astragalus siculus*. No trace of animal life is to be found in this zone; for the greater part of the year it is covered with snow, but by the end of summer this has almost all melted, except for that preserved in the covered pits for use in Catania and elsewhere. The ascent is best undertaken in summer or autumn, 7 to 8 hours being required from Nicolosi. Thucydides mentions eruptions in the 8th and 5th centuries B.C. The activity comprises three periods:—prehistoric, before 700 B.C., early historic, from 700 B.C. until the 16th century and the historic period from that time. During the historic period eruptions have taken place at intervals of approximately 6 years.

Geologically, Etna is a large volcanic cone which stands in a great Pliocene subsidence bay of the Ionian Sea. It is in contact with Tertiary sedimentary rocks in the north-west. Here occur grey Eocene and yellow and red Miocene sandstones and limestones with Pliocene marine marl and plastic clay. These latter entirely compose the floor of the platform upon which the volcanic pile has been built up. Near the coast ancient lava flows overlie Pleistocene conglomerates and gravels, thus proving that the subaerial activity did not begin until middle Quaternary times. The volcanic rocks consist of crystalline and vitreous lavas and tuffs, essentially basaltic in composition, largely porphyritic and wholly non-leucitic. Other types are augite and phonolitic andesites and labradorite rock. The andesites were the earliest erupted rocks. Basic plagioclase felspar and augite are the most common minerals, olivine being very subordinate or missing altogether. The constancy of composition indicates derivation from a remarkably uniform magma. At Acireale the lava has assumed the prismatic or columnar form in a striking manner; at the rock of Aci it is in parts spheroidal. The Grotte des Chèvres has been regarded as an enormous gas-bubble in the lava. The remarkable stability of the mountain appears to be due to the innumerable dykes which penetrate the lava flows and tuff beds in all directions and thus bind the whole mass together.

From the earliest times the mountain has naturally been the subject of legends. The Greeks believed it to be either the mountain with which Zeus had crushed the giant Typhon (so Pindar, *Pyth.* i. 34 *seq.*; Aeschylus, *Prometheus Vinctus*, 351 *seq.*; Strabo xiii. p. 626), or Enceladus (Virgil, *Georg.* i. 471; Oppian, *Cyn.* i. 273), or the workshop of Hephaestus and the Cyclopes (Cic. *De divin.* ii. 19; *cf.* Lucil., *Aetna*, 41 *seq.*, Solin, 11). Several Roman writers, on the other hand, attempted to explain the phenomena which it presented by natural causes (*e.g.*, Lucretius vi. 639 *seq.*; Lucilius, *Aetna*, 511 *seq.*). Ascents of the mountain were not infrequent in those days—one was made by Hadrian.

In Nov. 1928 grave consternation was caused by the renewed

activity of Etna. The Messina-Catania railway line was blocked by the streams of lava 100 ft. wide descending from the crater at an average speed of 20 ft. a minute. On Nov. 7 the lava reached the sea. The town of Mascati was completely wiped out and the village of Nunziata almost entirely destroyed. The loss was estimated at £2,000,000.

See Sartorius von Waltershausen, *Atlas des Ätna* (Leipzig, 1880); E. Chaix, *Carta Volcanologica e topographica dell' Etna* (showing lava streams up to 1892); G. de Lorenzo, *L'Etna* (Bergamo, 1907); C. S. du Riche Preller, *Italian Mountain Geology*, Part III. (1923).

ETON, a town of Buckinghamshire, England, on the Thames, opposite Windsor. Pop. 3,301. It is famous for its college, the largest of the ancient English public schools. The "King's College of Our Lady of Eton beside Windsor" was founded by Henry VI. in 1440–41 and endowed mainly from the revenues of the alien priories suppressed by Henry V. The founder followed the model established by William of Wykeham in his foundations of Winchester and New College, Oxford. The original foundation at Eton consisted of a provost, 10 priests, 4 clerks, 6 choristers, a schoolmaster, 25 poor and indigent scholars, and the same number of poor men or bedesmen. In 1443, however, Henry increased the number of scholars to 70. The bedesmen who soon disappeared were reduced. A connection was then established, and has been maintained since, though in a modified form, between Eton and Henry's foundation of King's College, Cambridge. One of the king's chief advisers was William of Waynflete, who had been bishop of Winchester and was appointed provost of Eton in 1443. The statutes in their final form provided for the establishment of *commensales* or commoners, distinct from the scholars; and these under the name of "oppidans" now form the principal body of the boys. The college survived the unsettled period at the close of Henry's reign; while Edward IV. curtailed its possessions, and was only just prevented from amalgamating it with the ecclesiastical foundation of St. George, Windsor Castle. The teaching embraces classical and modern subjects; but until the first half of the 19th century the normal course of instruction remained almost wholly classical.

The present constitution of the college dates from an act of 1868. Under the statute, last modified in 1904, the foundation consists of a provost, appointed by the Crown, and a body of fellows, comprising the provost of King's college, Cambridge, a vice-provost, representatives nominated respectively by the universities of Oxford and Cambridge, the Royal society, the lord chief justice and the masters of the school, the remaining four being co-opted. The scholarships are open to all boys who are British subjects between 12 and 15 years of age. Twenty-four foundation scholarships at King's college, Cambridge, are reserved for Etonians; and there are several scholarships and exhibitions tenable at Oxford or Cambridge, or either university.

The college buildings were founded in 1441 and occupied in part by 1443, but the whole original structure was not completed till 50 years later. The older buildings consist of two quadrangles. The outer quadrangle, or school-yard, is enclosed by the chapel, upper and lower schools and the original scholars' dormitory ("long chamber"), now transformed. It has in its centre a bronze statue of the royal founder. The buildings enclosing the inner or lesser quadrangle contain the residence of the officials, the library, hall and various offices. The chapel represents only the choir of the church which the founder originally intended to build; but as this was not completed Waynflete added an ante-chapel. The chapel contains some monuments of provosts and at the west end of the ante-chapel is a fine statue of the founder, by John Bacon. A chapel on the north side commemorates Etonians who fell in the World War. A chantry contains the tomb of Roger Lupton (provost (1503–35), whose most notable monument is the fine tower between the schoolyard and the cloisters. The space enclosed by two buttresses on the north side of the chapel, at the point where steps ascend to the north door, is the model of the peculiar form of court for the game of fives which takes its name from Eton, with its "buttress" (represented by the projecting balustrade), the ledges round the walls, and the step dividing the floor into two levels. From the foundation of the college the chapel was used as the parish church until 1854, and not until 1875, after the alteration of the ancient constitution had secularized the foundation, was the parish of Eton created into a separate vicarage. The chapel does not accommodate the whole school; and a new chapel, from the designs of Sir Arthur Blomfield, is used by the lower school. This contains some admirable modern tapestries, glass and woodwork. The library contains many manuscripts (notably an Oriental collection) and rare books; and there is also a library for the use of the boys. The college has far outgrown its ancient buildings, and new buildings, besides the lower chapel, include the new schools, with an observatory, a chemical laboratory, science schools, and museum and boarding-houses. In 1908 King Edward VII. opened a range of buildings erected in honour of the old Etonians who served in the South African War. The buildings include a school hall with a fine organ, a domed octagonal library, and a museum of antiquities.

The principal annual celebration is held on June 4, the birthday of King George III. Speeches in Upper School, and a procession of boats are regular features of the day. In rowing Eton occupies a unique position among the public schools, and a large proportion of the oarsmen in the University boat-race have been *alumni* of the school. Another annual celebration is the contest between collegers and oppidans at a peculiar form of football known as the wall game, from the fact that it is played against a wall bordering the college playing-field. This game takes place on St. Andrew's Day, Nov. 30. The field game of football commonly played at Eton has also peculiar rules. The leading cricket matches are those between Eton and Winchester (played alternately at the two schools) and Eton and Harrow (at Lord's ground, London). A singular custom termed the *Montem*, first mentioned in 1561, was observed here triennially on Whit-Tuesday. The last celebration took place in 1844. It consisted of a procession of the boys in a kind of military order, with flags and music, headed by their "captain," to a mound called Salt Hill, near the Bath road, where they levied contributions or "salt" from spectators. The average number of pupils exceeds 1,100.

See Sir H. C. Maxwell Lyte, *History of Eton College from 1440 to 1910* (1911); Willis and Clark, *Architectural History of Cambridge*, etc. (1856. vol. i.); A. C. Benson, *Fasti Etonenses* (1899); L. Cust, *History of Eton College* (1899); R. A. Austen Leigh, *Guide to the Buildings of Eton College* (1921). (M. R. J.)

ETOWAH MOUND, THE, on Etowah river, 3 m. S.E. of Cartersville, Barlow county, Georgia, is a quadrilateral truncated pyramid, 61 ft. high, with a broad roadway ascending the south side to within 18 or 20 ft. of the top, and formerly provided with steps made of crossbeams embedded in the earth. The base measures 380 by 330 ft., and the top 170 by 176 ft.; the area of the base is nearly three acres, and of the top not quite seven-tenths of an acre. The solid contents of the mound, including the roadway, are estimated at 4,300,000 cu. ft. The Etowah mound has been identified with the Guaxule of Hernando de Soto, but this is questioned; it is one of the sites from which have come copper plates with repoussé figures suggesting Mexican provenience. The name is from *Itawá* (corrupted to "High-tower"), of unknown meaning and probably not Cherokee, given to two or more former Cherokee towns in Georgia.

ÉTRETAT, a watering-place of France, in the department of Seine-Inférieure, on the coast of the English Channel, 16½ m. N. by E. of Havre by road. Pop. (1926) 1,687. It stands between curiously worn chalk cliffs at the mouth of a valley, the stream of which runs underground for some distance to emerge on the beach. A Roman road and aqueduct and other Roman and Gallic remains have been discovered. The church of Notre-Dame is a fine example of Romanesque architecture of the 11th and 13th centuries. Fishing is carried on.

ETRURIA, an ancient district of Italy, the extent of which varied considerably, and, especially in the earliest periods, is very difficult to define (*see* section *Language*). The name is the Latin equivalent of the Greek Τυρρηνία or Τυρσηνία, which is used by Latin writers also in the forms *Tyrrhenia, Tyrrhenii;* the Romans also spoke of Tusci, whence the modern Tuscany (*q.v.*). In early times the district appears to have included the whole of North Italy from the Tiber to the Alps, but by the end of the 5th cen-

tury B.C. it was considerably diminished, and about the year 100 B.C. its boundaries were the Arnus (Arno), the Apennines and the Tiber. In the division of Italy by Augustus it formed the seventh *regio* and extended as far north as the river Macra.

History.—The authentic history of Etruria consists mainly in the story of its relations with Carthage, Greece and Rome. At some period unknown, prior to the 6th century, the Etrurians extended their power not only northwards over, probably, Mantua, Felsina and Melpum, but also southwards into Latium and Campania. The chronology of this expansion is unknown, nor do we know for certain the names of the cities which constituted the two leagues of twelve founded in the conquered districts on the analogy of the original league in Etruria proper.

In the early history of Rome the Etruscans play a prominent part. According to tradition they were the third of the constituent elements which went to form the city of Rome. The tradition is still an unsolved problem. It is practically certain, however, that there is no foundation for the ancient theory (*cf.* Prop. iv. [v.] 1, 31) that the third Roman tribe, known as Luceres, represented an Etruscan element of the population, and it is held by many authorities that the tradition of the Tarquin kings of Rome represents the temporary domination of Etruscan lords, who extended their conquests some time before 600 B.C. over Latium and Campania. This theory is corroborated by the fact that during the reigns of the Tarquin kings Rome appears as the mistress of a district including part of Etruria, several cities in Latium, and the whole of Campania, whereas our earliest picture of republican Rome is that of a small state in the midst of enemies. For this problem *see* ROME: *History*, section The Monarchy.

After the expulsion of the Tarquins the chief events in Etruscan history are the vain attempts of the Etruscans to re-establish themselves in Rome under Lars Porsena of Clusium, the defeat of Octavius Mamilius, son-in-law of Tarquinius Superbus, at Lake Regillus, and the treaty with Carthage. This last event shows that the Etruscan power was formidable, and that by means of their fleet the Etruscans controlled the commerce of the Tyrrhenian sea. By this treaty Corsica was assigned to the Etruscans while Carthage obtained Sardinia. Soon after this decay set in. In 474 B.C. the Etruscan fleet was destroyed by Hiero I. (*q.v.*) of Syracuse, Etruria Circumpadana was occupied by the Gauls, the Campanian cities by the Samnites, who took Capua (*see* CAMPANIA) in 423, and in 396, after a ten years' siege, Veii fell to the Romans. The battle of the Vadimonian Lake (309 B.C.) finally extinguished Etruscan independence. For the archaeology, art and religion of Etruria, *see* ETRUSCANS.

ETRUSCAN LANGUAGE. From the days of Dionysius of Halicarnassus, who declared that Etruscan was like no other language, to the present time, many attempts of various kinds, none completely successful, have been made to decipher the monuments still extant of this difficult language. Scholars now base their labours on the internal study of the language and employ the principle of combination and chronology to elucidate less known details by established details, gaining some definite results.

Material.—There survive (1) a certain number of words preserved by Latin and Greek authors (*see* Skutsch *bibl.*) such as *aisar*=*deos* (Etr. *ais*=deity), *ister*=actor, whence the Latin *histrio;* (2) about 8,500 inscriptions from the 7th century B.C. to the time of Augustus, nearly all of which have been collected in the *Corpus*, 90% of which are only proper names. The longest inscriptions are (*a*) the tablet of S. Maria di Capua (300 words) and the Cippus Perusianus (120); (3) A liturgical text of about 1,500 words written in the wrappings of the famous mummy of the Museum of Agram (Zagreb). External evidence dates this in the 2nd century B.C. It should be remembered that Etruscan was used after the date of this material and that according to Ammian (xxiii., 5, 10) the soothsayers used it as a liturgical language up to the date of the 4th century A.D.

Alphabet.—The alphabet closely resembled the Central and Greek alphabets of the Boeotian type specially and shows that Etruscan only possessed surd occlusives which tended to become spirants, as is shown by the variations in the records both of pure Etruscan words as *sec* and *seχ*, *lart* and *larθ*, *acsi* and *aχsi* and in words borrowed from the Greek such as *σπυριδα* (acc.) and *sporta*, *θριάμβος* and *triumpus*, so that to the influence of an Etruscan substratum, scholars have attributed the change from *c* to *h* in the speech of Florence, *e.g.*, *hasa* for *casa*, *poho* for *poco*. In Etruscan *f* weakened to *h* as *flastntru* and *hastntru*, *cafatia* and *cahatia*. Then the short interior vowels are lately reduced and often disappear, perhaps with an initial accent. *Menelaos* is written *Menle; Heracles*, *hercle; Achilleus*, *aχle; Clutaimestra*, *Clutmsta*. The Latin loan word *pronopes* becomes *prumθs*.

Structure.—Etruscan-Latin bilingual texts are rare, very short, do not always agree and are of very little help. The few definite features are as follow. In names borrowed from Greek, Etruscan distinguished gender by the terminating *e* for the masculine (*hercle*, *aχle*, etc.) and *ai*, *ei* for the feminine (*Elinai*, *-ei*, Heeleene, *φersipnai*, *-ei*, Persephone). In certain true Etruscan names the feminine is sometimes in *i*, *larθ*, fem. *larθi*, or in *ia*, *irnθ*, fem. *arnθia* or in *θζ*, *lautni* (freed man), fem. *lautniθa*. These variations may depend on the form of the root as in the case-endings. The nominative is the normal form of the root. The genitive is in *s* or *ś* with roots ending in a vowel (*seθre* and *seθres*), in *uś*, with roots ending in a consonant as *velθur*, *velθurus: θinχvil*, and *θanχviluś*. The most characteristic genitive is in *l* and indicates filiation, thus *arnθ*, *arnθcl*, son of *Arruns*. It may even be added to another genitive, to form a genitive or filiative of the second degree, as *velθur* gives *velθuruś* son of Velθur and *velθuruśla*, the son of the son of *Velθur*. The dative is sometimes in *ś* identical with the genitive as *Mi* (this) *θuplθaś* (to Thupeltha) *alpan* (as a gift) *turce* (he gave). The more usual form is in *śi* as *auleśi* (to Aulus) *meteliś* (Metellus) *ve*(*lus*) (of Vel) *Vesial* (of Vesia) *clenśi* (to the son) = To Aulus Metellus son of Vel and Vesia. The word for son is *clan* in the nominative, *clenś*, genitive and *clenśi*, dative. It is not known whether an accusative existed. The plural is in *ar:clan*=son; *clenar*=sons; *ais*=deity; *aisar*=deities.

Verb.—As to the verb, all that is definite is that the 3rd person singular of the perfect tense was in *ce: amce*=has been; *turce*=has given; *tece*=has raised; *lupuce*=has lived. Sometimes this ending is missing as *avils* xxxvi *lupu*=lived 35 years.

Numerals.—The order of the numbers on the dice found at Toscanella is open to question but it is regarded as probable that *maχ*=1; *zal*=2; *θu*=3; *huθ*=4; *ci*=5 and *śa*=6. It is known that 7, 8, 9 are *cezp*, *semφ*, *muv*, but their exact identification is not settled. Tens were formed by adding *-alχ;* thus, from *ci*=5, we get *cealχ*, *celχ*=50, and from *cezp* we get *cezpalχ*.

The number of words definitely known by bilingual inscriptions or as contained in concordances is so limited that it is still impossible to decipher accurately any part of a lengthy text such as that on the Zagreb rolls. The following words are known: *usil*=sun; *tiv*=moon; *alpan*=offering; *fleres*=statue; *zamaθiman*=golden brooch; *hinθial*=soul; *lautn*=family; *ril*, *avil*=age or year; *ati*=mother; *puia*=wife; *sec*, *seχ*=daughter; *θura*=brother; *nefts*=grandson—borrowed from Latin *nepos*, *mi*=this; *-m*, *-c*=and. The syntax is known only through very simple phrases such as: *pumpui larθi puia larθal clevsinas aveleśla seχ sentinal θanχvilus*=Larthi Pompeia, wife of Larth Clevsinas son of Aulus, daughter of Tanaquilla Sentinei; or *trepi θanχvil vipenas arnθal arnθialiśla puia*=Tanaquilla Trebia, wife of Arruns Vipena, son of Arruns.

Origins.—Opinion is still divided as to the Lydian origin of the Etruscans as recounted by Herodotus. Some regard them as indigenous in Italy on the ground that, apart from archaeological evidence, it is impossible, on the linguistic material available, to identify the affinities of Etruscan with any other form of speech. Others point to the use by Lydian and that in the Caucasian languages of the genitive in *l*, to the plural in *ar* found in Caucasian speech, to the copula *-c* found in Lydian (*see* ASIANIC LANGUAGES), to the presence in Lycian and Etruscan of an important number of nominal suffixes, and to the discovery in Lemnos of an inscription in a language closely allied to Etruscan. F. de Saussure (Recueil, p. 573) assigned as Asianic origin to the ending *ηνος* in *Τυρσηνοι* and V. Thomsen ranged Etruscan with

the Caucasian group.

These views are not necessarily contradictory. It may be surmised that the first migration of Etruscans (*Tu[r]sci*) moved from Asia Minor at an early date to Greece (Pelasgians) and were soon separated from the other branch (*Turseni*) of the same stock who remained in Asia Minor whence they spread much later. This hypothesis explains the existence and the paucity of contacts between Etruscan and Asianic languages. Until a lengthy bilingual text has been discovered, we depend on the internal study of the language, a slow, difficult but relatively sure method. In 1928 Prof. Alfredo Trombetti read before the International Congress of Languages at The Hague his discoveries in connection with the dicipherment of Etruscan inscriptions.

See the *Reports* of the congress and *Anthropos*, parts 1–2 (1928).

(E. BEN.)

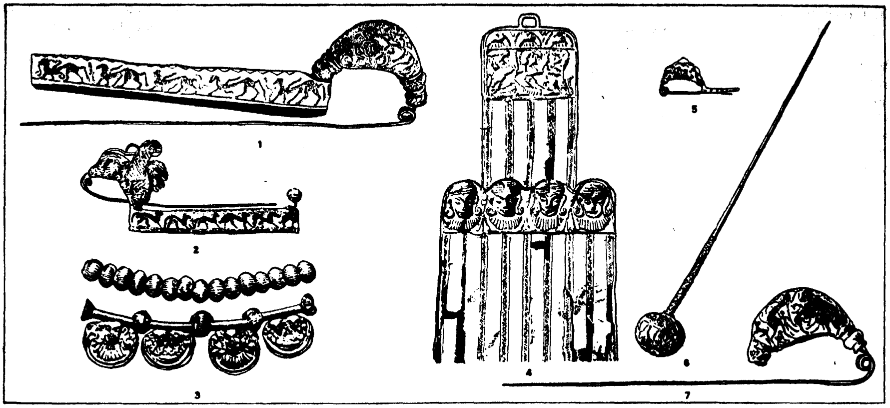
ETRUSCANS, THE. The problem of the origin and connection of the Etruscans has assumed a wholly new aspect owing to the progress of archaeological research. The expectation that the key to the language would some day be found has been disappointed, and it has become evident that the limited character and style of the inscriptions forbids any hope that they will ever yield historical information of any value. On the other hand the steady progress of archaeological exploration and comparative study has revealed the chronological sequence of the various sites and their relative antiquity, so that it is now possible to say when and where the Etruscans first appeared upon Italian soil and by what stages their power was extended. Several periods of antiquity are now distinguished in the complex whole long termed indiscriminately "Etruscan art." It is also possible to show the point of cleavage between the work of the indigenous Italians and that of their foreign overlords. Etruscan life has been studied in all its varied phases from the 8th century B.C. to the 1st, and the capital problem of origins has been approximately solved.

Literary Evidence.—Literary evidence in ancient writers is extraordinarily slight in amount and inferior in quality. The Etruscans produced no native historian. True, the emperor Claudius composed a so-called history in some 20 books, but it is unlikely that posterity has suffered any loss from the disappearance of this voluminous and, no doubt, curious work. In the sphere of ritual and religion Claudius may have gathered together a quantity of curious matter from the lost "Acherontian books" of the priests, and this would have had no little antiquarian interest, especially for students of folk-lore and ceremony. But as regards history in its proper sense it is highly probable that Claudius never possessed the material, even if he had been gifted with the ability to write anything that would meet modern requirements. Similarly, the great authors of the Augustan period are almost worthless for this purpose. Virgil is frankly and honestly writing a romance; his Mezentius of Caere, if not a complete invention, is at best the romantic embellishment of a figure of doubtful authenticity. Livy is the historian of Roman victories, the Etruscans are of no value or interest to him except as cannon-fodder. For the chronicle of the wars with Veii he may be fairly trustworthy and probably possessed a certain amount of real information, but he could know little of the brilliant periods of Etruscan pride and supremacy in the 6th and 7th centuries B.C. References to the Etruscans are found in a number of other classical writers, from the serious historian, Polybius, an excellent authority for the late period with which he deals, down to poets of the decadence like Statius and Silius Italicus. But apart from the military and political events recorded by Polybius and Livy all the statements of classical authors put together convey hardly any information. In regard to the question of Etruscan origins every poet and every prose writer except Dionysius of Halicarnassus accepts as a matter of course the story of their migration from Lydia as given by Herodotus, who tells how in the reign of Atys, son of Manes, there was great scarcity of food in all Lydia which lasted 18 years. "At last their king divided the people into two portions and made them draw lots so that the one part should remain and the other leave the country; he himself was to be the head of those who drew the lot to remain there, and his son, whose name was Tyrrhenus, of those who departed. Then one part of them, having drawn the lot, left the country, and came down to Smyrna and built ships, whereon they set all their goods that could be carried on shipboard and sailed away to seek a livelihood and a country; till at last, after sojourning with many nations in turn, they came to the Ombrici, where they founded cities and have dwelt ever since. They no longer called themselves Lydians but Tyrrhenians, after the name of the king's son who had led them thither." (Loeb, trans. I., p. 125.) But the apparent unanimity of all the Greek and Latin writers is of no value as evidence, because all are drawing on a single source. Dionysius of Halicarnassus, who composed his *Roman Archaeology* in the time of Augustus, was at least as much interested in destroying the credit of his predecessors as in ascertaining the truth. He unearthed a 5th century Lydian author, one Xanthus, who might be set up as a rival to Herodotus, not in the original but only in the 3rd century *rechauffé*, which one ancient critic at least judged to be a forgery. This document, Dionysius informs us, makes no mention of the emigration of Lydians under Tyrrhenus, and therefore he argues that the story told by Herodotus must be an invention. But it is obvious that there might be a score of reasons for the omission, even if the history of Xanthus were complete, so that the argument cannot be taken very seriously.

Dionysius states that the Etruscans were original, autochthonous, inhabitants of Italy. Here he is more deserving of attention; the theory is by no means impossible and has been revived by good modern archaeologists. But the insuperable difficulty is the language. Had the Etruscans been really indigenous, they would surely have spoken a language related in some degree to one or other of the dialects which were still being used in the days of Augustus by the descendants of the really native Italians, that is to say, of the peoples of the Stone and Bronze ages. And yet, as Dionysius himself says, their language was something entirely unique and peculiar; a statement fully endorsed by modern philologists. Dionysius' theory may contain a slight amount of truth. For the conclusion to which archaeologists are now beginning to rally is that whereas the Etruscans themselves were immigrants, a very small ruling hierarchy, the backbone of their power was in the native races which they subdued: their citizens, agriculturists, workmen, soldiers, artisans were almost all Italians.

Archaeological Evidence.—As to the place from which these foreign overlords came and the route by which they entered the country there has been a complete revolution of opinion. Niebuhr thought he had discovered traces of the Etruscan language still lingering in the common speech of some of the peoples in the Eastern Alps. From this he jumped to the conclusion that these were survivals from the beginning of the Iron age, and that the inhabitants of the Rhaetian Alps were descendants of an invading army which must be identified with an army of the first conquering Etruscans. This argument ignores the well known existence of quite late Etruscan colonies north of the Po, and Livy's statement that a certain number of Etruscans took refuge in the Alps from the invading Gauls of the 4th century and went wild in their savage surroundings; which would be a perfectly good explanation of any such phenomena as Niebuhr has noted. Archaeology has shown that no Etruscan settlements were made on the north side of the Apennines before 500 B.C., the very date that is to say when the Tarquins were being expelled from Rome and the Etruscans had been in full possession of a great part of Italy for several centuries.

So much progress has now been made in the relative dating of the various sites that it may be said without hesitation that all the earliest settlements were on the sea coast. Vetulonia and Tarquinii are the very earliest; Caere is almost equally ancient; Volaterrae (Volterra), though not actually on the coast, is within easy reach of the sea, and was the capital of a region which had its ports at Luna and Populonia. The comparatively late foundation of inland cities like Perusia (Perugia) and Arretium (Arezzo) is beyond all question. The only contradictory case that might seem to arise is that of Clusium, the modern Chiusi. But there is really nothing in Chiusi which obliges us to date it back to the first years of the conquest. On the contrary, the pre-Etruscan



FROM L. A. MILANI, "STUDI E MATERIALI DI ARCHAEOLOGIA E NUMISMATICA"

SPECIMENS OF ETRUSCAN GOLDSMITH WORK

1. Fibula or brooch from Vetulonia; 2. Fibula from the Tomba del Littore; 3. Necklace from the Tumulo della Pietrera; in the Museum of Florence; 4. Pendant from the Tumulo della Pietrera; in the Museum of Florence; 5. Fibula from Poggio alla Guardia; 6. Pin from southern Etruria, Tomba del Littore; in the Museum of Florence; 7. Fibula from Vetulonia

city of Camars, which stood there seems to have retained its native Italian character with extraordinary tenacity, and was probably not Etruscanized till the middle of the 7th century, so that even the city of Lars Porsenna is no exception to the rule that every inland Etruscan site is of later foundation; the original settlements are all along the line of the Tuscan Maremma. Geographical reasoning therefore points clearly to an invasion, or perhaps rather a colonization, by successive bands of emigrants who landed on the most prominent points of the sea coast of Tuscany. From the character of their earlier remains the date of the first permanent settlement may be placed at the end of the 9th century.

That the Etruscans were orientals or semi-orientals is proved by the whole character of their earliest art, and by many details of their religion and worship. It is an art which shows close contact with Mesopotamia, Syria and Cyprus on the one side and with Egypt on the other. The deities and mythological figures on Etruscan gold-work and jewellery of the 7th century are evidently the heroes and deities of Asiatic mythology. Masks of entirely Assyrian character decorate the handsome bronze cauldrons; Assyrian monarchs at the chase are shown on silver bowls of the same period, while other bowls and ivories figure purely Egyptian scenes, and one is inscribed with the name of a Phoenician owner. Much of this work was doubtless imported, but the very fact that the trade of these centuries was exclusively with the East is something wholly new in the history of Italy, which had never before traded with the Aegean, not even in the great days of Mycenae. And if much of the finer work was imported, a great deal was certainly produced in Italy, where the arrival of the Etruscans was signalized by the immediate rise of wholly new schools of design in metal-work and jewellery, the development of which can be traced as early as the 8th century. In the sphere of ritual and religion there are many details which are taken direct from Mesopotamia, and the whole feeling and atmosphere are purely oriental. The most striking identities are in the practices of divination and augury; for the custom of divining from the livers of sheep or the flight of birds is purely Chaldaean (*see* DIVINATION). There are models of clay livers from Mesopotamia inscribed in cuneiform which precisely resemble the bronze model of a liver found at Piacenza, divided into compartments each of which is labelled in Etruscan with the name of its presiding divinity.

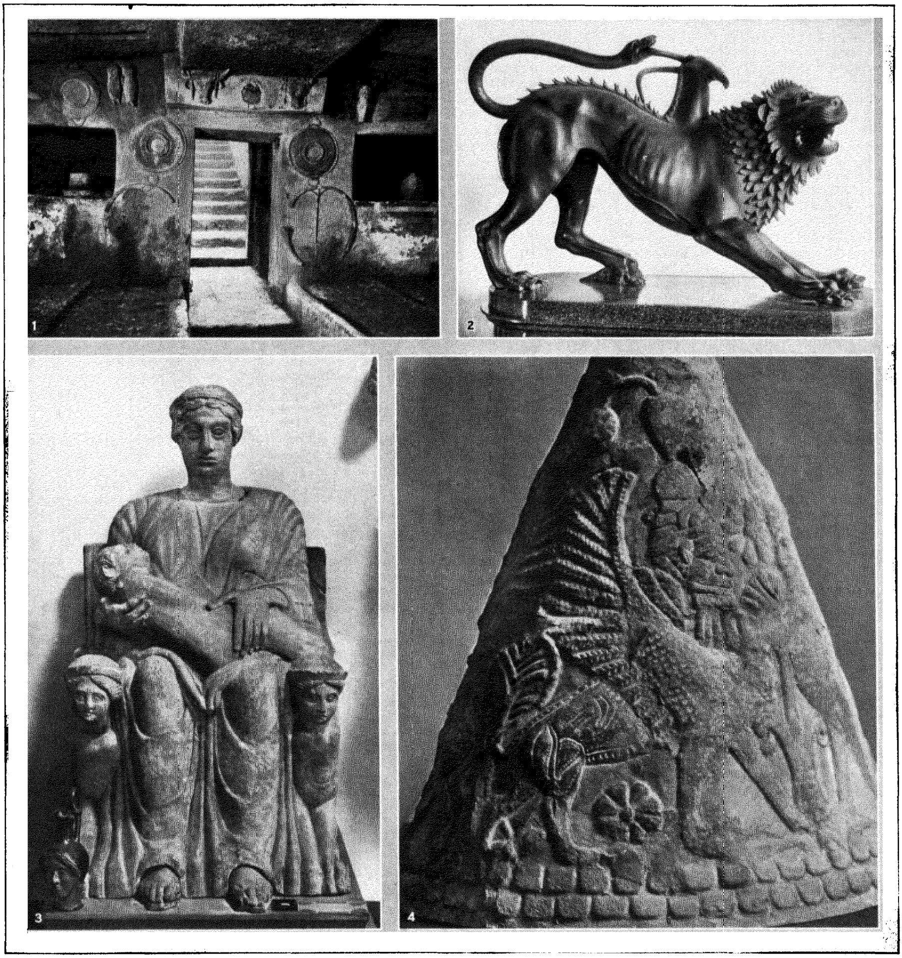
On the capital questions, therefore, of the origin of the Etruscans, and the date and place of their arrival in Italy, archaeology is ready with a clear answer. They came from some part of Asia Minor, whether or not it was Lydia, as Herodotus asserts, is immaterial. Their original home must be sought somewhere between the Hellespont and Syria. In its broad lines the tradition given by Herodotus is borne out by archaeological research.

The Etruscan nation was very loosely compacted, even in the days of its greatest power. It always retained the character of an aggregate of clans, probably resulting from the circumstances of the conquest by small isolated bands. Though these clans refrained from internecine war, they were quite unwilling to band together for any common cause except under the stress of some extraordinary emergency. Except in Macaulay's *Lays*, it may be doubted if Etruria ever acted as a whole. Each city seems to have considered itself free to conduct its own policy, and to make war or peace with little or no consideration for the interests of the rest. Thus history records few more pathetic instances of political blindness than the apathy of the great Etrurian cities in the long wars between Veii and Rome, which allowed the Romans, though actually the weaker, to swallow all Etruria piecemeal. A confederacy of 12 cities existed in the 6th century, which held its annual meetings at the shrine of Voltumna above the Lacus Volsiniensis (Lake of Bolsena). It is not necessary, however, to follow Livy in representing these meetings as something like a conference of premiers. Judging from the smallness of the results, it seems more likely that the confederation confined itself principally to affairs of religion. No complete list exists of the 12 members in early days, the pedestal of the statue of Claudius is too late in date to be good authority, even if complete.

From partial references, however, in Livy, Dionysius and Diodorus, it is possible to make up a list which, eked out by the names given on this pedestal, would include Vetulonia, Tarquinii, Vulci, Caere, Volaterrae (Volterra), Clusium (Chiusi), Arretium (Arezzo), Rusellae, Cortona, Perusia (Perugia), Populonia, to which must undoubtedly be added Veii.

EXAMINATION OF CITY SITES

Of several of the most ancient and important cities in this list a good deal is known as the result of excavation. Vetulonia, Tarquinii and Caere have been extensively explored; valuable though limited excavations have been made at Vulci; Populonia is periodically examined as often as the removal of the refuse of smelting lays bare an area of ancient tombs; Chiusi has much to teach, even though its riches have been wantonly plundered



PHOTOGRAPHS, ALINARI

ETRUSCAN ARCHAEOLOGICAL REMAINS

1. Interior of the Tomb of the Stuccoes, or Grotta Bella, Cervetri (ancient *Caere*). The Etruscans in their construction of tombs often reproduced the interior features of contemporary houses and by carving the soft rock or tufa imitated the wooden beams and other architectural details. The arrangement and contents of the tombs, which included furniture, gold and silver objects, utensils of daily life, clothing and ornaments, as well as wall-paintings and sculpture, furnish the best records yet discovered of the life and artistic achievements of the Etruscans
2. Bronze Chimaera from Arezzo, of the 5th century B.C., found in 1553. Two of the legs had been broken, and were restored by Benvenuto Cellini. This piece is not derived from the Greek style, but is of pure Etruscan origin. Archaeological Museum, Florence
3. The *Mater Matuta*, a funerary statue in *pietra fetida*, of the 5th century B.C., found near Chianciano. Archaeological Museum, Florence
4. The base of a large drinking bowl from an archaic tomb at Praeneste. The decoration, like that of much of the Etruscan work unmistakably Oriental in character, strongly resembles Assyrian designs. Museum of the Villa Giulia, Rome

and scattered; Volterra has preserved its late walls and numbers of late sarcophagi; Arezzo, Perugia and Cortona are each celebrated for individual works of art found sporadically. Only Rusellae is a quite virgin site awaiting the spade of the explorer.

Vetulonia.—Here was one of the earliest, if not the very earliest, of the settlements made by the Etruscans when they landed on the west coast of Italy, and here it has been possible to trace their graves from the very first generation. The commanding site on the hill of Vetulonia had previously been occupied for a long period by the native Italians, and by the unbroken consecutive sequence of the cemeteries it is possible to detect the precise moment when the new foreign influence appears. Native Italian burials begin on this site at a stage which, at Bologna, is well known as the very opening of the Villanovan period, and continue through the whole of the First and Second Benacci stages. Towards the end of the Second Benacci at Vetulonia new types of tombs begin to appear, together with whole series of foreign imports previously unknown, such as gold, silver, amber and Egyptian scarabs. This is the moment of the first effective colonization by the Etruscans. On the Bolognese analogy the date should be very near 800 B.C.

The Etruscan tombs at Vetulonia continue through the 8th century and down to the middle of the 7th; after which they disappear, at any rate in the area which has hitherto been explored. The picture which is given is therefore a complete picture of the life of the invaders for a little over 100 years after their first settlement. It may be studied in all its details in the very rich collection in the museum at Florence. This material shows a certain seriation, a progress from simpler to more complicated designs and technique, especially in the gold-work, which exhibits all the steps in the development of a local school. The finest tombs belong to the latter half of the 8th and, perhaps, the beginning of the 7th century, especially the Tomba del Duce, which is particularly valuable for the many points of similarity between its contents and those of the Regolini-Gulassi and similar tombs at Caere and Praeneste; of the bronze-work the finest examples are bronze cauldrons, resembling those dedicated at Olympia; the best jewellery is from the Lictor's tomb, Le Migliarine and La Pietrera. A bucchero pottery cup from the Tomba del Duce bears an Etruscan inscription of 46 letters, almost, if not quite, the earliest epigraphical document in the language. A silver cup from the same tomb, as well as the silver casing of the ossuary, were finely ornamented with oriental designs.

Caere.—This town is famous for the Regolini-Galassi tomb found there nearly a century ago, the contents of which form the most valuable part of the small Vatican museum of Etruscan antiquities. The principal cemetery, however, lies on the other side of the ancient town at the place known as Banditaccia. Most of the great tumuli have long been known and are well described in Dennis. They contain usually two or three gallery tombs apiece, of which the most important have been named from their most striking features as the tombs "Dei Pilostri," "Del Triclinio," "Dei Tarquinii" and "Dei Sarcofagi." A large mausoleum of this kind was used for a long period, so that the dates range from the beginning of the 7th down to the middle of the 4th century B.C. The character of the great vases and tomb-furniture is best illustrated in the Campana collection in the Louvre, which was principally formed from the pillage of such tombs as these. Internally, the structure of a gallery tomb reproduces the features of the contemporary house, varying in the number and arrangement of its rooms, but imitating the architectural details of the wooden beams by carving the soft tufo rock.

Since Dennis wrote his account the general appearance of Banditaccia, as Canina names it, has been very much changed by recent excavations, the results of which remain unpublished. With its carefully laid out streets and quarters allocated to each class of burial it now suggests a Pompeii of the dead. The numerous antiquities found in these later excavations are exhibited in the Museo di Villa Giulia at Rome. The Regolini-Galassi is probably the best known of a group of four tombs, of which the others were found respectively at Praeneste and at Cumae. All four belong precisely to the same generation and contain objects of identical or very similar character. The Regolini-Galassi tomb has no architectural interest. It is merely a narrow passage divided by a partition into two chambers, with a recess on each side of the fore chamber. The passage is roofed by overlapping blocks, without any attempt to apply the principle of the arch, which seems to have been still unknown. No information has been preserved as to the style of the building in the two Praeneste tombs, known respectively as the Barberini and the Bernardini. In the fore chamber at Caere there was buried a warrior, laid on a bed of bronze, which was perfectly preserved. In the chamber behind this were all the ornaments and jewellery of a woman, whose body had fallen into dust but whose bridal trousseau lay in place precisely as she had worn it. On the low wall between the two chambers stood great bronze cauldrons; along the roof had been nailed bowls and dishes of silver and bronze, and on the walls around the warrior had been nailed bronze shields and bundles of arrows. Near him stood a four-wheeled chariot, and in the right hand niche was a two-wheeled chariot. An inventory of the contents of the Regolini-Galassi tomb would occupy many pages. The gold-work alone would stock a large jeweller's shop; it includes huge fibulae, bracelets, plaques and chains, executed principally in the technique either of granulation or of filigree. There are silver cups, silver jugs and engraved silver bowls.

More of these bowls were found in the Bernardini and Barberini tombs, in which also there were a number of carved ivories. All these belong to a well-marked school of oriental work, the centre of which seems to have been in or near Cyprus. Bowls with precisely similar scenes of oriental date and mythology have been unearthed on several sites in Cyprus, indeed the Cesnola collection of Cypriote antiquities in the Metropolitan Museum of New York contains one which must have been actually made by the same hand as a bowl from the Bernardini tomb. In the less known Artiaco tomb of Cumae were bronze basins, a silver ossuary, and gold ornaments of which some are almost precise duplicates of those in the Regolini-Galassi. The sporadic occurrence of an Etruscan burial so far south is curious and enigmatic.

This group of four tombs, so rich that their contents are sufficient to characterize the work and civilization of an entire period, must be placed in the 7th century; the question is to what point in the century they should be assigned. The tendency of more recent examination is to bring these nearer to 700 B.C., perhaps precisely 670 B.C., which makes the approximation of types to Vetulonia more consistent and intelligible.

Tarquinii.—This site, now known as Corneto, shares with Vetulonia the claim to be the earliest of all the settlements. It derives its name from the family of Tarquin, or in its native form Tarchon, so well known in the legendary history of early Rome. Excavations on this site have revealed four extensive cemeteries of the pre-Etruscan Villanovans, beginning in the First Benacci period and coming down to a stage which overlaps, as at Vetulonia, the Etruscan occupation. An exact synchronism between the latest Villanovan at Corneto and the earliest Etruscan at Vetulonia is furnished by silver filigree bracelets of identical pattern found on both sites. This corroborates the sequence dating established for the arrival of the Etruscans, whose effective occupation of their earliest posts must fall in the middle of the Second Benacci period. It is a dating which tallies with the end of the 9th or beginning of the 8th century, to which we are also driven by internal criticism of the pottery, gold-work and other contents of the Etruscan graves themselves.

Two tombs at Corneto are of great importance for chronological dating, viz., the Warrior's tomb and the Bocchoris tomb. The former contains a fine set of bronze vessels and gold ornaments which closely resemble examples found in the great circle-graves at Vetulonia, as well as an interesting set of geometric pottery. The Warrior's tomb is certainly not later than the 8th century, but some critics would place it at 800 B.C., or even earlier, while others bring it down almost to 700 B.C. Far more closely dated than the Warrior's tomb is one which is named the Bocchoris tomb, from a vase of Egyptian faience inscribed with the name of Bokenranf, known to Greek writers as Bocchoris, who reigned

in Egypt for only six years (734–728 B.C.). Genuinely Egyptian objects are extraordinarily rare in Italy, and a vase so closely dated by an inscription is absolutely unique. As the Egyptian vase fixes the date of the tomb to within a generation, it is important to note a piece in the Regolini-Galassi, which is a distinct argument in favour of bringing the date of the whole Regolini-Galassi group up to almost 700 B.C.

The very important frescoed tombs of Corneto are dealt with below in the paragraph on painting.

Vulci.—The remains of the cemeteries of this important city are very extensive, but in spite of the wholesale pillaging of tombs in the middle of the 19th century, only a small amount of scientific work has been done there. The results of Gsell's excavations, unfortunately limited to a small proportion of the whole area, have not yet found their way into a public museum, though published in a carefully written volume. Dennis gives an admirable account of the site, to which there is little more to add except the information given by Gsell. Pillage from Vulci has found its way sporadically into several museums, especially outside Italy. The Campana collection of the Louvre contains a certain amount of material, but the best individual group which has been preserved is the Polledrara tomb, sometimes known by the ridiculous nickname of the Grotto of Isis, now in the British Museum. This is remarkable for its Egyptian objects, carved ostrich-eggs, faience bottles and a scarab of Psammetichus I. As this king reigned from 663 to 609 B.C., the scarab gives only an approximate dating. The pottery, however, is of a very closely differentiated class which assigns the Polledrara tomb quite definitely to within a few years of 600 B.C. All the bronze work in it has the finesse and delicacy of a distinctly later stage than the Regolini-Galassi.

The cemeteries at Vulci covered an immense area and comprised a great variety of tomb-forms of all dates. Tumuli, of which the so-called Cucumella is the best example, large chambers such as the Francois tomb and the Campanari, and plain trench graves have produced a quantity of archaeological material, especially pottery, which is now scattered in many places.

Volaterrae (Volterra).—This was undoubtedly a city of very ancient foundation and of great importance, but owing to the curious local conditions very few traces of the oldest period survive. The battered stone effigy of a warrior, inscribed with the name of Larthi Atharnies, now in the Florence museum, is almost the only evidence that Volterra is as ancient as Tarquinii and Vetulonia. Periodical landslips have carried away so much of the land that it may be doubted whether the more ancient cemeteries will ever be discovered. By a curious irony, however, the latest and most debased period of Etruscan art is represented in the museum by a series of sarcophagi of the 2nd and 3rd centuries, made of the local alabaster carved with bloodthirsty travesties of scenes from Greek story. The walls and gateways are, with those of Perugia, among the finest examples of late-Etruscan architecture.

Clusium (Chiusi).—This is one of the most individual and peculiar of all the Etruscan cities in respect of its art and customs. Probably this may be explained by the long survival of a native tradition which showed extraordinary tenacity. Chiusi was not fully Etruscanized in feeling until well on in the 7th century. It is peculiar in retaining the custom of cremation as its sole burial rite, a habit which gave rise to the curious art of its so-called canopics, ossuaries of pottery moulded in the semblance of human masks which, though often grotesque, sometimes arrive at a considerable degree of realism in portraiture. This was the genesis of a school of sculpture and modelling which has never been sufficiently studied. At Palermo is a considerable collection of Chiusan bas-relief which it is hoped may be eventually transferred to Florence. Apart from this the only place in which Chiusan antiquities can be reviewed as a whole is the museum of Florence, though isolated specimens from this region, which was pitilessly sacked all through the 19th century, may be found in many European collections, and the local museum at Chiusi itself contains some very fine examples. At Florence the finest tomb groups are those of Poggio alla Sala and Pania, from the latter of which came a magnificently carved ivory situla of the 7th century. An isolated specimen of great interest is also the silver bucket engraved with a procession of foot soldiers and inscribed with the name Plicasnas, which forms a link with the art of southern Etruria. Chiusi was the centre of the finest production of the black pottery known as Etruscan bucchero.

Populonia.—This place owes its importance entirely to its proximity to the island of Elba, here only 6 m. away from the mainland. It is likely that even before the Etruscans arrived the iron-mines of Elba had been discovered and exploited by the Villanovans, of whose graves a considerable number have been found here. The ore was brought over from the island to the mainland to be smelted, and the masses of scoriae cover an immense area. As the smelting continued in Roman times the Etruscan cemetery was buried under the débris, and it is only by degrees that the tombs are brought to light as the rubbish is removed by a company which has found it worth while to re-work the refuse. The most interesting are chambers surrounded by circular tumuli of stone blocks. Populonia is likely to prove one of the most instructive sites as the long sequence of its occupation is revealed; the material in the museum at Florence, the best of which is of the 6th and 5th centuries, already includes a fine chariot, painted vases and gold jewellery.

ART AND RELIGION

Etruscan Art.—It is an error to deny the existence of an independent Etruscan art or to treat it as a mere offshoot and dependent of the Greek. Until the end of the 7th century Greek influence on Etruria was very slight, and in the nature of things it could not be very important before that time. But for at least 150 years before this the Etruscans had lived in an art-loving atmosphere and their tombs of the 7th, if not of the 8th century, which may be less certain, had been filled with exquisite objects in bronze and gold and silver and ivory. The contents of these tombs show no trace of Greek inspiration. The art which they mirror is derived from the Near East, from centres which were in touch with Egypt, Assyria, Syria and Cyprus. All Etruscan trade at this period was with Phoenicians, Cypriotes and others who were swarming round crucibles of Egypto-Assyrian civilization situated somewhere in the Levant. Then the Etruscans themselves were very fine craftsmen, and although they imported freely, yet they probably came over with a considerable heritage of artistic tradition from their original homes, which they certainly developed to a great extent on their own lines in Italy.

In the latter half of the 7th century Corinthian influence began to be felt in Etruria, and with the beginning of the 6th appear the painted Attic vases. From this moment Greek influence is certainly predominant, and in many branches, especially of the minor arts, Etruscans of the 6th century and afterwards were principally interpreters and imitators of Greek fashions. In the major arts of architecture and sculpture, however, the Etruscans remained to a great extent independent. Temples and houses and tombs were constructed on original plans which were quite un-Hellenic, even if some of the external ornament was often borrowed. Above all, in their statuary the Etruscans never lost the original genius which inspired the earliest work of Vulca and continued down to the 3rd century. Many copies of Greek masterpieces were executed in Etruscan studios, but side by side with these were such pure products of native inspiration as the Chimaera of Arezzo, the Wolf of the Capitol and the Orator from Lake Trasimene. The statue of the Orator discloses the parentage of Roman portrait-sculpture; from this it is clear that the Romans derived much of their peculiar gift from their Etruscan inheritance, or perhaps from actual Etruscan masters living amongst them. The finest extant piece of Etruscan sculpture of the early time is the Apollo of Veii, dating from the last years of the 6th century, but probably by no means the earliest product of a school of which the other works have perished. If it has affinities with Ionian sculpture, it is none the less a perfectly independent creation.

In many Etruscan tombs the walls are covered with frescoes, the finest of which are those at Corneto and in the neighbourhood of Chiusi. With the exception of those in the Grotta Campana

PHOTOGRAPHS, ALINARI

ETRUSCAN SCULPTURE AND BRONZE

1. Sarcophagus, with figures of a noble and his wife, dating from the end of the 6th or the beginning of the 5th century B.C. From Cervetri (*Caere*). Museum of the Villa Giulia, Rome. 2. Funerary group in *pietra fetida*, 5th century B.C., from Chianciano. Archaeological Museum, Florence. 3. Archaic head of a warrior, on a funerary pillar, found at Orvieto (Volsinii). Archaeological Museum, Florence. 4. The Apollo of Veii, a statue of painted terra cotta dating from the last years of the 6th century B.C. It was found in 1916, and is generally considered the finest example extant of early Etruscan sculpture. In the Villa Giulia, Rome. 5. Head of the Apollo of Veii. 6. Stone effigy of a warrior known as Larthi Atharnies, 8th century B.C., found at Volterra. Archaeological Museum, Florence. 7. Bronze cauldron on tripod, found in the Regolini-Galassi tomb, Cervetri. Etruscan Museum of the Vatican. 8. Figure of a warrior on primitive grave stone, found at Volterra. Archaeological Museum, Florence

at Veii, which are purely decorative and probably belong to the 7th century, none of these paintings is earlier than 600 B.C. Consequently they are so much affected by Greek style and subjects that their value is a good deal impaired as records of Etruscan civilization. Nevertheless there are a good many scenes from which valuable details may be gleaned as to customs and habits, especially in social life. The favourite scene is a funeral banquet, with all the preparations for it and the procession which preceded it. Probably the motive was simply to ensure by magic a repetition of the material pleasures enjoyed in this world. Chariot-races, dancing, wrestling, prize-fighting and athletic contests are depicted among the amusements. The style is closely in harmony with the contemporary vase painting of the time, so that in the first half of the 6th century Ionic fashions are dominant, while after this Attic vase painting, especially the severe red-figured style of 500 B.C. comes into play. In some tombs of the end of the 5th century Pythagoreanism begins to assert itself and to affect the representation with a mystic and gloomy atmosphere. The most characteristic of the paintings, however, are essentially gay and happy, without the slightest suggestion of melancholy, and with only slight references to the presence of the Genius of death.

It is from the tomb-paintings that the best idea may be obtained of the games and amusements to which the Etruscans, like the Lydians, were so much addicted. Horse-riding and chariot-races were much in vogue; wrestling and boxing-matches took place on every important occasion. And on every occasion, whether important or not, there was music. The favourite instrument was a double-pipe of the Phrygian kind but a syrinx was also used. The Romans credited the invention of more than one kind of horn or trumpet to the Etruscans, from whom they confessed to have borrowed the *lituus* and from whom they learned the use of the pipes and the flute.

Religion.—Of the religion it is not possible to make any satisfactory study in the absence of documents. The names of a certain number of deities are known, but little can be said of their functions or attributes. The existence of a celestial triad corresponding to the Roman Jupiter, Juno and Minerva is affirmed by late Roman writers, and the Etruscan equivalents of these names are known to be Tinia, Uni and Menrva. Corresponding to these there seems to have been a triad of infernal deities, perhaps Mantus, Mania and the equivalent of Demeter. Fufluns was the Etruscan equivalent of Bacchus, Sethlans of Vulcan, Turms of Mercury. Tiv was the deity of the moon, Thesan of the dawn, Catha of the sun. Several of these names, and others more difficult of identification, are given on the bronze laver of Piacenza. Besides these a very important deity was Voltumna, whom the Romans called Vertumnus; it was at his shrine that the annual meetings of the confederacy took place. In the underworld there were various demons, especially Charun and Tuchulcha.

The influence of Etruscan rite and ceremonial upon the Romans was very wide and deep. Not only did the latter borrow from Vetulonia the insignia of their magistrates, the curule chair and the fasces, the purple toga and the trumpets, but the rites with which they laid out a city were Etruscan and their processions and triumphs were on an Etruscan model. The augurs and haruspices were Etruscan and as late as the time of the emperor Julian the Etruscan soothsayers formed a part of every Roman army. In every department of their public life the debt of the Romans to their neighbours and sometime rulers is unmistakable.

Writing and the Alphabet.—The Etruscans used a form of alphabet which is a variant of one of the early Greek alphabets. It contains letters not used by the Campanian Greeks and represents an older inheritance of independent tradition. The first instances of its appearance are a little before 700 B.C., the inscribed statues of Avtiles Feluskes and Larthi Atharnies, as well as the bucchero cup from the tomb of the Prince at Vetulonia belong to the 8th century. A little later than 700 are the three versions of the alphabet, given respectively on an ivory tablet from Marsiliana, and two earthenware pots, found respectively at Veii and at Caere. Of literature in the proper sense there are no remains, and it is impossible to tell whether any existed, though it may be significant that the Latin writers never mention any. Religious books, however, were composed in the later periods and the outlines of an *Etrusca disciplina* were known to Cicero.

The Army and Navy. Conquests and Settlements.—Of the Etruscan army some idea may be formed from such representations as those on the situla of the Certosa found at Bologna. Cavalry must have been important and chariots are found in every large grave. But the foot soldiers were, doubtless, the backbone of the force. These were armed principally with either of two weapons, the spear or the axe, which was sometimes used not only for striking but for throwing. Javelins and arrows are also commonly found in the graves. Shields and helmets were of several designs, some adapted from the Greek, others borrowed from the eastern Alps. Swords, probably rare and much prized, were of various models, derived from Hallstatt and from Greece.

The Etruscan navy was extremely formidable and rendered them the scourge of the western Mediterranean for several centuries. It enabled them to defeat the Phocaeans, to conquer Corsica and Sardinia, and to hold their own against Carthaginians and Greeks down to 474 B.C., when their defeat at Cumae marked the beginning of a series of disasters from which they never recovered.

The Etruscan power had reached its height about 30 years before this, and it was in the last few years of the 6th century that a new experiment was made in the direction of empire-building. Colonies were sent to establish themselves north of the Apennines, to build up a new Etruria which should include the whole basin of the Po and extend to the shores of the Adriatic, but the Gauls swept away this newly annexed region. Livy's words must not be forced into a statement that there was ever an Etruscan empire stretching from the Alps to Messina, but nevertheless it must be recognized that the Etruscans were the creators of more than a third of ancient Italy. The limits of their permanent achievement, the territory in which their work lived on, even when their political power had been destroyed, might be defined by a line drawn from Milan to Chioggia meeting another line drawn from the mouth of the Po to the mouth of the Tiber. The peoples whom they administered, and by whom they were eventually assimilated, were principally those who have survived into modern days as the Tuscans and the Umbrians.

The Roman conquest of Etruria after centuries of fighting virtually concluded by the series of deadly duels with Veii was completed just before the Punic wars. Numerous Roman colonies were planted throughout the conquered territory, which eventually passed into the Roman empire as the 7th division of the administration devised by Augustus.

Bibliography.—Of the older books C. O. Muller's *Die Etrusker*, as revised by G. Deecke, will always be a standard, and *The Cities and Cemeteries of Etruria* by G. Dennis, now accessible in the "Everyman" series, is an imperishable classic. G. Martha's *Art étrusque*, once important, is no longer up to date. The best and most comprehensive of modern works are those of P. Ducati in Italian; his two small volumes entitled *Etruria Antica*, give a complete review of the entire subject and are accompanied by a full bibliography. Art is studied in a larger work by Ducati called *Arte Etrusca*. The special subject of painting is well treated by F. Weege, *Etruskische Malerei*, and briefly but clearly by F. Poulsen, *Etruscan Tomb Paintings*. Amongst detailed monographs of local excavations Falchi's *Vetulonia* and Gsell's *Fouilles de Vulci* are valuable; A. Minto's *Marsiliana d'Albegna* and *Populonia, la necropoli arcaica* are important to the specialist. The results of excavations for the period down to 650 B.C. are incorporated with a critical analysis in *Villanovans and Early Etruscans* by D. Randall-MacIver, and a small popular volume on *The Etruscans* by the same author reviews the entire subject. R. A. Fell's *Etruria and Rome* treats of the political and military history from a topographical standpoint. The wars between Rome and the Etruscans are adequately described in most of the standard histories. Articles by Körte, von Duhn and others are to be found in Pauly-Wissowa and in Ebert's *Real Lexikon der Vorgeschichte*.

(D. R.-M.)

ETTENHEIM, a town of Germany, in the republic of Baden, situated on the Ettenbach, under the western slope of the Black forest. Pop. (1925) 3,091. Founded in the 8th century by Eddo, bishop of Strassburg, Ettenheim remained attached to that see until 1802, when it passed to Baden. It has a mediaeval town hall,

and in the Roman Catholic Church lies the last prince bishop of Strassburg, d. 1803. Its industries include the manufacture of tobacco, and there is a considerable trade in wine and agricultural produce. The Benedictine abbey of Ettenheimmünster, founded in the 8th century and dissolved in 1803, occupied a site south of the town.

ETTINGSHAUSEN, CONSTANTIN, BARON VON (1826–1897), Austrian geologist and botanist, was born in Vienna on June 16, 1826. Professor of botany at Vienna and then at Graz, he carried out important researches on the Tertiary floras of various parts of Europe, and on the fossil floras of Australia and New Zealand. He died at Graz on Feb. 1, 1897.

ETTLINGEN, a town of Germany, in the republic of Baden, on the Alb and the railway Mannheim-Basel, 4½ m. S. of Karlsruhe. Pop. (1925) 9,435. The first notice of Ettlingen dates from the 8th century. It became a town in 1227 and was presented by the emperor Frederick II. to the margrave of Baden. Surrounded by old walls and ditches, it presents a mediaeval appearance. Among its most striking edifices are an old princely residence, with extensive grounds and the buildings of a former monastery. There are also many Roman remains, notable among them the "Neptune" sculpture, now embedded in the wall of the town-hall. Its chief manufactures are paper, explosives, spinning, weaving and machine building. Considerable trade is done in wine and fruit which are cultivated in the neighbourhood.

See Schwarz, *Geschichte der Stadt Ettlingen* (Karlsruhe, 1900).

ETTMÜLLER, ERNST MORITZ LUDWIG (1802–1877), German philologist, was born at Gersdorf near Löbau, in Saxony, on Oct. 5, 1802. He studied from 1823 to 1826 at the University of Leipzig. In 1830 he delivered at Jena, under the auspices of the university, a course of lectures on the old Norse poets. The rest of his life was spent at Zürich, where he taught first in the gymnasium and then in the university. He died at Zürich in April 1877. To the study of English Ettmüller contributed by an alliterative translation of Beowulf (1840), an Anglo-Saxon chrestomathy entitled *Engla and Seaxna scopas and boceras* (1850), and a well-known *Lexicon Anglo-Saxonicum* (1851), in which the explanations and comments are given in Latin. He edited a large number of High and Low German texts, and to the study of the Scandinavian literatures he contributed an edition of the *Völuspa* (1831), a translation of the *Lieder der Edda von den Nibelungen* (1837) and an old Norse reading book and vocabulary. He was also the author of a *Handbuch der deutschen Literaturgeschichte* (1847), which includes the treatment of the Anglo-Saxon, the Old Scandinavian and the Low German branches.

ETTRICK, a river and parish of Selkirkshire, Scotland. The river rises in Capel Fell, a hill in the extreme south-west of the shire, and flows north-east for 32 m. to its junction with the Tweed, its principal affluent being the Yarrow. In the parish of Ettrick was born James Hogg, the "Ettrick shepherd" (the site of the cottage being marked by a monument erected in 1898). About 2 m. below Ettrick church is Thirlestane Castle, the seat of Lord Napier and Ettrick, a descendant of the Napiers of Merchiston, and beside it is the ruin of the stronghold that belonged to John Scott of Thirlestane under James V. Two miles up Rankle Burn, a right-hand tributary, lies the site of Buccleuch, another stronghold of the Scotts, which gave them the titles of earl (1619) and duke (1663). Only a fragment remains of Tushielaw tower, occupying high ground opposite the confluence of the Rankle and the Ettrick. Lower down the dale is Deloraine, recalling one of the leading characters in *The Lay of the Last Minstrel.* Carterhaugh, a corruption of Carelhaugh, where Ettrick and Yarrow meet, was the scene of the ballad of "Young Tamlane."

ETTY, WILLIAM (1787–1849), British painter, was born at York on March 10, 1787, the son of a baker and confectioner. At the age of eleven and a half William was bound apprentice in the printing-office of the *Hull Packet.* He completed his term of seven years, and having in that period come by practice, at first surreptitious, though afterwards allowed by his master "in lawful hours," to know his own powers, he removed to London.

The kindness of an elder brother and a wealthy uncle, William Etty, himself an artist, stood him in good stead. He began by copying without instruction from nature, models, prints, etc., his first academy, as he himself says, being a plaster-cast shop in Cock Lane, Smithfield. Here he made a copy from an ancient cast of Cupid and Psyche, which was shown to Opie, and led to his entry in 1807 as student of the Academy, whose schools were at that time conducted in Somerset House. Among his fellow scholars were Wilkie, Haydon, Collins and Constable. In the summer of 1807 he was admitted to be a private pupil of Sir Thomas Lawrence. For some years after he quitted Sir Thomas's studio, even as late as 1816, the influence of his master was traceable. In 1811, after repeated rejections, his "Telemachus Rescuing Antiope" was hung in the Academy. For the next five years he persevered with quiet and constant energy, and he was even beginning to establish something like a name when in 1816 he resolved on a journey to Italy. In 1820 his "Coral-finders," exhibited at the Royal Academy, had a great success, more than equalled by that of "Cleopatra's Arrival in Cilicia," shown in the following year. In 1822 he again set out on a tour to Italy. Though Etty was impressed by the grand *chefs-d'oeuvre* of Raphael and Michelangelo at Rome, he always regarded Venice as the true home of art in Italy. His wonderful colouring in his paintings of the nude owes much to his close study of and admiration for the great Venetian masters.

Early in 1824 he returned home, and in that year he was made A.R.A. and in 1828 R.A. In the interval he had produced one of his greatest works, the "Combat (Woman interceding for the Vanquished)," and the first of the series of three pictures on the subject of Judith, both of which ultimately came into the possession of the Scottish Academy. Etty's career was from this time one of slow but uninterrupted success. During the next ten years of his life he was a constant attendant at the Academy life school, where he used to work regularly with the students, notwithstanding the remonstrances of some of his fellow-Academicians, who thought the practice undignified. The course of his studies was only interrupted by occasional visits to his native city, and to Scotland. On the occasion of one of these visits he gave the finishing touches to his trio of Judiths. In 1840 and again in 1841 Etty went to the Netherlands to study the masterpieces of Rubens. Two years later he was in France collecting materials for what he called "his last epic," his famous picture of "Joan of Arc." In 1848 he retired to York, where many of his best pictures are to be seen. There are fine examples of Etty in the National Gallery and in South Kensington Museum, London, notably "Youth at the Prow and Pleasure at the Helm." A collection of his pictures was shown in London in the summer of 1849; on Nov. 13 of that year he died. He received the honours of a public funeral in his native city.

The key to Etty's choice of subjects and his manner of painting is to be found in his own words: "When I found that all the great masters of antiquity had become thus great through painting great actions, and the human form, I resolved to paint nothing else; and, finding God's most glorious work to be Woman, that all human beauty had been concentrated in her, I resolved to dedicate myself to painting, not the draper's or milliner's work, but God's most glorious work, more finely than ever had been done."

See Etty's autobiography, published in the *Art Journal* for 1849, and A. Gilchrist, *Life of William Etty, R.A.* (2 vols., 1855).

ÉTUDE (Fr.), in music, has not only the ordinary meaning of a study or technical exercise but also that of a finished composition, based on the treatment of a particular type of phrase or figure and possessed therefore of a study-like character. An étude in this sense may be a study, not only from the standpoint of the performer, but also from that of the composer, as an essay in the handling of the material which he has chosen. Chopin's études for the pianoforte contain some of his choicest inspirations, while Schumann's Études Symphoniques may be similarly ranked.

ETYMOLOGY, that part of linguistics which deals with the origin or derivation of words (Gr. ἔτυμος, true, and λόγος, account). The Greek word ἔτυμος, as applied to words, referred to the meaning rather than to the origin, and the Stoics asserted that the discovery of τὸ ἔτυμον would explain the essence of the

things and ideas represented by words. Plato, in the *Cratylus*, approaches the modern view and jests at *e.g.*, the derivation of *οὐρανός*, heaven, *ἀπὸ τοῦ ὁρᾶν τὰ ἄνω*, from looking at things above. Until the comparative study of philology and the development of phonetic laws, the derivation of words was largely a matter of guesswork. This popular etymology, or *Volksetymologie* has had much influence in the form which words take (*e.g.*, "crawfish" or "crayfish," from the French *crevis*, modern *écrevisse*), and has frequently occasioned homonyms. Skeat has embodied in certain canons some principles to be observed in giving the etymology of a word: (1) Ascertain the earliest form and use of the word. Observe chronology. (2) Observe history and geography; borrowings are due to contact. (3) Observe phonetic laws, especially as regards the relation of consonants in Aryan languages, and compare vowel sounds. (4) In comparing two words, A and B, of the same language, of which A has fewer syllables, A must be taken *prima facie* to be the more original word. (5) In comparing two words, A and B, of the same language and the same number of syllables, the older form can usually be distinguished by the principal vowel's sound. (6) Teutonic strong verbs and the Latin "irregular verbs" are commonly to be taken as primary, related forms as derivative. (7) The *whole* of a word ought to be accounted for; and, in tracing changes of form, infringement of phonetic laws is suspicious. (8) Mere resemblances of form and in sense between unrelated languages are not to be regarded. (9) When words in two languages are *too much* alike, one has probably borrowed from the other. (10) An explanation of an English word must *also* explain its cognate forms (Intro. to *Etym. Dict. of the Eng. Lang.* 1898).

An English word is either "the extant formal representative or direct phonetic descendant of an earlier (Teutonic) word, or it has been *adopted* (popularly) or *adapted* (in literature) from some foreign language"; finally, there is *formation, i.e.*, the combination of words or parts of words with each other or with formative syllables. (*See* Introduction to the Oxford *N.E.D.*, p. xx.) A further classification of words by origin is that into (1) naturals, *i.e.*, purely native words, like "mother," "house"; (2) perfectly naturalized foreign words, like "cat," "beef"; (3) denizens, words naturalized but keeping the foreign pronunciation, spelling and inflections, *e.g.*, "focus," "camera"; (4) aliens, *e.g.*, *menu, lakh, tarbush;* (5) casuals, *e.g.*, *bloc, Ausgleich*, differing from "aliens" in their temporary use. The full etymology of a word should include its phonetic descent, source, and, if of foreign origin, whether by adoption or adaptation, or, if *formed*, the origin of its several parts. (*See* also DICTIONARY.)

EU (ö), a town of north-west France, in the department of Seine-Inférieure, on the river Bresle, 64 m. N.N.E. of Rouen on the Ouest-État railway, and 2 m. E.S.E. of Le Tréport, at the mouth of the Bresle, which is canalized between the two towns. Pop. (1926) 5,438.

Eu (Augusta) was in existence under the Romans. The first line of its counts, supposed to be descended from the dukes of Normandy, had as heiress Alix (died 1227), who married Raoul (Ralph) de Lusignan. Through their granddaughter Marie, the countship of Eu passed by marriage to the house of Brienne. King John confiscated the countship in 1350, and gave it to John of Artois (1352). The countship passed, through heiresses, in the 15th century, to the house of Cleves, and to that of Lorraine-Guise. In 1660 Henry II. of Lorraine, duke of Guise, sold it to Anne Marie Louise d'Orléans, duchesse de Montpensier (*q.v.*), who made it over (1682) to the duke of Maine, bastard son of Louis XIV., as part of the price of the release of her lover Lauzun. The second son of the duke of Maine, Louis Charles de Bourbon (1701–1775), bore the title of count of Eu. The estates of Eu were confiscated at the Revolution; but at the Restoration they were bestowed by Louis XVII. on the duchess-dowager of Orléans who, in 1821, bequeathed them to her son, afterwards King Louis Philippe. They were again confiscated in 1852, but were restored to the Orléans family by the National Assembly after the Franco-German War. The title of count of Eu was revived in the 19th century in favour of the eldest son of the duke of Nemours, second son of King Louis Philippe.

The extensive forest of Eu lies to the south-east of the town. The Gothic church of St. Laurent (12th and 13th centuries) has a choir with three tiers of ornamented buttressing and double arches between the nave pillars; the chapel of the Jesuit college (*c.* 1625) contains the tombs of Henry, third duke of Guise, and his wife, Katherine of Cleves; and the château, begun by Henry of Guise in 1578, was continued by Mademoiselle de Montpensier in the latter half of the 17th century, and restored by Louis Philippe. In 1902 it was largely destroyed by fire. The town has a tribunal of commerce, and manufactories of casks and glass; the port has trade in grain and timber.

EUBOEA or **NEGROPONTE,** the largest island of the Greek archipelago, about 90 m. from north-west to south-east, and from 30 m. to 4 m. in breadth. Its mountains prolong the chains bounding Thessaly to east and south, and continue south into Andros, Tenos and Myconos islands. Three principal masses are separated by fertile lowlands. In the north the highest peaks are Mts. Gaetsades (4,436 ft.) and Xeron (3,232 ft.), the former famed for medicinal plants in antiquity, and for hot sulphurous springs near the coast at Aedipsos (mod. Lipsos), called the Baths of Heracles, used in antiquity by Sulla, and frequented now for the cure of gout, rheumatism and digestive disorders. Opposite the Maliac gulf is the promontory of Cenaeum, where the highest point, Lithada (2,221 ft.), retains the old name of the Lichades islands off the cape. Here, and on the mainland coast of Trachis, was the scene of the death of Heracles (Sophocles, *Trachinian Women*). Almost facing the Gulf of Pagasae, the promontory Artemisium saw the naval battle between Greeks and Persians in 480 B.C.

In the centre, north-east of Chalcis, rises Dirphys (now Mt. Delphi, 5,725 ft.), whose bare summit carries snow till May, with pines and firs below, and then chestnuts and planes, one of the most conspicuous peaks in eastern Greece. At the south end, Mt. Ocha (now St. Elias, 4,830 ft.) is visible from Chios. The south-west promontory is Geraestus, the south-east, the dreaded Caphareus, overlooking the storm- and current-swept channel towards Andros. The whole east coast is rocky and harbourless, especially the part called "the hollows" where a Persian squadron went ashore in 480 B.C. Consequently the main traffic from the north Aegean to Athens used the inshore channels.

In Greek belief, Euboea had been torn from the mainland by earthquake, and ancient writers record tremors and volcanic activity here. The northern strait is at narrowest 1½ m. wide, and at Chalcis, the Euripus channel, divided by a rock with ruined castle, is bridged, on the Boeotian side by a stone arch, on the Euboean, which is navigable, by an iron swing-bridge. The first bridge here was built by Boeotians when Euboea revolted from Athens in 411 B.C., making it "an island to all but themselves," and impeding Athenian supplies of gold and corn from Thrace, timber from Macedon, and horses from Thessaly. Extraordinary changes of current occur in the "fair-swirling" Euripus: Strabo says that it varied seven times daily, Livy more discreetly that it is "irregular." Modern shipping is warned of its vagaries by signals. The name was corrupted in the middle ages to Evripo and Egripo, and extended to the whole island. The Venetians, observing the "black bridge," mis-heard it as Negroponte.

Euboea has few streams. In the north-east the Budorus flows into the Aegean from two headwaters which may be the Cereus and Noleus, sheep drinking of which became in one case white, in the other black. On the north coast, near Histiaea, issues the Callas, with alluvial fertility, enhanced, as in the Achmet-aga district of the Budorus, by foreign settlers after the War of Liberation; south of Chalcis, the Lelantus, whose fertile coast plain was a breeding-place of horses, and a standing cause of feud between Chalcis and Eretria. In Chalcis the aristocracy were nicknamed *Hippobotae*, "ranchers." The mountains have good pasture for sheep and cattle; the latter seem to have given Euboea its name. Forests are still extensive, and are better managed than formerly, but have been widely devastated by goats, fires, and reckless felling. In the mountains were formerly mines of iron and copper, and ancient Chalcis had fame from its swords. Magnesite is largely worked for export; lignite coal

on the coast at Kymi, for local steamships; and from Carystus, at the south end, comes the green and white *cipollino* marble, very popular with architects in imperial Rome, and now again exported abundantly. The scenery of Euboea, especially in the northern highland, is among the most beautiful in Greece.

Population.—Euboea had other early names, Macris and Doliche from its length, Ellopia and Abantis from sections of its people. Various tribes occupied its principal districts: in the north, Histiaei and Ellopes from Thessaly; in the centre Curetes and Abantes (the latter prominent in Homer); in the south Dryopes from Thessaly, in Carystus, Dystus, and Styra. The modern population is no less various: Greeks have immigrated from the mainland and other islands; the south is occupied, like much of Andros, by Albanians; and there are Vlach (Rouman) shepherds in the hill-country. Only one family remains of the English "philhellene" settlers of a century ago.

History.—The history of Euboea is mainly that of its chief cities Chalcis and Eretria (*q.v.*) on either margin of the Lelantine plain, about which their quarrels involved distant allies of each. Both were of Ionian origin, and colonized early in Campania, north-east Sicily, and in the Chalcidic promontory of the Macedonian coast. The later and more important colonies were from Chalcis. "Euboic" weights and measures facilitated intercourse, and were adopted by Athens (*see* SOLON) and many Ionian cities, and by Corinth with modifications. Eretria, repaying later the help of Miletus in the Lelantine war, by the raid on Sardis about 500 B.C. (*see* IONIA) incurred utter destruction by Persia in 480 B.C. Thenceforward, though Eretria was rebuilt, and Histiaea and Carystus were prosperous, Chalcis predominated, but Athens imposed a cleruchy (*q.v.*) there in 506 B.C. and at Histiaea after the revolt of 446. The excuse for Athenian domination in Euboea lay in its production of corn and cattle, its command of the sea-routes from north and east, and its strategical value in hostile hands. In 411, Euboea recovered independence, and took subordinate part in fourth-century politics. After the battle of Chaeronea (338 B.C.) it fell to Philip II. of Macedon. Philip V. fortified and garrisoned Chalcis, with Demetrias on the gulf of Pagasae, and Corinth, to be the "fetters of Greece." Hence its importance also for the Romans, in their wars with Antiochus and Mithridates.

Euboea (Negroponte) becomes once more important after the Fourth Crusade. In the partition of the Eastern empire among Latin adventurers, it was divided into three fiefs, but all soon became valuable dependencies of Venice; and the lion of St. Mark may still be seen over the sea-gate of Chalcis, and elsewhere. At length, in 1470, Chalcis was captured by Mohammed II., and the whole island fell to the Turks. In 1688, Francesco Morosini besieged Chalcis for three months, but in vain. After the Greek War of Independence, the island was included, in 1830, in the new Greek State. In 1899 it became a separate province. It produces much grain and exploits its minerals mainly with foreign capital.

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(J. L. MY.)

EUBULIDES, a native of Miletus, Greek philosopher and successor of Eucleides as head of the Megarian school. Indirect evidence shows that he was a contemporary of Aristotle, whom he attacked. Tradition says that Demosthenes was one of his pupils. His name has been preserved chiefly by some celebrated, though false and captious, syllogisms of which he was the reputed author. He wrote a treatise on Diogenes the Cynic and a number of comedies. (*See* MEGARIAN SCHOOL.)

EUBULUS, of Anaphlystus, Athenian politician, was a persistent opponent of Demosthenes and was chiefly instrumental in securing the acquittal of Aeschines (who had been his own clerk) when accused of treachery. Eubulus took little interest in military affairs, and was (at any rate at first) a strong advocate of peace at any price with Philip of Macedon. He devoted himself to matters of administration, especially in the department of finance. He proposed the law providing that any proposal to use the Theoric fund for military purposes should be punished with death. As one of the chief members of an embassy to Philip, Eubulus allowed himself to be won over, and henceforth did his utmost to promote the cause of the Macedonian. The indignant remonstrances of Demosthenes failed to weaken Eubulus's hold on the popular favour, and after his death (before 330 B.C.) he was distinguished with special honours, which were described by Hypereides in a speech now lost. Eubulus had a considerable reputation as an orator, but none of his speeches has survived, nor is there any appreciation of them in ancient writers. Aristotle (*Rhetoric*, i. 15. 15) mentions a speech against Chares, and Theopompus (in his *Philippica*) gave an account of his life, extracts from which are preserved in Harpocration.

See Demosthenes, *De corona*, pp. 232, 235; *De falsa legatione*, pp. 434, 435, 438; *Adversus Leptinem*, p. 498; *In Midiam*, pp. 580, 581; Aeschines, *De falsa legatione, ad fin.*; Index to C. W. Müller's *Oratores Attici*; A. D. Schäfer, *Demosthenes und seine Zeit* (1885).

EUBULUS, Athenian poet of the Middle comedy, flourished about 370 B.C. Fragments from about 50 of the 104 plays attributed to him are preserved in Athenaeus. They show that he took little interest in political affairs, but confined himself chiefly to mythological subjects, and to ridicule of the Tragedians, especially Euripides. His language is pure, and his versification correct.

Fragments in T. Kock, *Comicorum Atticorum fragmenta*, ii. (1884).

EUCALYPTUS, a large genus of trees of the family Myrtaceae, indigenous, with only a few exceptions, to Australia and Tasmania. In Australia the eucalypti are commonly called "gum-trees" or "stringy-bark trees." The genus, from the evidence of leaf-remains, appears to have been represented by several species in Eocene times. The leaves are leathery, hang obliquely or vertically, and are studded with glands which contain a fragrant volatile oil. The petals cohere to form a cap which is discarded when the flower expands. The fruit is surrounded by a woody cup-shaped receptacle and contains very numerous minute seeds. The eucalypti are rapid in growth, and many species are of great height, *E. amygdalina*, the tallest known tree, attaining to as much as 480ft., exceeding in height the Californian big-tree (*Sequoia gigantea*), with a diameter of 81ft. *E. globulus* is the blue gum tree of Victoria and Tasmania. The flowers are single or in clusters, and nearly sessile. This species attains a height of 375ft. Since 1854 it has been successfully introduced into the south of Europe, Algeria, Egypt, Tahiti, New Caledonia, Natal and India, and has been extensively planted in California, and, with the object of lessening liability to droughts, along the line of the Central Pacific railway. By aqueous distillation of the leaves a complex straw-coloured fluid is obtained of sp. gr. 0·910 to 0·930, and soluble in its own weight of alcohol. About 70% of this fluid consists of a volatile oil—Eucalyptol—which passes over between 347° and 351° F., and crystallizes at 30°F. It consists chiefly of a terpene and cymene. Eucalyptus oil also contains, after exposure to the air, a crystallizable resin derived from eucalyptol. The dose of the oil is ½ to 3 minims. Eucalyptol may be given in similar doses, and is preferable for purposes of inhalation. The oil derived from *E. amygdalina* contains a large quantity of phellandrene, which forms a crystalline nitrate, and is very irritating when inhaled. The oils from different species of *Eucalyptus* vary widely in composition.

Internally, eucalyptus oil acts as other volatile oils. Like quinine, it arrests the normal amoeboid movements of the polymorphonuclear leucocytes, and has a definite anti-periodic action; but it is a very poor substitute for quinine in malaria. In large doses it is an irritant to the kidneys, by which it is largely excreted, and is a marked nervous depressant, abolishing the reflex functions of the spinal cord and ultimately arresting respiration by its action on the medullary centre. An emulsion with gum solution has been used as a urethral injection, and has been given internally in pulmonary tuberculosis and other microbic diseases of the lungs and bronchi. The oil has acquired an extraordinary popular reputation in influenza, but there is no evidence to show that it has any marked influence upon this. It has been used as an antiseptic by surgeons, and is an ingredient of "catheter oil." *Eucalyptus rostrata* and other species yield eucalyptus or red gum,

which must be distinguished from Botany Bay kino. Red gum is powerfully astringent and is given internally, in doses of 2 to 5 grains, in cases of diarrhoea and pharyngeal inflammation. Red gum is official in Great Britain. *E. globulus, E. resinifera* and other species yield what is known as Botany Bay kino, an astringent dark-reddish amorphous resin, which is obtained in a semi-fluid state by making incisions in the trunks of the trees. The kino of *E. gigantea* contains a notable proportion of gum. J. H. Maiden enumerates more than thirty species as kino-yielding. From the leaves and young bark of *E. mannifera* and *E. viminalis* is procured Australian manna, a hard, opaque, sweet substance, containing melitose. On destructive distillation the leaves yield much gas, 10,000 cu. ft. being obtained from one ton. The wood is extensively used in Australia as fuel, and the timber is of remarkable size, strength and durability. Maiden enumerates nearly 70 species as timber-yielding trees including *E. amygdalina,* the wood of which splits with remarkable facility, *E. botryoides,* hard, tough and durable and one of the finest timbers for shipbuilding, *E. diversicolor* or "karri," *E. globulus, E. leucoxylon* or ironbark, *E. marginata* or "jarrah" (*see* JARRAH WOOD), *E. obliqua, E. resinifera, E. siderophloia* and others. The timber is often very hard, tough and durable, and useful for shipbuilding, building, fencing, etc. The bark of different species of *eucalyptus* has been used in paper-making and tanning, and in medicine as a febrifuge.

For further details *see* Baron von Müller's monograph of the genus, *Eucalyptographia* (Melbourne, 1879–84); J. H. Maiden, *Useful Native Plants of Australia* (1889); R. T. Baker and H. S. Smith, *A Research on the Eucalyptus Especially in Regard to Their Essential Oils* (Sydney, N.S.W., 1920); R. N. Parker, *Eucalyptus Trials in the Simla Hills, Calcutta* (1925).

EUCHARIS, in botany, a genus of plants of the family Amaryllidaceae, containing six species, natives of Colombia. *Eucharis amazonica* of *Egradiflora* is the best-known and most generally cultivated species. It is bulbous, with broad-stalked leaves, and an erect scape 1½ to 2 ft. long, bearing an umbel of three to ten large, white, showy flowers. The flowers resemble the daffodil in having a prominent central cup or corona. The plant is propagated by removing the offsets, which may be done in spring, potting them singly in 6-in. pots. It requires good loamy soil, with sand enough to keep the compost open, and should have a good supply of water. Other species met with in gardens are *E. Bakeriana, E. Mastersii, E. Lowii* and *E. Sanderii.* A remarkable hybrid between *Eucharis* and the allied genus *Urceolina* has been produced to which the compound name *Urceocharis* is given.

EUCHARIST, one of the ancient titles of the central sacramental rite of the Christian Church (Gr. εὐχαριστία, "Thanksgiving"). The term is probably to be regarded as the Greek equivalent of the Hebrew *Berakhah,* the Jewish "blessing" addressed to God at meals for and over the food and drink. It is in this sense that the term was originally used in connection with the common meal of the early Christian community, at which the "blessing" or "thanksgiving" had special reference to Jesus Christ. As early as the 2nd century it was applied also to the food and drink, the bread and wine, over which the blessing had been pronounced. Finally, it was used of the whole meal, and of the rite into which the meal developed.

Other names of the eucharist are: the *Lord's Supper,* so called from its particular reference to, and connection with, Jesus; *Communion,* Gr. κοινωνία and *Holy Communion,* from the fellowship with Jesus Christ and Christian believers, of which the observance was taken to be both the expression and the means; *Mass* Lat. *missa* or *missio,* a work of no doctrinal significance, derived from the "dismissal" with which Christian services of worship concluded (*see* LITURGY) and eventually used of any complete service, eucharistic or otherwise, its restriction to the eucharist dating from the close of the 4th century. In the Greek and Russian Churches the rite is known as *The Divine Liturgy,* Gr. ἡ θεία λειτουργία as being pre-eminently the public service rendered to God by the Christian society. In the Syriac-speaking, Coptic and Armenian Churches it is designated by words meaning "oblation" or "present" (Syr. *Qurbana;* Copt. *Prosfora;* Arm. *Patarag;* mod. *Badarak*). The Abyssinian Church terms it "the consecration" (Eth. *Qeddase*).

In the New Testament.—The earliest attestation of the eucharist is supplied by St. Paul in 1 Cor. xi. 17–34. From this passage it is clear that it was the practice of the Corinthian Christians to assemble for a common meal of religious significance. Paul protests that the Corinthians' conduct of the meal had nullified its religious significance. Faction and class-division, instead of fellowship and unity, characterized the gatherings. It was apparently the custom of each believer to bring his own provisions for the meal and to eat them without waiting for, or sharing with, his fellows. The rich, therefore, had more than they required, while the poor went hungry. This, according to Paul, was no "Lord's Supper." It was a mere satisfaction of the appetite for which their homes were the proper place.

The Lord's Supper is of a different order. Paul proceeds to recall the tradition of it which he had committed to the Corinthians and which he had received from (ἀπό) the Lord:—"The Lord Jesus on the night in which He was betrayed took bread, and having given thanks, broke it and said: This is My body which is for your sake. This do in memory of Me. Likewise also the cup after supper, saying: This cup is the new covenant in My blood. This do, as often as you drink it, in memory of Me." Then, in explanation of this command, Paul adds "For as often as you eat this bread and drink this cup, you proclaim (καταγγέλλετε) the death of the Lord until He come." It follows that the believer may not partake of the bread and the cup in disregard of the sacred character of the action in which they have figured. Paul continues: "Wherefore whoever eats the bread or drinks the cup of the Lord unworthily, shall be guilty of the body and blood of the Lord. Let a man prove himself, and thus let him eat of the bread and drink of the cup. For he who eats and drinks, eats and drinks judgment to himself if he do not rightly judge the body."

The passage presents difficulties, and it is too allusive to allow a detailed picture of the eucharist as observed by Paul to be drawn from it. Certain points, however, are beyond doubt. Though the Lord's Supper was not a liturgy, it was nevertheless a formal observance. Paul regards it as a presentation of Christ's death, which according to Christ's quoted words was of the nature of a covenant-sacrifice. Paul further taught that the Supper rested on the authority of Christ, in virtue of His institution of it and express command to continue it. The eucharist, therefore, for Paul was in some way a re-presentation of the crucifixion, ordained by Christ Himself to assure to His followers the enjoyment, until His proximate return, of the blessings which the crucifixion, as a covenant-sacrifice, had secured. This interpretation, however, cannot be taken as current outside the sphere of Pauline influence; Paul himself fails to cite the general assent of Christians in confirmation of the tradition which he asserts.

According to Paul, the eucharist was instituted at the Last Supper of Jesus with His disciples. Fuller accounts of this meal are found in the Synoptic Gospels. The passages in question are Mark xiv. 22–25, Matt. xxvi. 26–29, Luke xxii. 14–20; of these the oldest tradition, and next in order of time after Paul, is that of Mark. In substance the Synoptist and Pauline accounts are in agreement, with, however, two main exceptions. The Synoptists date the supper on the night of the Passover, and they omit the command to continue it. The *textus receptus* of Luke indeed includes the command, but the passage in which it occurs is an interpolation from the Pauline account; and whatever view be taken of the problem of the Lucan text, the command is no part of the original. The evidence, therefore, does not warrant the attribution to Jesus of the words "This do in memory of Me."

Two other sayings of Jesus at the supper appear in the Synoptist record. One is common to the three, though they report it in slightly differing forms: "I will not again drink of the product of the vine until that day when I drink it new in the Kingdom of God"; the other occurs in Luke alone: "I greatly desired to eat this Passover with you before I suffer, for I tell you that I will not eat it until it be fulfilled in the Kingdom of God."

The precise significance of the Synoptic record is difficult to ascertain. Jesus's words after the blessing of the cup may be held to give His sanction to a sacrificial view of His death; but

the Synoptist record is not an account of the institution of a sacrificial-sacramental action such as that described by Paul. Certain scholars have supposed that the Synoptist story implies a repetition of what Jesus did and said at the Supper. As a prelude to the narrative of Jesus's passion and death, however, the story need imply no more than that his death is to be interpreted, on His own authority, as a covenant-sacrifice. The two non-Pauline sayings suggest that the Supper was "an anticipation of the heavenly banquet in the kingdom" (the phrase is A. D. Nock's, *Early Gentile Christianity in Essays on the Trinity and Incarnation*), which Jesus's death was to inaugurate.

Both the date and the character of the meal raise a difficulty. According to the Synoptists, it was a Passover Supper, and was celebrated on the first evening of the Passover Feast. According to the Fourth Gospel, which gives no account corresponding with the accounts of Paul and the Synoptists, Jesus's Last Supper with His disciples occurred a day earlier, and was not Paschal in character. The objections to the Synoptist chronology are insuperable; the details of the meal, also, do not suggest a Passover Supper. The form of the tradition found in the Fourth Gospel is indubitably correct. The interpretation of Jesus's death in terms of Passover significance is perhaps a partial explanation of the form which the tradition takes in the Synoptist account.

The details of the Supper in the latter, however, throw some light on its character. They belong, apparently, to the ordinance known as the *Qiddush*. This was a domestic ceremony observed at home by a family or by a group of friends on the eve of a Sabbath or Feast-day, in "sanctification" of the day, hence its name. It was preceded by a social meal. Towards the close of the meal, the president of the group took a cup of wine and "sanctified" the day by reciting over the cup a blessing, which was, in effect, a thanksgiving for the Sabbath or Feast, or if they coincided, for both together. The cup was then given to the members of the group to partake of it. There was a similar blessing and breaking of bread. In the event of the coincidence of Passover and Sabbath, it was necessary to transfer the *Qiddush* from Friday, the Sabbath-eve, to Thursday, as Friday was reserved for the killing of the lambs and other Passover preparations. This Thursday *Qiddush,* nevertheless, was celebrated in the accustomed manner, and its blessing was a thanksgiving for the combined commemoration. It is hardly improbable that we have here the true explanation of the events reported of the Last Supper in the New Testament. Jesus, after the usual meal with His disciples, celebrated the *Qiddush,* and speaking and acting as is recorded, gave to it an eschatological import. Whether he called the bread his body during the meal or after the blessing of the *Qiddush* cup is of no consequence; the records are not clear on this point, and either would have been possible. It has been suggested that in the combined Passover-Sabbath commemoration we have also the explanation of the Synoptists' Passover tradition of the Supper. This may well have been a contributory factor.

But though the *Qiddush* accounts for the Last Supper, it affords no explanation of the origin of the eucharist. This perhaps is not now far to seek. Jesus and his disciples formed one of the *Chaburōth,* or "groups of friends," which were a feature of the religious-social life of contemporary Judaism. These groups met to discuss religious questions of mutual interest, to administer charity from their common fund, and for a common meal. The latter was of a formal religious kind, the president solemnly breaking and distributing bread over which he had first addressed a thanksgiving to God. "To break bread" was the general expression for eating the meal. The cup of wine was not essential, except at such a ceremony as the *Qiddush;* water was ordinarily sufficient, should drink be required. When, however, wine was drunk, the customary thanksgiving was first recited over it. Such a meal was a regular institution in the common life of Jesus and His disciples; it is of the background of the Gospels. The Last Supper and the Sabbath-Passover *Qiddush* was, therefore, no unusual occurrence. It represented consistent practice since Jesus had first formed the group. It is from this practice, rather than from any direct institution by Jesus, that the eucharist derives its origin. The practice was too firmly established for the group to abandon it, when its Master had been taken away; the primitive apostolic eucharist is no other than the continuation of Jesus's *chaburah* meal. This is the "breaking of the bread," Gr. ἡ κλάσις τοῦ ἄρτου of Acts ii. 42 (cf. *id.* ii. 46 and xx. 7). It was to become a distinctive feature of the life of Christian groups in every place.

For the original company of disciples the thought of the meal was inseparable from that of the presence of Jesus. How far they regarded the eucharist as the occasion of the presence of the risen Jesus with them cannot certainly be stated; the story of the Emmaus Supper and the accounts of the appearances in John xxi. 14, and Acts i. 4 (*cf.* Mark xvi. 14; Matt. xviii. 20) point to some such belief. How far a belief of this kind penetrated into the wider Christian circle is equally beyond ascertainment, but it is beyond question that the meal was now marked by particular reference to Jesus.

On this foundation there was variety both in the interpretation and in the manner of conducting the meal. For the earlier conservative Jewish element of the community, it was still primarily a *chaburah* meal of fellowship. In other and newer circles, as the death of Jesus came to be regarded as of central importance, the meal was inevitably related directly with what Jesus had done and said the day before He suffered, and became a constituent part of a wider doctrinal whole. The latter type of interpretation is illustrated in the Fourth Gospel and in the thought of Paul. In this treatment of the eucharist, the cup of wine is indispensable. The writer of the Fourth Gospel, though he omits mention of the blessing of the bread and the cup, nevertheless knows the story.

It is difficult to interpret John vi. except in reference to the Last Supper and to the eucharistic practice of the circle from which the Gospel proceeds. The sayings concerning "eating (τρώγειν) the flesh" and "drinking the blood" are to be understood of the bread and wine of the eucharist. This "realist" interpretation did not readily win wide acceptance in the writer's time:—"Many of His disciples when they had heard this said: 'This is a hard saying. Who can accept it?' . . . From that time many of His disciples went back and walked no more with him" (Jn. vi. 60, 66). But it was to attain increasing prominence as attention came to be concentrated on the Last Supper and as the former common meal assumed the features of a cultual act. As has been already noted, it was in process of becoming a cultual act within the sphere of Pauline influence at least half a century before the Fourth Gospel was written. This difference between the Pauline and Johannine lines of interpretation should, however, be observed; for the former, the emphasis and interest centre in the eucharistic action, for the latter, they centre in the eucharistic objects, the bread and the wine. Much of the history of the eucharist during the period under review consists in the combination and interplay of these two emphases and interests.

In the Sub-Apostolic and Patristic Periods.—The eucharistic diversity to which the New Testament points only gradually came to an end. In *The Teaching of the Twelve Apostles* (? A.D. 100) there are forms of thanksgiving over bread and wine, the latter being placed first, and a eucharistic prayer which is to be said "after being filled." The blessings of the bread and wine are reminiscent of the corresponding Jewish blessings. The *Didache* is the earliest document in which the term "eucharist" is used in its Christian technical sense, but in no one of its forms of prayer is there any reference to the body and blood of Jesus or to His crucifixion. Thanksgiving is offered to God over the cup "for the holy vine of David Thy servant," and over the bread "for the life and knowledge" which with the holy vine are made known "through Jesus Thy servant." The vine is suggestive of Psalm lxxx. 8–19, and signifies the true, the spiritual Israel, the Church, for the "gathering together" of which "into Thy Kingdom" prayer is made after the thanksgiving over the bread.

The eucharist of the *Didache* is still associated with a common meal, as the words "after being filled" indicate. The uppermost thought of its prayers is that of the community, blessed by God through Jesus, and of its unity. The one eucharistic loaf is taken

as symbolical of that unity (*cf.* 1 Cor. x. 17), and participation is restricted to authentic members of the community, the baptized. The "Lord's Day" is to be the occasion of the eucharistic celebration, which is held to be the fulfilment of Malachi i. 11: "In every place and time offer we a pure sacrifice." In spite of its divergences from what was to be the eucharistic norm, the *Didache* does not completely lack affinity with the norm, and traces its descent from New Testament practice. Divergences of other kinds are to be noted in *The Acts of John, The Vercelli Acts of Peter* and *The Acts of Thomas*. Though these proceed from unorthodox circles, they are nevertheless survivals of the diversity of tradition.

In the central Graeco-Roman Church, the eucharist had become an established "rite" by the middle of the 2nd century. It was not yet a "liturgy," but it had a fixed order, the matter of its prayers was settled, and its celebrant was duly authorized. *The Epistle to the Corinthians* of Clement of Rome (*c.* A.D. 96) had stated that Christ had fixed the worship to be performed, and the persons who should perform it.

Ignatius of Antioch (*c.* A.D. 108) insists that the eucharist, to be genuine (βεβαία) must "be celebrated by the bishop or by one whom he appoints" (Smyrn viii. 1). This is in the interest of unity, which is stressed no less by Ignatius than by the *Didache*. The normal celebrant of the eucharistic service, the bishop, is the local focus of Christian unit, as the eucharist itself is at once the symbol, the safeguard, and the means of that unity, as being "one flesh of our Lord Jesus Christ and one cup for union with His blood" (Philad. iv. 1). The Ignatian conception of the local church is the *chaburah,* extended and adapted to its extension; and it is noteworthy that the term *"agape"* which Ignatius uses for eucharist (Smyrn viii. 2) is the Greek equivalent of *chaburah.*

Ignatian references to the eucharist are, however, incidental; fuller information is to be found in Justin Martyr and Irenaeus, at the middle and end of the same century. Both these authors derive the eucharist from the Last Supper, and appear to know no other tradition. Both regard the bread and wine as in some sense the body and blood of Christ. How they are so, neither states; Jesus's words at the Supper are adduced as sufficient ground for the belief. According to Irenaeus, the bread "receiving the invocation of God . . . is eucharist, consisting of two parts, an earthly and a heavenly" (Adv. Haer. iv. 18). In virtue of the "heavenly," the eucharist can be as Ignatius had taught (Eph. xx. 2) following the Johannine thought (Jn. vi. 54 *sqq.*), "a medicine of immortality." In their view of the eucharistic objects, both Justin and Irenaeus are "realists," but their realism is a matter of imagination rather than of thought. Both writers further treat of the eucharist in sacrificial terms, seeing in it the fulfilment of Malachi i. 11. The sacrifice is one of praise and thanksgiving for creation and redemption, and the offering of it is commanded by Jesus Christ. Irenaeus considers the sacrifice to be an oblation of first fruits, which should be offered to God "not as though he is in need," but as tokens of thankfulness (Adv. Haer. iv. 17). Justin interprets the words "Do this in memory of Me" as "Offer this," and thinks of the eucharist as also a commemoration of Jesus Christ's passion. Justin and Irenaeus mark a definite stage in the development of the eucharist. No interpretation of it after their time differs fundamentally from theirs. Henceforward, in the main stream of Christian tradition, the eucharist is not regarded except as a continuation of the Last Supper, and its significance is believed to lie in the words: This is My body, This is My blood, and Do this in memory of Me.

The development of sacrificial theories of the eucharist is in some measure a Christian attempt to meet the pagan objection that Christians had no sacrifices and were, therefore, atheists; and in some measure also an attempt to solve the problem of post-baptismal sin and lapse, by so identifying the eucharistic action with the sacrifice of the cross as to make the former a means of securing the effects of the latter. Cyprian (A.D. 258) speaks of the eucharist as an offering of the body and blood of Jesus Christ, and a century later the eucharistic prayer of Sarapion conceives the liturgical action as "making the likeness of the death," so being a reconciliatory sacrifice.

Notice should here be taken of an important eucharistic conception and terminology, the symbolical, particularly connected with the names of Tertullian, Cyprian and Augustine, though it is not restricted to Africa and the West. The bread and wine are said to be figures, symbols, likenesses, or antitypes (figurae, imagines, σύμβολα, ὁμοιώματα, ἀντίτυπα) of the body and blood. They "re-present" (repraesentant) them, *i.e.,* make them present. The symbol is not the sign of an absent reality, but is in such a way associated with its reality that it is in some sense what it symbolizes and possesses the effect of the reality. A similar idea is applied to the liturgical action. This is a copy or analogue both of the Supper and of the passion in such a way "that as often as the memorial of the victim pleasing to Thee is celebrated, so often is the work of our redemption set in operation" (Leonian Secret in Muratori, *Liturgia romana vetus* i. 303–304).

The central section of the Canon of the Roman Mass (4th–5th century), is an example of the analogue. It is an imitation of the Supper in word and act, solemnly performed before God. As such it strictly has no moment of consecration, but the repetition of Jesus's words is necessary as completing the association of the analogue, both objects and acts, with the realities of the Supper. Hence the later transformation of these words into "the form of consecration." The central moment of the action is the offering of "the holy bread of eternal life, and the chalice of eternal salvation," the making of the memorial of Christ in accordance with the command: Do this. Here the analogue has passed from the Supper to the cross. The eucharist on this presentation of it is a sacrificial-sacramental action of saving efficacy, and the worshippers partake of the bread and the wine, not as a personal act of piety, but as participants in the saving transaction. This view, it will be observed, has points of contact with the Pauline in its stress upon the eucharistic action.

The symbolic theory was destined, however, to be superseded by a theory of the realist type. The simpler realism of Justin and Irenaeus in time proved unsatisfactory. If the bread and wine are to be regarded as the body and blood, the questions: How are they so? and What makes them so? must at some point arise; and the answers given to them must in their turn re-act upon eucharistic belief and practice.

Cyril, bishop of Jerusalem in A.D. 350, is the first to go beyond the earlier realism. His thought was, doubtless, moulded by the pneumatological controversies of his time, and by their effect upon the doctrines of incarnation and sacraments. Cyril teaches that the Holy Spirit, who is a living person within the Godhead, descends upon the bread and wine at the prayer of the celebrant, and changes them into the body and blood (Cat. Myst. v.). This is the first appearance of the Epiklesis, the normal Eastern form of consecration.[1] It is a departure which is to become a rule. A theologian contemporary with Cyril set himself to work out the implications of Cyril's idea. According to Gregory of Nyssa, the objects are "transmade" (μεταποιεῖσθαι) or "transelemented" (μεταστοιχειοῦν) into Christ's body and blood, just as, in His days on earth, bread and wine taken by Him as food were metabolized into His flesh and blood at digestion, the whole being dignified by its union with the Logos. Such is the effect of eucharistic consecration; it is real and objective, but for Gregory it is a change of relation, not of nature. Subsequent Greek speculation was content to re-echo the ideas and terms of Cyril and Gregory without further pursuing their lines of thought. When Greek orthodox eucharistic theology attains its final formulation in the *De Fide Orthodoxa* of John of Damascus (*c.* A.D. 759), these ideas and terms re-appear, though John advances beyond Gregory in his complete identification of the eucharistic objects with Christ's body and blood, and in his notion of the eucharistic body as identical with that born of Mary (*De Fid. Orth.* xiii.).

In its effect upon popular devotion and cultus, Cyril's conversion teaching was revolutionary and has proved permanent. Hitherto the intercessory prayer of the eucharistic service had not been connected with the central action. Cyril introduces them after the consecration and before communion, as being more efficacious at that point because presented with the "holy and

[1]See note at end of article.

most awful sacrifice," which is "Christ propitiating God" for men (*see* Cat. Myst. v.). John Chrysostom (A.D. 407) in whose service the intercessions occur in a similar position, holds the time after the consecration as specially propitious for prayer, particularly on behalf of the dead, as then "we supplicate the Lamb that taketh the sin of the world and that now lies (on the altar)" (Hom. in 1 Cor. xli. 4). Both here and elsewhere he uses language which suggests that prayer at the eucharist is to be offered to Christ, believed to be present in virtue of the consecration; and at all times he stresses the awfulness and solemnity of the eucharistic service. There is here a change in emphasis, which is, in fact, the forming of a new tradition, as it was a change made easily intelligible to the mass of worshippers by a corresponding development of ritual and ceremony, and therefore easily shaping cultual outlook and practice. The eucharist was now, and in the Greek Orthodox and kindred Churches continues to be, a propitiatory sacrifice, in which an awful Divine victim is offered with certain efficacy.

In the West the conversion theology was introduced by Ambrose of Milan (A.D. 397), who associates the consecration with the repetition of the words: This is My body, and This is My blood (De Myst. ix.). It succeeded in no more than partially establishing itself, since the thought of the West was dominated by Augustine (A.D. 430). More fully than had been done before, Augustine dealt with the notion and nature of sacraments; but he made little advance on the earlier theory. He continued, and in a measure explicated, the symbolic tradition; and his thought was destined to influence eucharistic thinking and discussion in the middle ages. He takes a sacrament to be the sign of a Divine thing; in it "one thing is seen, but another is understood" (Serm. cclxxii.). The bread and wine, therefore, sanctified to become sacraments of Christ's body and blood, are as such the means of communicating a supernatural gift, but are always to be distinguished from the gift. This view was not congenial to the forms of eucharistic devotion which were developing under the influence of the conversion theology. The latter, however, was never excluded from the West. Caesarius of Arles (A.D. 543) and Gregory the Great (A.D. 604) maintain it; and it appears in some of the prayers of the Latin sacramentaries. The petition in the present Roman Canon: "Which oblation do Thou bless . . . in order that it may be unto us the body and blood of Thy most dear son, Jesus Christ" (*Quam oblationem*) probably represents a middle position between the complete conversion theory on one hand, and on the other the symbolic teaching of the older form of the petition: "Bless unto us this oblation, because it is the figure of the body and the blood." The propitiatory theory of the sacrifice inevitably accompanied the conversion view, and likewise finds expression in the sacramentaries. The language of certain writers, among them Gregory the Great, suggests that the eucharist is a renewal of the sacrifice of Christ on the Cross.

From the middle of the 2nd century, some kind of reservation of the eucharist has been commonly practised. Justin attests that the consecrated objects were taken by deacons to those who could not be present at the gathering. At a later period, it was permitted to take away portions of the consecrated bread and to consume them at home. From the 4th century, the consecrated bread was reserved in a box on the altar or in a chamber attached to the church.

In the Middle Age.—In the East the conversion doctrine was established as the orthodox belief, and the middle age marked no advance upon, or withdrawal from, the position laid down by John of Damascus. In the West, on the other hand, the middle age was to see the conflict between the symbolic and conversion theologies and a decision in favour of the latter. The conflict began in A.D. 844 with the re-publication by Paschasius Radbertus, of Corbie, of his work *On the Body and Blood of the Lord.* This is the first systematic treatise on the eucharist. Paschasius asserted that the bread and wine are changed by consecration into the body and blood of Christ that were born of Mary. The change, however, is not apparent to the senses; it is inward and requires faith in order to be known. The sacramental gift, therefore, is spiritual in character. Paschasius was in the tradition of Ambrose, and he knew the teaching of John of Damascus, but he was not unaffected by Augustine.

He was answered by Ratramnus, also of Corbie, in a treatise under the same title. Charles the Bald had asked Ratramnus two questions: Is the eucharist Christ's body and blood in mystery or in sensible reality (in veritate?) and: Is it the body that was born of Mary and is exalted in heaven? Ratramnus's treatise is an answer to these questions. He proceeds to answer the first by defining the terms *mystery, figure* and *sensible reality. Mystery* denotes that which contains something hidden and is open only to the eye of faith. *Figure* (figura) is that which conveys its meaning under a veil. *Sensible reality* (veritas) is that which is set forth clearly and openly in its natural character. In the eucharist, bread and wine are received, but Christ's body and blood are understood. The latter, therefore, are received in *mystery* and *figure,* not in *sensible reality.* The second question Ratramnus answered negatively. Following Ambrose he distinguishes between the sacrament of the flesh and the sensible reality of the flesh. Christ suffered in the latter; the eucharist and the former are the same thing, the eucharistic body cannot, in consequence, be identified with the latter. The eucharist is Christ's body and blood, because in it the power of Christ is communicated. Ratramnus's treatise left unsolved the problem which Paschasius's doctrine raised, mainly because it suffered from the vagueness which characterized the Western symbolic tradition. Ratramnus's dissent from the conversion doctrine is unambiguous, but it is not clear whether he believed that the body and blood were truly, though not in *sensible reality,* present in the eucharist, or whether he held the eucharist to be no more than a means of conveying power to unite the recipient with Christ. Other writers of the period took part in the controversy. Hincmar and Remigius of Rheims, and Ratherius of Verona, siding with Paschasius, and Amalarius of Metz, Florus of Lyons, and Rabanus Maurus, taking the opposition; but these no more than the protagonists contributed towards the solution of the problem.

Two centuries elapsed before the question was again discussed. In the meantime the conversion teaching of Paschasius had gained wide acceptance, and was being interpreted in a materialistic sense. The mass was popularly believed to be the occasion of a physical miracle. The use of symbolic language was treated as a mark of unorthodoxy. The immediate cause of the second controversy was a letter written in A.D. 1050 by Berengar of Tours to Laufranc of Bec, condemning the doctrine of Paschasius and defending that put forward by Ratramnus. He was condemned by two councils, and required to sign a confession of faith to the effect that the consecrated bread and wine are not only a sacrament, but the real body and blood of Christ, and that these, "not only sacramentally, but in sensible reality (*in veritate*), are taken in the priests' hands." Berengar submitted, but later published his views at length, in his treatise, *On the Holy Supper.* He revives the symbolic teaching, appealing to Augustine and the prayers of the Roman mass. He allows a change of the bread and wine into the body and blood in the sense that they become signs of the latter by consacration; but he denied "subjective change" on the ground that such is impossible without a corresponding change in appearance and perceptible property. Berengar was as vague as Ratramnus. His contemporaries interpreted his language in more ways than one. Guitmund of Aversa understood him to teach a theory of impanation and invination, *i.e.,* that in the eucharist Christ assumes bread and wine, as at the incarnation he had assumed flesh. Berengar was required to sign a second declaration in 1079, affirming that the bread and wine are "substantially converted" (*substantialiter converti*) and that after consecration they are the real body and blood born of Mary "not only by way of sign and power of sacrament, but in property of nature and reality of substance." Berengar subscribed, and the conversion theology was victorious. Conversion, for the most part in, its crudest form, was now the orthodoxy of the West.

In the 12th and 13th centuries the balance was to some extent redressed. Scholasticism set it itself to re-examine, and within the limits of orthodoxy, to re-state the whole of sacramental doctrine. Orthodoxy consequently tied down the scholastics' eucharistic theory to conversion. Setting out from Augustine's distinc-

tion between the sacrament and that which it signifies, and from his definition of a sacrament as a visible sign of an invisible grace, they formulated their theory in terms of *substance* and *accidents*. Both terms had been used in the discussions of the previous century; and Berengar had already made the distinction between "subject" in the sense of *substance* and *accidents*. *Substance* denotes the underlying reality or being which constitutes a thing what it is and is not perceptible by the senses. *Accidents* are the properties and attributes which inhere in the substance, and which are perceptible by the senses. The substance in a thing can be perceived only by thought; likewise in the eucharist, the body and blood which are the substances of the sacrament can be apprehended only by faith. At the consecration the substances of the bread and wine change "by transition" (*per transitionem*) into the body and blood. The accidents remain as and what they were. They do not inhere in, and are not affected by, the body and blood; they exist *per se*. It is then the accident only, not the body, that is taken into the priest's hands. There is here a marked refinement of the view current in authoritative circles in the 11th century.

The term used to describe the change is "transubstantiation" (transubstantiatio): it occurs, seemingly for the first time, in the *Exposition of the Canon of the Mass*, attributed to Peter Damiani (A.D. 1072). The verb appears in the Definition of Faith of the Fourth Lateran Council (A.D. 1215): Christ's "body and blood are verily contained in the sacrament of the altar under the species of bread and wine, the bread being transubstantiated into the body and the wine into the blood, by Divine power." The context does not make it clear that the word "transubstantiated" is to be interpreted precisely in the sense outlined above, but the belief usually denoted by the term was general in the Western Church at the time of the Council.

It remained for Thomas Aquinas (A.D. 1227–1274) to cast the doctrine in its final form. Aquinas represents alike the farthest reach of the scholastic re-action from earlier mediaeval materialism, and the extreme of refinement in conversion doctrine. Treating of the presence of Christ in the eucharist, he states that it is not local, but is "after the manner of a substance" (*per modum substantiae*, Sum. Theol. iii. lxxvi. 1), so that where the sacrament is moved, Christ can be said to move only *per accidens*, not *per se* (S. T. iii. lxxvi. 6). Similarly, he affirms that the whole Christ, body and blood, is present in each particle of the sacrament and under each species by concomitance (iii. lxxvi. 1). The spiritual reception of the body and blood is dependent upon the disposition of the communicant; the wicked receive only sacramentally. Aquinas also addressed himself to the problem of the existence in the sacrament of the accidents of bread and wine when the substance was the body and the blood. He thinks that they exist in dimensive quantity, as though in a subject (*sicut in subjecto in quantitate dimensiva*, iii. lxxvii. 2); this is admittedly miraculous, though of course not thereby unreasonable.

The doctrine of transubstantiation was all but universally accepted. Some scholastics, however, challenged it, particularly those dissatisfied with the treatment of the problem of the continued existence of the accidents, conspicuous among whom was Wyclif. The doctrine had the twofold merit for its own time of harmonizing with current philosophy, and of satisfying the demand of popular religion for a miraculous conversion in the mass; but such was its dependence upon the scholastic philosophy that it was unintelligible apart from that philosophy and incapable of surviving its supersedence.

Throughout the middle age the doctrine of the eucharistic sacrifice was secondary to that of the eucharist itself. The earlier mediaeval theologians were content to accept the later patristic views; but, together with a new interest in the effects of the sacrifice, expiatory ideas early appeared and developed in conjunction with conversion teaching. Paschasius maintained that Christ, as priest and victim, offered himself in the mass for daily sins, though this offering is one with, and not a renewal of, that of the Cross. The expiatory idea quickly found favour, and passed to the scholastics as orthodox.

It was not until the 13th century that there was any scholastic attempt at an exact treatment of the subject, and that an examination of the nature and essentials of sacrifice was undertaken. Thomas Aquinas holds that the offering of sacrifice is a law of nature (S. T., ii. ii. lxxxv. 1) and that it is necessary that "something is done" to the object offered, *i.e.*, bread is broken, is eaten, and is blessed (ii. ii. lxxxv. 3). In the eucharist the consummation of the sacrifice consists in the consecration of the matter, not in the communion of the faithful; participation, however, is necessary to a sacrifice, and the priest communicates both for himself and as representative of the faithful (iii. lxxx. 12). The priest consecrates in the person and by the power of Christ (iii. lxxxiii. 1). The eucharist, therefore, is offered by Christ himself, and possesses the efficacy of the sacrifice of the Cross, of which it is representative and commemorative. As such it blots out the mortal sins of those for whom it is offered, according to their moral disposition, "as if the sacrament of penance had been administered to them" (Vasquez). There were protests against expiatory teaching from time to time during the middle age, but they made no mark. At the close of the period it was generally held that the mass was a sacrifice for actual sin, as the Cross was a sacrifice for original sin.

The effects of mediaeval eucharistic controversy on popular religion were manifold. Interest was inevitably concentrated on the mass and the sacrament. But the popular mind could not appreciate the subtleties of scholastic doctrine. Popular interpretation of transubstantiation was no less crude than in the case of earlier conversion doctrine. Legend told how the miniature figure of a man had been seen in the priest's hands at the elevation of the host, and it was believed that on certain occasions the host had bled on being broken by the priest.

In the 13th century, the moment of consecration, emphasized by the new ceremony of the elevation of the host—Eudes de Sully, bishop of Paris, was apparently the first to decree it in A.D. 1208—had become the climax of the eucharistic service; the elevation of the chalice was to follow a century later, and the significance of the ceremony was further increased by the accompaniment of censings, the lifting-up of lighted candles, and the ringing of bells. At the same time communion became increasingly infrequent. The introduction of the Festival of Corpus Christi in A.D. 1264 considerably encouraged eucharistic devotion.

A cultus of the reserved sacrament developed, and before the close of the period under review the ceremonies of exposition and benediction had made their first appearance in northern Germany (*see* E. Bishop, "Pastor Dreygerwolt's Diary," in *Liturgica Historica*, Oxford, 1922). The popular mind was also quick to seize on the bearing of the expiatory view of the sacrifice. Masses were multiplied with special intention, particularly for the repose of the souls of the dead. The exaggerations both of belief and practice which gathered around the eucharist in the middle age and the attendant growth of the power of the priests led irresistibly to the Protestant reaction of the 16th century. It should, however, never be forgotten that the eucharist, both the service and the sacrament, was at all times for not a few an occasion and stimulus of spirituality. The presentation of the service as a moving-picture, whether of the passion and death, or of the whole life, of Christ gave nourishment to the artistic imagination, and its effect is to be seen in the poetry, painting and sculpture of the middle age. For the majority also, the mass was the one means of contact with culture, and the sole avenue of escape from the hardship of environment. In spite of the abuses connected with it and with the system of which it was part, the mass has exercised an incalculable influence on the cultural and spiritual development of Western Europe.

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(E. C. RA.)

REFORMATION AND POST REFORMATION

The Eucharist from 1500.—The offering of the sacrifice of the mass by the priesthood was the centre of the life of the mediaeval Church. When the Reformation reaffirmed the primitive idea of the priesthood of all believers, and transferred the centre of religious interest to the faith of the believing man, it was inevitable that the practice and theory of the mass, as it had come to be, should be challenged.

Luther.—In the *Praeludium de captivitate babylonica*, one of the three great reforming manifestoes of 1520, Luther denounced three "captivities," which the Papal Babylon had imposed upon the Church in the matter of the eucharist: (1) in conflict with the command of Christ and the teaching of St. Paul the cup was withheld from the laity; (2) the doctrine of the transubstantiation of the elements was enforced, though it had no foundation in Scripture and was objectionable in philosophy; and (3) the mass was regarded as a sacrifice. As against the doctrine of transubstantiation, Luther leaned to the alternative theory that the substances of the bread and wine remain, together with the substances of Christ's body and blood. This theory Luther had learnt from the later Nominalist scholastics who had declared it to be more rational and more biblical than the doctrine of transubstantiation, and had accepted the latter doctrine.

But it was in the sacrificial conception of the mass that Luther saw the gravest and most iniquitous corruption of the sacrament, for by the doctrine of the sacrifice of the mass it was implied that man could do a work which God would accept as a satisfaction for sin. The mass, according to Luther, was not a sacrifice, but a promise. It was a summary of the Gospel, whereby Christ promises to us, antecedent to our own merit, the forgiveness of our sins. This promise can be accepted by faith and faith alone. In the Latin mass of 1523 and the German mass of 1526 Luther translated his doctrine into practice. The main order of the mediaeval mass was allowed to stand when it had been purged of the sacrificial idea. This meant that the solemn offertory of the elements, and the canon of the mass were expunged. In place of the latter was substituted a simple recital of the words of institution.

Zwingli developed his eucharistic doctrine under different influences and in a different direction. Like Luther, he rejected the sacrifice of the mass. In the Lord's Supper we receive from God, we do not offer to Him. But, whereas Luther retained a realistic doctrine of the presence of Christ's body and blood in the elements received, Zwingli regarded the elements as *signs* of the broken body and outpoured blood. The word *est* in *Hoc est corpus meum* he interpreted as *significat*. Zwingli's teaching in this respect had affinity, as he himself claimed and as Luther allowed, with the characteristic Augustinian distinction between the *sacramentum* and the *res sacramenti*. The two leaders with Melancthon and Oecolampadius, met in conference at Marburg in 1529, and though they were able to agree on 14 articles of faith, they were obliged to register a difference in belief with respect to the corporal presence of Christ—the Sacrament. Luther maintained and Zwingli denied that the body and blood of Christ were received not only by the faithful, but also by the ungodly, recipient. An examination of Zwingli's teaching seems to show that in his earlier period, and again towards the end of his life, his teaching was less negative in form than during the controversy. He cannot without qualification be credited with Zwinglianism, as it was later understood.

Calvin.—The Importance of Calvin in respect of eucharistic doctrine lies in the rôle which he strove to fulfil, of mediator between the Zwinglian doctrine and the Lutheran. With Zwingli, he rejected the cumbersome doctrine of the ubiquity of Christ's glorified body whereby Luther had tried to combine belief in Christ's corporal presence in the sacrament with His exaltation to the right hand of God. But Zwingli, Calvin held, had allowed himself to be drawn by controversy into too much denial. The elements are not only *signs*, as Zwingli taught, of the spiritual grace, but also *instruments* whereby the grace is imparted to the faithful receivers. Calvin took as his starting point the session of Christ at the right hand of God. This meant that Christ shares in the omnipotence and majesty of God, therefore, though His glorified body is in heaven, Christ is able to project this power without spatial limitation. Thus Christ bestows upon the faithful receiver of the sacrament, not, indeed, the substance, but the saving power of His body. "We say that the body and blood of Christ are truly and efficaciously, but not naturally, offered to us. By this we mean that it is not the very substance of the body or the true and natural body of Christ that is there given, but all the benefits which Christ by His body has procured for us. The presence of the body is such as the intention of the sacrament requires." (*Instit.*, 1st ed., 1536, cap. iv., *Opera* i. p. 123.) Calvin further developed the idea that the life-giving virtue of Christ's glorified body is so diffused by the Holy Spirit that in the Supper the souls of the faithful are enabled to feed upon the substance of the glorified body (*see* Calvin on 1 Cor. xi. 24).

The Council of Trent.—The Roman Catholic Church replied to the eucharistic doctrines of the Reformers at the 13th and 22nd sessions of the Council of Trent. At the 13th session (Oct. 1551) the doctrine of transubstantiation was reaffirmed and an anathema pronounced against any who should affirm that "in the most holy sacrament of the eucharist the substance of the bread and wine remains together with the body and blood of our Lord Jesus Christ," or should deny "that wonderful and singular conversion of the whole substance of the bread into the body and of the wine into the blood, the appearances (*speciebus*) of the bread and wine alone remaining, which transformation the Catholic Church most fitly names transubstantiation." At the 22nd session (Sept. 1562) the mass was declared to be a true, proper, propitiatory sacrifice offered on behalf of the sins, penalties, satisfactions and other necessities of the faithful, both living and departed, and an anathema was pronounced against any who should affirm the sacrifice of the mass to be only a sacrifice of praise and thanksgiving, or a bare commemoration of the sacrifice completed on the Cross, or who should affirm it to be of benefit only to him who received it, and not also to the faithful living and departed.

Thus the Reformation and the Counter-Reformation of the 16th century left the Church of Rome and the Churches of the Reformation sharply opposed in their doctrine of the eucharist. Important attempts, to be noted later, were made from both sides during the 17th century to find a basis for agreement, but the gulf has never since been bridged. Among Protestants, too, the difference in eucharistic doctrine between Lutherans and Reformed, inherited from the 18th century, remained a dominant factor in the history of the Churches during the 17th century.

Alongside the two dominant types of Protestant eucharistic doctrine, the Lutheran and the Reformed, must be recognized a leaven of Socinianism which, in spite of the opposition of orthodox theologians, penetrated throughout the Churches of the Reformation. The Racovian Catechism (first published 1605, a year after the death of Faustus Socinus), rejects the Roman, the Lutheran and the Calvinistic forms of eucharistic teaching, and regards the Lord's Supper, not as a means of grace, but solely as a remembrance of the death of Christ. This type of interpretation grew increasingly influential with the spread of rationalism in the 18th century.

A different spirit inspired the Quakers who, alone of Christian sects, rejected on principle the outward sacramental rite: "The communion of the Body and Blood of Christ" wrote Robert Barclay "is inward and spiritual, which is the participation of his flesh and blood, by which the inward man is daily nourished in the hearts of those in whom Christ dwells, of which things the breaking of bread by Christ with his disciples was a figure, which they even used in the Church for a time, who had received the substance, for the cause of the weak; even as abstaining from things strangled and from blood, the washing of one another's feet and the anointing of the sick with oil, all which are commanded with no less authority and solemnity than the former; yet seeing they are but the shadows of better things, they cease in such as have obtained the substance." (*Apology,* Thesis Theol. xiii.)

The Reformation had appealed from the authority of the Church to the authority of Scripture, and it allowed no doctrine to be taught as necessary to salvation except such as could be proved from Scripture. The interest was dogmatic, and the dogmatic standpoint continued in the ascendant until about the middle of the 17th century.

Criticism.—But from the later years of the 16th century, there was a tendency and an increasing tendency, to carry theological debate from the sphere of dogma into the sphere of history. The Roman Catholic claimed that the Church had preserved in fact the original deposit of faith and appealed to the continuous testimony of history to make good his claim. This claim made it incumbent upon Protestants to show not only that the original texts of Scripture did not, in fact, support the corruptions and accretions which they rejected, but also how and when these corruptions had set in. This change in the field of controversy explains the character of some of the great works of the 17th century on the eucharist. Aubertin (Albertinus) *De Eucharistia,* 1655, was for long a standard work of reformed theology. It is divided into three books, of which the first establishes the scriptural teaching, the second examines the teaching of the fathers of the first six centuries, and the last traces the course of the corruption which changed the primitive doctrine into the transubstantiation of the contemporary Church of Rome. The fathers, Aubertin holds (p. 903), maintain a change in the elements *accidentaliter* by the addition of a special significance and grace, not a change *substantialiter,* though he allows that from the end of the 2nd and beginning of the 3rd century there was a tendency to assign "too much power and efficacy"—he speaks as a Protestant—to the eucharistic signs. But this tendency, in their teaching, was not peculiar to their theory of the eucharistic elements. It appears also in their attitude towards the waters of baptism (*q.v.*). The beginning of the idea of transubstantiation in the eucharist, he traces to Anastasius of Sinai in the 7th century.

On the other hand the Port Royalists, Nicole and Arnauld, in their monumental reply to the Protestant Claude, *La perpétuité de la foi de l'Église Catholique touchant l'Eucharistie* (1669) argue that if the substantial change in the elements was not a part of the original faith of the Church, it must have been a most notable innovation, that no such innovation can be proved to have taken place, and that, though the fathers do not use the term transubstantiation, they assume the truth of the idea. The doctrine has therefore remained the same through all the ages of the Church. This appeal to history lies behind the various attempts to heal the breach of the Reformation; which, from George Cassander in the 16th century to Leibnitz and Bossuet at the end of the 17th, engaged the thoughts of some of the best minds of Christendom. The hope was shared by some Protestants and some Catholics (without much encouragement from authority on either side) that Christian antiquity might form a common meeting ground for the sundered Churches.

England.—The appeal to antiquity was represented in all the communions of Christendom, but it was especially characteristic of the Church of England. The eucharistic teaching of the Anglican Prayer Book and Articles is broadly in line with that of Calvin. Transubstantiation is repudiated, and Article XXIX., *Of the wicked which eat not the Body of Christ in the use of the Lord's Supper,* rules out the Lutheran doctrine of the corporal presence of Christ. The affirmative statements of eucharistic doctrine, both in the Articles and in the Catechism, are in line with Calvin. But the 16th century divines of the reformed Church of England, from Cranmer onward, were remarkable for their appeal to patristic testimony in justification of their doctrinal reform, and in the 17th century High Anglican divines and others under the influence of Patristic teaching, tempered the eucharistic doctrine of the Reformation period with a cautious revival of the sacrificial idea. Andrewes was willing to call the eucharist not only the commemoration of a sacrifice but also, and alternatively, a commemorative sacrifice. Joseph Mede, a Cambridge *savant* of no definite school in theology, complained that all Western Christendom, whether Roman or Protestant, had forgotten the primitive idea attested by Irenaeus, that the bread and wine are offered in sacrifice to God in recognition of His Lordship of creation; and Mede further maintained that it was not incompatible with the Reformed religion to allow that Christ is offered in the eucharist—though commemoratively only.

Such teaching, it should be added, never passed unchallenged in the Church of England. Thus Cudworth, the Cambridge Platonist, in reply to Mede, denied that the eucharist could be properly spoken of as a sacrifice. The proper idea, Cudworth maintained, was that it was a symbolical feast upon a sacrifice. But Mede's doctrine was taken up by influential divines, such as Bishop Bull and Dr. Grabe. In their doctrine of the presence of Christ in the eucharist the Anglo-Catholic divines of the 17th century remained essentially true to the Calvinian type. Even Thorndyke, who, perhaps, represents the most advanced Anglican teaching of the century on the eucharist, carefully stops short of affirming a *substantial* presence of the body and blood and emphatically denies a *substantial* change in the elements. "Calvin's words (about the presence of Christ)" said Cosin "agree so well with the style and mind of the primitive fathers that no Reformed Catholic could desire to use any other."

Daniel Waterland (1683–1740) continued on into the 18th century the tradition of the old learned Anglican theology. In his treatise on the eucharist he has two extremes in view: (1) the developments of eucharistic doctrine among the non-jurius divines, supported by their friend, Johnson, in the Established Church, and (2) the reduced interpretation of the Supper as a purely commemorative rite advanced by Bishop Hoadley. Waterland himself follows in the line of Cranmer and Hooker. He will not allow the idea of a material sacrifice of bread and wine, nor will he allow that Christ is offered in the eucharist. "We do not offer Christ to God in the eucharist, but God offers Christ to us in return for our offering ourselves." He also finds the idea of the union of the Spirit with the elements (akin to the doctrine of the Greek Church, favoured by Johnson and the non-jurius) to be "a gross notion and groundless." "If it were admitted," he adds, "Yet could it not make the elements, in any just sense, our Lord's body, but the notion would resolve into a kind of 'impanation' of the Spirit, for the time." *Doctrine of Eucharist* ch. vii. *fin.*

This line of teaching criticized by Waterland, which represents the consecration in the eucharist as effected through the invocation of the Spirit upon the elements, as in the Greek liturgies, had left its mark upon the First Prayer Book of Edward VI., and though it disappeared from the Prayer Book of 1552, it was revived in the Scottish book of 1637. It has been maintained—though not exclusively—in the Scottish Episcopal Church, and through that Church was transmitted to the Episcopal Church of America. When Bishop Seabury was consecrated first bishop of the American Episcopal Church he recommended to his congregations in Connecticut an office for the communion which conformed closely to the Scottish type. In 1789 the Convention of the American Church drew up an office in which an invocation of the Spirit was retained, but they brought the language expressing the intention of the prayer into close conformity with the invocation which opens the consecration prayer in the English Prayer Book. The "Deposited Book" of 1927 proposed to authorize a consecration prayer for the Church of England which included an invocation of the Holy Spirit upon the elements.

Waterland holds a peculiarly representative position in the tradition of Anglican theology. His works remained a standard authority with the High Churchmen of pre-Tractarian days, and so late as 1880 his treatise on the eucharist was reprinted by special request of the archbishops of Canterbury and York as "a safe and perspicuous guide to these tenets on the sacrament of the Lord's Supper, which, as a matter of fact, have been held by the great majority of the ablest and most learned theologians of the Reformed Church of England." (Preface by Bishop Jackson of London.)

The Tractarian divines went behind Waterland and revived the more advanced teaching of some of his predecessors of the 17th century, while in their doctrine of the Real Presence, they and their successors have often been insensitive to limits which the 17th century divines had instinctively respected. It has been

characteristic of much of the modern teaching of the High Church school in the Church of England to relate the sacraments more closely to the Incarnation than to the Atonement. It has been a congenial thought that the Divine life which appeared incarnate in Jesus Christ is perpetuated through the sacramental principle in the Church. Eucharistic sacrifice is frequently interpreted by this school as answering to the idea that Christ continually presents in heaven the sacrifice of Himself.

Recent Tendencies.—The revival in sacramental practice has not been confined to the Anglo-Catholic party in the Church of England, nor, indeed, to the Anglican communion. The function of the sacraments in the life of the Church meets to-day with a wider recognition than it did a century ago. At the same time there is a tendency with all parties to sit loosely to the old formulations. If Christ's body can no longer be thought of as existing *locally* in heaven, all the terms of thought are changed. Moreover, the historical criticism of the Bible and the felt necessity of relating the religion of the Bible to the general religious history of mankind, as we are now coming to see it, inevitably react upon current ideas of the Christian sacraments. In particular the anachronism of trying to extract a theory of the Presence from a few words of Christ (themselves differently reported by different writers) is widely recognized.

Various movements, religious and intellectual, have long since weakened the attachment of the Lutheran and Reformed Churches of the Continent to the classical forms of eucharistic doctrine which they inherited from the age of the Reformation. Pietism was impatient of theology, and Rationalism was disposed to regard the old language of mystical communion as mere metaphor for moral obligation. The revival of religious thought and feeling in the last century encouraged a more sympathetic attitude to the confessional statements of doctrine, and the traditions of confessional orthodoxy have never died out. But it is worthy of notice that the two most influential Protestant theologians of the last century, Schleiermacher and Ritschl, wished to propound a conception of the eucharist suited to the faith of a Protestant Church, which should transcend the differences inherited from the 16th century. True to Reformation principles Schleiermacher would exclude any idea that the body of Christ is offered in sacrifice. He would not allow that the body and blood of Christ should be supposed to stand related to the bread and wine independently of the act of communion. On the other hand the Church must affirm connection between the reception of the bread and wine and the spiritual reception of the flesh and blood of Christ. He points out that the difference between Luther and Calvin in their answer to the question: What do the wicked receive? would disappear with the disappearance of unworthy partaking.

Ritschl starts out from the communal character of the sacrament. In the sacrament the Church thankfully acknowledges that sacrificial death of Christ on which its own existence depends. The value of the sacrament to the individual is the assurance of forgiveness guaranteed to him primarily by the Church, but ultimately by Christ Himself. The confessional differences as to the manner of the presence of Christ's body and blood cannot be resolved by an appeal to the words of institution, and it is to be noted that the confessional doctrines of the presence of the body and blood all fail to recognize that the bread *broken* and the wine *outpoured* present the body and blood as emblems of Christ's *death*. Moreover, it is manifest that Christ intended that all believers should unite in the action, not that they should separate in their celebration, according to the interpretation which they put upon the action. The confessional dispute makes it impossible for the sacrament to be, in practice, the uniting action of the Church (*Unterricht in der christlichen Religion,* 3rd ed., Bonn, 1886, sec. 90).

There is affinity between this teaching of Ritschl and Harnack's provocative judgment on Luther's eucharistic doctrine. Luther declares once and again that word and sacrament alike contain the forgiveness of sins, and that in this alone their whole value consists. That is the essential saving truth of the Gospel. Unfortunately, Luther allowed himself to become entangled in the idea that the body in the sacrament is not the natural and historical body of Jesus, but the body glorified. This opened the way to the thought of a union with Christ through the eucharist, more intimate and more mystical than through the Word. Here, according to Harnack, lies the worst of heresies, for vague feeling is thus exalted over faith. And for this reason the "mystical" Calvinian teaching on the Supper is of all the Reformed doctrines the least satisfactory, for it unites the defects of Zwingli with the defects of Luther. Luther provides the corrective to himself. The truth is, that while the various sensible signs under which the Word is presented are of importance, since they bring the word of Jesus Christ close to the heart, yet they are unable to add anything to the power of the Word (*Hist. of Dogma,* E.T. vol. vii. p. 258 seq.).

With reference to the Epiklesis mentioned on p. 795 it should be noted that a petition for the descent of the Spirit upon the bread and wine was not entirely a novelty. An example of an earlier form occurs in the eucharistic prayer of the *Verona Fragments,* which contain parts of a Latin translation of a lost Greek work, probably the *Apostolic Tradition* of Hippolytus (A.D. 235). This prayer asks, not that the bread and wine may be changed by the Spirit's descent, but that the recipients may partake of them "for the fulfilling of the Holy Spirit (*in repletionem spiritus sancti*) to the strengthening of faith in truth"; and it should be noticed that the conception of the Spirit implied in the *Fragments* is undeveloped. In these respects the Verona type of invocation is essentially different from Cyril's Epiklesis.

Bibliography.—Harnack, *History of Dogma,* E.T. vol. vii.; Loofs, *Leitfaden z. Dogmengeschichte* 4te Aufl.; Waterland, *A Review of the Doctrine of the Eucharist;* Darwell Stone, *A History of the Doctrine of the Holy Eucharist,* vol. ii.; Barclay, *Protestant Doctrine of the Lord's Supper;* Kattenbusch, *art.* "Sakrament," Hauck Herzog, *R.E.;* Hugh Watt, art. "Eucharist" (Reformation, and post Reformation period) Hastings, *E.R.E.* (J. M. C.)

EUCHRE, a game of cards. The name is supposed by some to be a corruption of *écarté,* to which game it bears some resemblance; others connect it with the Ger. *Juchs* or *Jux,* a joke, owing to the presence in the pack, or "deck," of a special card called "the joker"; but neither derivation is quite satisfactory. The "deck" consists of 32 cards, all cards between the seven and ace being rejected from an ordinary pack. Sometimes the sevens and eights are rejected as well. The "joker" is the best card, *i.e.* the highest trump. Second in value is the "right bower" (from Dutch *boer,* farmer, the name of the knave), or knave of trumps; third is the "left bower," the knave of the other suit of the same colour as the right bower, also a trump: then follow ace, king, queen, etc., in order: Thus if spades are trumps the order is (1) the joker, (2) knave of spades, (3) knave of clubs, (4) ace of spades, etc. The joker, however, is not always used. When it is, the game is called "railroad" euchre. In suits not trumps the cards rank as at whist. Euchre can be played by two, three or four persons. In the cut for deal, the highest card deals, the knave being the highest and the ace the next best card. The dealer gives five cards to each person, two each and then three each, or vice versa: when all have received their cards the next card in the pack is turned up for trumps.

Two-handed Euchre.—If the non-dealer, who looks at his cards first, is satisfied, he says, "I order it up," *i.e.* he elects to play with his hand as it stands and with the trump suit as turned up. The dealer then rejects one card, which is put face downwards at the bottom of the pack, and takes the trump card into his hand. If, however, the non-dealer is not satisfied with his original hand, he says "I pass," on which the dealer can either "adopt," or "take up," the suit turned up, and proceed as before, or he can pass, turning down the trump card to show that he passes. If both players pass, the non-dealer can make any other suit trumps, by saying "I make it spades," for example, or he can pass again, when the dealer can either make another suit trumps or pass. If both players pass, the hand is at an end. If the trump card is black and either player makes the other black suit trumps, he "makes it next"; if he makes a red suit trumps he "crosses the suit"; the same applies to trumps in a red suit, *mutatis mutandis.* The non-dealer leads; the dealer must follow suit if he can, but he need not win the trick, nor need he trump if unable to follow suit. The left bower counts as a trump, and a trump must be played to it if led. The game is five up. If the player who orders up or adopts makes five tricks (a "march") he

scores two points; if four or three tricks, one point; if he makes less than three tricks, he is "euchred" and the other player scores two. A rubber consists of three games, each game counting one, unless the loser has failed to score at all, when the winner counts two for that game. This is called a "lurch." When a player wins three tricks, he is said to win the "point." The rubber points are two, as at whist. All three games are played out, even if one player win the first two. It is sometimes agreed that if a score "laps," *i.e.* if the winner makes more than five points in a game, the surplus may be carried on to the next game. The leader should be cautious about ordering up, since the dealer will probably hold one trump in addition to the one he takes in.

Three-handed (Cut-throat) Euchre.—In this form of the game the option of playing or passing goes round in rotation, beginning with the player on the dealer's left. The player who orders up, takes up, or makes, plays against the other two; if he is euchred his adversaries score two each; by other laws he is set back two points, and should his score be at love, he has then to make seven points.

Four-handed Euchre.—The game is played with partners, cutting and sitting, and the deal passing, as at whist. If the first player passes, the second may say "I assist," which is the same as "ordering up," or he may pass. If the first player has ordered up, his partner may say "I take it from you," which means that he will play alone against the two adversaries, the first player's cards being put face downwards on the table, and not being used in that hand. Any player can similarly play "a lone hand," his partner taking no part in the play. Even if the first hand plays alone, the third may take it from him. Similarly the dealer may take it from the second hand, but the second hand cannot take it from the dealer. If all four players pass, the first player can pass, make it, or play alone, naming the suit he makes. The third hand can "take it" from the first, or play alone in the suit made by the first, the dealer having a similar right over his own partner. If all four pass again, the hand is at an end and the deal passes. The game is five up, points being reckoned as before. If a lone player makes five tricks his side scores four: if three tricks, one: if he fails to make three tricks the opponents score four. It is not wise for the first hand to order up or cross the suit unless very strong. It is good policy to lead trumps through a hand that assists, bad policy to do so when the leader adopts. Trumps should be led to a partner who has ordered up or made it. It is sometimes considered wise for the first hand to "keep the bridge," *i.e.*, order up with a bad hand, to prevent the other side from playing alone, if their score is only one or two and the leader's is four. This right is lost if a player reminds his partner, after the trump card has been turned, that they are at the point of bridge. If the trump under these circumstances is not ordered up, the dealer should turn down, unless very strong. The second hand should not assist unless really strong, except when at the point of four-all or four-love. When led through, it is generally wise, *ceteris paribus,* to head the trick. The dealer should always adopt with two trumps in hand, or with one trump if a bower is turned up. At four-all and four-love he should adopt on a weaker hand. Also, being fourth player, he can make it on a weaker hand than other players. If the dealer's partner assists, the dealer should lead him a trump at the first opportunity; it is also a good opportunity for the dealer to play alone if moderately strong. If a player who generally keeps the bridge passes, his partner should rarely play alone.

Extracts from Rules.—If the dealer give too many or too few cards to any player, or exposes two cards in turning up, it is a misdeal and the deal passes. If there is a faced card in the pack, or the dealer exposes a card, he deals again. If anyone play with the wrong number of cards or the dealer plays without discarding, trumps being ordered up, his side forfeits two points (a lone hand four points) and cannot score during that hand. The revoke penalty is three points for each revoke (five in the case of a lone hand), and no score can be made that hand; a card may be taken back, before the trick is quitted, to save a revoke, but it is an exposed card. If a lone player expose a card, no penalty; if he lead out of turn, the card led may be called. If an adversary of a lone player plays out of turn to his lead, all the cards of both adversaries can be called, and are exposed.

Bid Euchre.—This game resembles "Napoleon" (*q.v.*). It is played with a euchre deck, each player receiving five cards, the others being left face-downwards. Each player "bids," *i.e.,* declares and makes a certain number of tricks, the highest bidder leading and his first card being a trump. When six play, the player who bids highest claims as his partner the player who has the best card of the trump suit, not in the bidder's hand: if it is among the undealt cards, which is ascertained by the fact that no one else holds it, he calls for the next best, and so on.

See Dick and Fitzgerald, *Two-handed and Four-handed Euchre* (1897); The U.S. Playing Card Co., *Euchre and how to play it* (Cincinnati, 1897).

EUCKEN, RUDOLF CHRISTOPH (1846–1926), German philosopher, was born on Jan. 5, 1846, at Aurich in East Friesland. He studied at Göttingen under Lotze, and at Berlin under Trendelenburg, whose ethical tendencies and historical treatment of philosophy attracted him. From 1871 to 1874 Eucken taught philosophy at Basle and from 1874 to 1920 held the chair of philosophy at Jena. In 1908 he was awarded the Nobel prize for literature. He died on Sept. 15, 1926.

Eucken's early works deal with the philosophy of Aristotle, but his later ones are mainly concerned with ethical and religious problems. Rejecting naturalism on the ground that the feeling of *ought* is inexplicable if man is only a derivative of natural processes, and distrusting pure intellectualism, he maintains that man is the meeting place of nature and of spirit, and that it is his duty and privilege to overcome his non-spiritual nature by incessant active striving after the spiritual life which involves all faculties, especially will and intuition. Historical religion is often merely a means of consolation and may become contracted, but true culture advances both form and energy and seeks a total coherency.

Eucken's chief works are:—*Die Methode der aristotelischen Forschung* (1872); *Die Grundbegriffe der Gegenwart* (1878; Eng. trans. 1880); *Geschichte der philos. Terminologie* (1879); *Die Einheit des Geisteslebens* (1888); *Die Lebensanschauungen der grossen Denker* (1890; Eng. trans. W. Hough and Boyce Gibson, *The Problem of Human Life,* 1909); *Der Wahrheitsgehalt der Religion* (1901); *Thomas von Aquino und Kant* (1901); *Gesammelte Aufsätze* (1903); *Philosophie der Geschichte* (1907); *Der Kampf um einen geistigen Lebensinhalt* (1896); *Grundlinien einer neuen Lebensanschauung* (1907, Eng. trs., 1911); *Einführung in die Philosophie der Geisteslebens* (1908; Eng. trans., *The Life of the Spirit,* F. L. Pogson, 1909); *Der Sinn und Wert des Lebens* (1908; Eng. trans., 1909); *Hauptprobleme der Religions-philosophie der Gegenwart* (1907); *Können wir noch Christen sein* (1911, Eng. trs., 1914); *Erkennen und Leben* (1912, Eng. trs., 1913); *Collected Essays* (ed. translated 1914); *Der Trager des deutschen Idealismus* (1915); *Mensch und Welt* (1918); *Was bleibt unser Halt* (1918) and *Lebens Erinnerungen* (1921, Eng. trs. 1921). *See* W. R. Boyce Gibson, *Eucken's Philosophy of Life* (1906) and *God with Us* (1909); H. Pöhlmann, *R. Euckens Theologie* (1903); O. Siebert, *Euckens Welt- und Lebensanschauung* (1904); K. Kesseler, *Euckens Bedeutung für das moderne Christentum* (1912); W. Tudor Jones, *The Philosophy of Eucken* (1914); M. Booth, *Eucken: His Philosophy and Influence* (1913); J. Budde, *Welt- und Menschheitsfragen in der Phil. Euckens* (1921). *See* Überweg, *Grund. der Gesch. der Phil.*, Pt. 4 (1923) for full bibliography.

EUCLASE, a rare mineral, occasionally cut as a gem-stone. Like beryl, it is a silicate of beryllium and aluminium, but hydrogen is also present; the formula is $HBeAlSiO_5$ or $Be(AlOH)SiO_4$. It crystallizes in the monoclinic system as striated prisms terminated by acute pyramids. Cleavage is perfect, parallel to the clinopinacoid, and this renders the stone fragile with a tendency to chip, hence its name from the Greek εὖ, "easily," and κλάσις, "fracture." The colour is generally pale-blue or green, though sometimes the mineral is colourless. When cut it resembles certain kinds of beryl (aquamarine) and topaz, from which it may be distinguished by its specific gravity (3·1). Its hardness (7·5) is rather less than that of topaz. Euclase occurs with topaz near Ouro Preto, Brazil, and with topaz and chrysoberyl in the goldbearing gravels of the river Sanarka in the southern Urals.

EUCLID (Eucleides) (*c.* 450–374 B.C.), founder of Megarian school of philosophy, born at Megara, and became a devoted

disciple of Socrates. When a decree was passed forbidding the Megarians to enter Athens, he and his friends withdrew to Megara. It has been conjectured that this was the period of Plato's residence in Megara, of which indications appear in the *Theaetetus*. He is said to have written six dialogues, of which only the titles remain. For his doctrine (a combination of the principles of Parmenides and Socrates) *see* MEGARIAN SCHOOL.

EUCLID (in Greek *Eukleides*), Greek mathematician (*fl.* about 300 B.C.), probably received his early mathematical training at Athens from the pupils of Plato; but we know nothing for certain of the circumstances of his life except that he taught and founded a school at Alexandria in the time of Ptolemy I., who reigned from 306 to 283 B.C. Mediaeval translators and editors mostly called him *Megarensis*, through confusion with the philosopher Eucleides of Megara, Plato's contemporary; this error was finally exposed by Commandinus in 1572. Proclus tells the story of Euclid's reply to King Ptolemy, who asked whether there was any shorter way in geometry than that of the *Elements*—"There is no royal road to geometry." Another anecdote relates that a pupil, after learning the very first proposition in geometry, wanted to known what he would get by learning these things, whereupon Euclid called his slave and said, "Give him threepence since he must needs make gain by what he learns."

Euclid's great work is the *Elements* (στοιχεῖα) (*see* GEOMETRY), in 13 books; of the books formerly purporting to be books xiv., xv., the first, by Hypsicles (2nd century B.C.) adds some interesting theorems about the regular solids, two of which it attributes to Aristaeus and Apollonius respectively; the second, much inferior, was written, at least in part, by a pupil of Isidorus of Miletus in the 6th century A.D.

The names of some earlier compilers of *Elements* are handed down; the first was Hippocrates of Chios (5th century B.C.), famous for his quadrature of certain *lunes,* intended to lead up to the squaring of a circle; the latest before Euclid was Theudius, whose text-book was that in use in the Academy and was probably that from which Aristotle drew his illustrations. The older elements were at once superseded by Euclid's and then forgotten. For his subject-matter Euclid doubtless drew upon all his predecessors; but it is clear that the whole design of his work was his own; he evidently altered the arrangement of whole books, redistributed propositions between them, and invented new proofs where the new order made the earlier proofs inapplicable; his changes began at least as early as i. 5 (the *pons asinorum*), since Aristotle cites a different proof of that theorem. He incorporated, too, the splendid new discoveries of Eudoxus and Theaetetus; book v. expounds Eudoxus's wonderful theory of proportion applicable to commensurable and incommensurable magnitudes alike; books x. and xiii. owe much to the original investigations of Theaetetus into (*a*) irrationals of different classes and (*b*) the geometry of the five regular solids, while book xii. uses Eudoxus's "method of exhaustion" for the purpose of proving that circles are to one another as the squares, and spheres are to one another as the cubes, on their diameters, and of finding the solid content of a pyramid, a cone and a cylinder. Books i.–iv. and vi. may be said to represent, roughly, the essence of the Pythagorean geometry, while books vii.–ix. on the elementary theory of numbers again owe something to the Pythagoreans.

It seems clear that the famous postulate 5 (the parallel postulate) is due to Euclid himself. No trace of such a postulate appears in Aristotle; Euclid then, realizing that some postulate is necessary to establish the theory of parallels, deliberately framed one, stating it in the direct form most useful for his purpose in that it gives a criterion by which to judge whether two lines drawn in a construction will or will not meet. The use of the postulate or some equivalent is the mark of Euclidean geometry. Many attempts to prove the postulate were made by prominent mathematicians from ancient times onwards. Gauss was the first to affirm, and Beltrami the first to establish (1868), the impossibility of proving it. The first to consider seriously the possibility of other hypotheses was Saccheri (*Euclides ab omni aevo vindicatus,* 1733), though he tried to prove that Euclid's was the only true one. Lobachewsky (1826) and (about the same time) J. Bolyai were the first to work out systematically a non-Euclidean geometry, while Riemann developed another in 1854.

It is safe to say that no other scientific text-book in the world has remained in use practically unchanged for more than 2,000 years. In this country it was not till the middle of the 19th century that a so-called "away from Euclid" movement began, which has led to the appearance of a multitude of rival text-books of geometry giving the substance of Euclid's early books in so many different forms as to produce a state of chaos in geometrical teaching which calls for remedy; but the text-book that shall really replace Euclid has not yet been written and probably never will be.

The following are the other works of Euclid which are extant; the first two belong to elementary geometry.

1. The *Data,* containing 94 propositions, has for its object to prove that, if certain elements in a figure are given, then other things are given, *i.e.,* can be determined. A systematic collection of such results must obviously be of great use in facilitating and shortening the analysis preliminary to the solution of a problem. The following is an example: *If two straight lines contain a given area in a given angle, and if the difference, or the sum, of them be given, then shall each of them be given;* this gives the geometrical solution of the simultaneous algebraical equations $y \pm x = a$, $xy = b^2$, or the equivalent quadratic equation in a single variable.

2. A book *On divisions* (*of figures*) was discovered in Arabic at Paris and edited by Woepcke in 1851. John Dee was the first to find (in Latin) a similar treatise by one Muhammad Bagdadinus which, in 1563, he handed to Commandinus, who published it in Dee's name and his own in 1570. The genuine treatise has now been restored and edited by R. C. Archibald (Cambridge, 1915). The type of problem dealt with is that of dividing a given figure (*e.g.,* a triangle, a parallelogram, a quadrilateral, a circle, or a figure bounded by an arc of a circle and two straight lines) by one or more straight lines into parts equal, or having given ratios, to one another or to other given areas.

3. The *Optics* of Euclid is extant in Greek in two forms, one being Euclid's own treatise and the other a recension by Theon. The *Catoptrica* (edited by Heiberg in the same volume) is not by Euclid but is a later compilation from ancient works on the subject.

4. The *Phaenomena,* extant in Greek, is a treatise on the geometry of the sphere intended for use in astronomy, and is similar in content to the work of Autolycus *On the Moving Sphere.*

5. A work on the *Elements of Music* is attributed to Euclid by Proclus and Marinus. Of two extant treatises of the kind the first, *Sectio Canonis,* giving the Pythagorean theory of music, is scarcely Euclid's in its present form, but may have been abstracted from the genuine *Elements of Music* by some less qualified editor. The *Introductio harmonica* is not by Euclid but by Cleonides, a pupil of Aristoxenus.

Of lost geometrical works by Euclid all except one, the *Pseudaria,* belonged to higher geometry.

1. The purpose of the *Pseudaria* was, we are told, to distinguish, and to warn beginners against, different types of fallacies to which they are liable in geometrical reasoning unless they have firmly grasped the principles and are guided by them alone.

2. The *Porisms,* in three books, was an advanced work of which Pappus gives a summary account with lemmas designed for use with it (*see* PORISM).

3. The *Conics,* in four books, corresponded in content to the first four books of Apollonius's *Conics,* though Apollonius added new theorems and generalized the treatment throughout. Euclid still called the conics by their old names, "Sections of a right-angled cone, an obtuse-angled cone, and an acute-angled cone" respectively; it was Apollonius who first gave them the names "parabola," "hyperbola," "ellipse," arising out of his generation of them all from one circular cone, in general oblique. Euclid was, however, aware that an oblique section of any right cone or cylinder gives a "section of an acute-angled cone" (ellipse).

4. Regarding the *Surface-Loci* (τόποι πρὸς ἐπιφανείᾳ), in two books, mentioned by Pappus, we can only conjecture that the

loci dealt with were *loci on surfaces,* perhaps also loci which *are* surfaces. Conics would appear to have entered into the subject, for one of the lemmas to the treatise given by Pappus contains a complete proof of the focus-directrix property of all three conics: a fact which further suggests that Euclid was acquainted with this property and assumed it as known (though it does not appear in Apollonius's *Conics*).

A fragment in Latin, *De levi et ponderoso,* included in Gregory's edition of Euclid, contains a statement of the principles of Aristotle's dynamics, but is not by Euclid; and there seems to be no independent evidence that Euclid wrote on mechanics at all.

TRANSLATIONS AND EDITIONS

This notice of Euclid would be incomplete without some account of the earliest and the most important translations and editions of the *Elements.* In ancient times Heron and Pappus of Alexandria, Proclus and Simplicius, all wrote commentaries. Theon of Alexandria (4th century A.D.) brought out a new recension of the work, with textual changes and some additions; Theon's version was the basis of all published Greek texts and translations therefrom until, early in the 19th century, Peyrard, discovered in the Vatican the great ms.gr. 190 containing an ante-Theonine text. Boëtius (about 500 A.D.) is said to have translated the *Elements* into Latin, but the geometry of the Pseudo-Boëtius which we possess contains no more than fragments of such a translation (the definitions of book i., the postulates and axioms, the enunciations of the propositions of book i. and of some propositions of books ii., iii., iv., but no proofs, except of props. 1–3 of Book i.). Arabic translations were made (1) by al-Hajjāj b. Yūsuf b. Maṭar, first for Hārūn ar-Rashīd (786–809) and again for al-Ma'Mūn (813–833); (2) by Isḥāq b. Ḥunain (d. 910); the latter translation was revised by Thābit b. Qurra (d. 901); the Isḥāq-Thābit version and six books of the second (abridged) version by al-Hajjāj survive, the former in the Bodleian, the latter at Leyden; (3) a third Arabic version was that of Naṣīraddīn aṭ-Ṭūsī (b. 1201); one form of this was printed at Rome in 1594.

The first extant Latin translation of the *Elements* was made (about 1120) by Athelhard of Bath, who obtained a copy of an Arabic version in Spain, whither he went disguised as a Mohammedan student. Next, Gherard of Cremona (1114–87) translated from the Arabic the "15 books of Euclid" as well as the commentary on books i.–x. by an-Nairīzī (about 900). The first Latin translation to be printed was that of Johannes Campanus (13th century), also made from the Arabic; Campanus's translation was more complete than Athelhard's, but he evidently used the latter, since the definitions, postulates, axioms, and the 364 enunciations are word for word the same in both translations. The first printed edition of the *Elements,* containing Campanus's translation (now rare), is a beautiful production by Erhard Ratdolt (Venice, 1482) with margins of 2¼in. and with figures in the margin; Ratdolt claims that no one before his time had been able to print diagrams like letters; 1482 saw two forms of the book (differing in the first sheet); others came out in 1486 and 1491. The first translation from the Greek was made by Bartolomeo Zamberti and appeared at Venice in 1505.

The *editio princeps* of the Greek text was brought out at Basle in 1533 by Simon Grynaeus the elder, with a preface addressed to a notable Englishman, Cuthbert Tonstall (1474–1557). Unfortunately the mss. used were two of the 16th century, which are among the worst.

The first English translation was that of Sir Henry Billingsley (1570), who was lord mayor of London in 1596–97, a magnificent volume of 928 folio pages, with a preface by John Dee: *The Elements of Geometrie of the most auncient Philosopher Euclide of Megara. Faithfully (now first) translated into the English toung, by H. Billingsley, Citizen of London.*

The most important Latin translation is that of Commandinus (1572), which was closely followed by Gregory and all translators down to Peyrard, including Simson.

The great Oxford edition (1703), in Greek and Latin, by David Gregory, was still, until the appearance of Heiberg and Menge's new text, the only edition of the complete works of Euclid. Peyrard's Greek text, published in three volumes between 1814 and 1818, and containing the *Elements* and the *Data,* represents the first approach to a better text, in so far as it adopted or recorded the readings of the Vatican ms.gr. 190; it was accompanied by translations into Latin and French. The edition of books i.–vi., in Greek and Latin, by Camerer and Hauber (Berlin, 1824–25) is valuable for its exhaustive notes, while E. F. August's Greek text of books i.–xiii. (1826–29) still further improved upon Peyrard's. All texts are now superseded by *Euclidis opera omnia* (8 vols., Leipzig, 1883–1916) edited by Heiberg and Menge; vols. i.–v. contain the *Elements* with Latin translation, apparatus criticus, scholia, etc., and vols. vi.–viii. the other extant works, scholia, fragments, etc. Book i. has been separately edited, with introduction and notes, by T. L. Heath (*Euclid in Greek Book I.,* Cambridge, 1918) and by G. Vacca (Firenze, 1916).

The number of editions in English is legion. We need here only mention Robert Simson's (first edition, in Latin and English, Glasgow, 1756, containing the *Elements* books i.–vi., xi., xii. and the *Data*); James Williamson's translations of the whole 13 books (vol. i., Oxford, 1781; vol. ii. London, 1788); T. L. Heath's *The Thirteen Books of Euclid's Elements,* translated from the text of Heiberg, with Introduction and Commentary, 3 vols. (Cambridge, 1908; second edition revised, with additions, 1926).

For more detailed accounts *see* Pauly-Wissowa's *Realencyklopädie;* G. Loria, *Le scienze esatte nell' antica Grecia,* pp. 188–268 (Milano, 1914); T. L. Heath, *History of Greek Mathematics,* vol. i., pp. 354–446 (Oxford, 1921). (T. L. H.)

EUCRATIDES, king of Bactria (*c.* 175–129 B.C.), came to the throne by a rebellion against the dynasty of Euthydemus, whose son Demetrius had conquered western India. His authority was challenged by a great many other pretenders and Greek dynasts in Sogdiana, Aria (Herat), Drangiana (Sijistan), etc., including Pantaleon, Agathocles, Antimachus, Antalcidas "the victorious" (*νικηφόρος*), and Plato, whose unique coin is dated from the year 147 of the Seleucid era (=166 B.C.). In the west the Parthian king Mithradates I. attacked Eucratides; he succeeded in conquering two provinces between Bactria and Parthia. But the principal opponent of Eucratides was Demetrius (*q.v.*) of India, who attacked him with a large army "of 300,000 men"; Eucratides fled with 300 men into a fortress and was besieged. But at last he beat Demetrius, and conquered a great part of western India. According to Apollodorus of Artemita, the historian of the Parthians, he ruled over 1,000 towns (Strabo xv. 686; transferred to Diodotus of Bactria in Justin 41, 4. 6); and the extent of his kingdom over Bactria, Sogdiana (Bokhara), Drangiana (Sijistan), Kabul and the western Punjab is confirmed by numerous coins, he is called "the great King Eucratides." On one his portrait and name are associated on the reverse with those of Heliocles and Laodice; Heliocles was probably his son, and the coin may have been struck to celebrate his marriage with Laodice, who seems to have been a Seleucid princess.

In Bactria Eucratides founded a Greek city, Eucratideia (Strabo xi. 516, Ptolem. vi. 11. 8). On his return from India Eucratides was (*c.* 150 B.C.) murdered by his son, whom he had made co-regent (Justin 41, 6). This son is probably the Heliocles just mentioned, who on his coins calls himself "the Just" (*βασιλέως Ἡλιοκλέους δικαίου*). In his time the Graeco-Bactrian kingdom lost the countries north of the Hindu Kush. Mongolian tribes, the Yue-chi of the Chinese, called by the Greeks Scythians, by the Indians Saka, among which the Tochari are the most conspicuous, invaded Sogdiana in 159 B.C. and conquered Bactria in 139. Meanwhile the Parthian kings Mithradates I. and Phraates II. conquered the provinces in the west of the Hindu Kush (Justin 41, 6. 8); for a short time Mithradates I. extended his dominion to the borders of India (Diod. 33. 18, Orosius v. 4. 16). When Antiochus VII. Sidetes tried once more to restore the Seleucid dominion in 130, Phraates allied himself with the Scythians (Justin 42, 1. 1); but after his decisive victory in 129 he was attacked by them and fell in the battle. The changed state of affairs is shown by the fact that on his later coins Heliocles passes over to a native silver standard, and his bronze coins

became quite barbarous. These and the coins of many other Greek kings of these times are records of a desperate struggle of the Greeks to maintain their nationality and independence in the Far East, which accelerated their destruction; about 120 B.C. almost the whole of eastern Iran was in the hands either of a Parthian dynasty or of the Mongol invaders, who are now called Indo-Scythians. Only in the Kabul valley and western India the Greeks maintained themselves about two generations longer (*see* MENANDER). (ED. M.)

EUDAEMONISM, in ethics, the name applied to theories of morality which find the chief good of man in some form of happiness (from Gr. *εὐδαιμονία,* literally the state of being under the protection of a benign spirit, a "good genius"). The term eudaemonia has been taken in a large number of senses, with consequent variations in the meaning of eudaemonism. To Plato the "happiness" of all the members of a state, each according to his own capacity, was the final end of political development. Aristotle, as usual, adopted "eudaemonia" as the term which in popular language most nearly represented his idea and made it the key-word of his ethical doctrine. None the less he greatly expanded the content of the word, until the popular idea was practically lost: if one be called *εὐδαίμων* ("happy") he must have all his powers performing their functions freely in accordance with virtue, as well as a reasonable degree of material well-being; the highest conceivable good of man is the life of contemplation. Aristotle further held that the good man in achieving virtue must experience pleasure (*ἡδονή*), which is, therefore, not the same as but the sequel to or concomitant of eudaemonia. Subsequent thinkers have to a greater or less degree identified the two ideas, and much confusion has resulted. Among the ancients the Epicureans expressed all eudaemonia in terms of pleasure. On the other hand attempts have been made to separate hedonism, as the search for a continuous series of physical pleasures, from eudaemonism, a condition of enduring mental satisfaction. Such a distinction involves the assumptions that bodily pleasures are generally different from mental ones, and that there is in practice a clearly marked dividing line—both of which hypotheses are frequently denied. Among modern writers, James Seth (*Ethical Princ.*, 1894) resumes Aristotle's position, and places eudaemonism as the mean between the ethics of sensibility (hedonism) and the ethics of rationality, each of which overlooks the complex character of human life. The fundamental difficulty which confronts those who would distinguish between pleasure and eudaemonia is that all pleasure is ultimately a mental phenomenon, whether it be roused by food, music, doing a moral action or committing a theft. There is a marked disposition on the part of critics of hedonism to confuse "pleasure" with animal pleasure or "passion"—in other words, with a pleasure phenomenon in which the predominant feature is entire lack of self-control, whereas the word "pleasure" has strictly no such connotation. Pleasure is strictly nothing more than the state of being pleased, and it is purely arbitrary to confine the word to those cases in which such stimuli are the proximate causes.

EUDEMOS OF RHODES, pupil of Aristotle, whose *Metaphysics* and *Physics* he revised. The *Eudemian Ethics* was probably not meant as an original work, but as an edition of a course on ethics by Aristotle. Eudemos gives a theological turn to the doctrines of his master and regards reason as the Divine element in our nature. Of his history of astronomy and mathematics, now lost, numerous extracts are to be found in later writers.

See the fragments edited by Spengel (1866; 2nd ed., 1870), and by Mullach (1881).

EUDOCIA AUGUSTA (*c.* 401–*c.* 460), the wife of Theodosius II., East Roman emperor, was born in Athens, the daughter of the sophist Leontius. The masterful Pulcheria, sister of the emperor Theodosius and co-empress, selected her for his wife. She was baptized and changed her name—Athenaïs—to Eudocia, and married Theodosius in 421. Soon she and Pulcheria fell out, but Theodosius contrived to live contentedly with both for many years: ultimately (440) she was disgraced, and withdrew to Jerusalem, but the facts of the case are obscure. She died at Jerusalem about 460, having devoted herself latterly to literature. Among her works were a paraphrase of the Octateuch in hexameters, a paraphrase of the books of Daniel and Zechariah, a poem on St. Cyprian and on her husband's Persian victories. A *Passion History*, which Zonaras attributed to Eudocia, is perhaps of different authorship.

See W. Wiegand, *Eudokia* (Worms, 1871); F. Gregorovius, *Athenaïs* (Leipzig, 1892); C. Diehl, *Figures byzantines* (1906), pp. 25–49; also THEODOSIUS. On her works *see* A. Ludwich, *Eudociae Augustae carminum reliquiae* (Königsberg, 1893).

EUDOCIA MACREMBOLITISSA (*c.* 1021–1096), daughter of John Macrembolites, was the wife of the Byzantine emperor Constantine X. After his death (1067), to protect her infant son and to enable the menace of the Turks on the eastern frontier to be met, she married Romanus Diogenes and made him regent. On his capture in 1071 she vacated the throne in favour of her son and retired to a convent. The Ἰωνιά ascribed to her really dates from the 16th century.

See J. Flach, *Die Kaiserin Eudokia Makrembolitissa* (Tübingen, 1876); P. Pulch, *De Eudociae quod fertur Violario* (Strasbourg, 1880); and in *Hermes*, xvii. (1882), p. 177 ff.

EUDOXIA LOPUKHINA (1669–1731), tsaritsa, first consort of Peter the Great, was the daughter of the boyarin Theodore Lopukhin. Peter, then a youth of 17, married her on Jan. 27, at the command of his mother. The marriage was in every way unfortunate. Accustomed from her infancy to the monastic seclusion of the *terem*, or women's quarter, Eudoxia's mental horizon did not extend much beyond her embroidery-frame or her illuminated service-book. From the first her society bored Peter unspeakably, and after the birth of their second, short-lived son Alexander, he practically deserted her. In 1698 she was sent to the Pokrovsky monastery at Suzdal for refusing to consent to a divorce, and in 1699 she took the veil. But the nuns persisted in regarding her as the lawful empress; and she was permitted an extraordinary degree of latitude, unknown to Peter, who dragged her from her enforced retreat in 1718 on a charge of adultery. Eudoxia was compelled to make a public confession. She was then divorced and consigned to the remote monastery of Ladoga, where she remained for ten years till the accession of her grandson, Peter II., when the reactionaries proposed to appoint her regent. She was escorted with great ceremony to Moscow in 1728 and exhibited to the people attired in the splendid, old-fashioned robes of a tsaritsa; but her friends soon saw that a convent was a much more suitable place for her than a throne. She disappeared again in a monastery at Moscow, where she died in 1731.

See R. N. Bain, *Pupils of Peter the Great* (1895), chaps. ii. and iv.; and *The First Romanovs* (1905), chaps. viii. and xii. (R. N. B.)

EUDOXUS of Cnidus, Greek savant, probably lived from 408 to 355 B.C. It is chiefly as a mathematician and astronomer that his name has come down to us (*see* ASTRONOMY, *History*). From a life by Diogenes Laërtius, we learn that he studied at Athens under Plato, but, being dismissed went to Egypt, where he remained for 16 months with the priests of Heliopolis; here he probably began his astronomical observations. He then founded a school in Cyzicus and the Propontis, and subsequently, accompanied by a number of pupils, went to Athens, where he took a part in public affairs, and towards the end of his life he returned to his native place, where he died. Strabo states that he discovered that the solar year is longer than 365 days by 6 hours; Vitruvius that he invented a sun-dial. The *Phaenomena* of Aratus is a poetical account of the astronomical observations of Eudoxus. Several works have been attributed to him, but they are all lost; some fragments are preserved in the extant Τῶν Ἀράτου καὶ Εὐδόξου φαινομένων ἐξηγήσεω βιβλία τρία of the astronomer Hipparchus (ed. C. Manitius 1894).

Eudoxus was a mathematician of some importance. He discovered that part of geometry which is now included in the fifth book of Euclid; the proofs he used were very much like those now used. He also originated several theorems of the "golden section" of a line. Eudoxus used the "method of exhaustion," which he had established to show that the volume of a pyramid or cone was one-third of the volume of a prism or cylinder on the

same base. The "method of exhaustion" was of great use to geometers, for, although it was very laborious, it was rigid and avoided the use of infinitesimals. It is probable that the proof that the volumes of spheres are to one another as the cubes of their radii is due to him. Eudoxus was the first astronomer to give a scientific explanation of the paths of planets. He assumed that each planet was fixed to a transparent spherical shell capable of rotating about an axis inside another spherical shell and so on. Four shells, each rotating in a different direction and performing a different function, were necessary for each planet. Altogether 26 spherical shells were necessary for the solar system, but later astronomers were forced to increase this number as new discoveries were made, and eventually the idea was superseded.

See J. A. Letronne, *Sur les écrites et les travaux d'Eudoxe de Cnide; d'après L. Ideler* (1841); G. V. Schiaparelli, *Le Sfere omocentriche di Eudosso* (Milan, 1876); T. H. Martin in *Académie des inscriptions*, Oct. 3, 1879; article in Ersch and Gruber's *Allgemeine Encyklopädie.*

EUDOXUS of Cyzicus (fl. *c.* 130 B.C.), Greek navigator, was employed by Ptolemy Euergetes to command a fleet exploring the Arabian Sea. After two successful voyages, Eudoxus left the Egyptian service, and proceeded to Cadiz to fit out an expedition for African discovery. Strabo says that he made at least two voyages southward along the coast of Africa.

See E. H. Bunbury, *Hist. of Ancient Geography*, ii. (1879); P. Gaffarel, *Eudoxe de Cyzique* (1873).

EUFAULA, a city of Barbour county, Ala., U.S.A., in the south-eastern part of the State, on the Chattahoochee river. It is served by the Central of Georgia railway and by river steamers. The population was 4,939 in 1920 (54% negroes) and was estimated locally at 7,000 in 1928. It is the jobbing centre for a large agricultural area, a shipping point for cotton, and has bauxite mines and numerous manufacturing industries. The city was founded about 1800.

EUGÈNE OF SAVOY (FRANÇOIS EUGENE), PRINCE (1663–1736), fifth son of Prince Eugène Maurice of Savoy-Carignano, count of Soissons, and of Olympia Mancini, niece of Cardinal Mazarin, was born in Paris on Oct. 18, 1663. Originally destined for the church, Eugène desired to enter the army, but his mother had fallen into disgrace at court, and Louis XIV. refused him a commission. This, and his mother's influence produced in him a lifelong resentment against the king. He went to Vienna, where his relative the emperor Leopold I. received him kindly, and he served with the Austrian army during the campaign of 1683 against the Turks. His courage in a cavalry fight at Petronell (7th July) and in the great battle for the relief of Vienna won for him the command of a regiment of dragoons. He was wounded at the capture of Buda (Aug. 3, 1686) and at the siege of Belgrade (1688). A decree of banishment from France was now issued against all Frenchmen who continued to serve in foreign armies. "The king will see me again," was Eugène's reply when the news was communicated to him; he continued his career in foreign service.

Prince Eugène's next employment (1689) was partly diplomatic. He was sent by Leopold to Italy with the view of securing the co-operation of the duke of Savoy with the Italian and Spanish troops. Later in 1689 he served on the Rhine and was again wounded. He returned to Italy in time for the battle of Staffarda, in which the coalition was defeated by the French marshal Catinat; but in the spring of 1691 Prince Eugène raised the siege of Coni, took possession of Carmagnola, and in the end completely defeated Catinat. He followed up his success by entering Dauphiné, where he took possession of Embrun and Gap. Eventually the further prosecution of the war was abandoned owing to the defection of the duke of Savoy, and Eugène returned to Vienna, where he received the command of the army in Hungary. Louis XIV. now secretly offered him the bâton of a marshal of France, the government of Champagne and a pension. Eugène indignantly rejected these offers and proceeded to serve against the Turks. He surprised the enemy (Sept. 11, 1697) at Zenta, on the Theiss. The victory was one of the most complete ever won by the Austrian arms. Peace was at length concluded at Karlowitz on Jan. 26, 1699.

Two years later he was again in active service in the War of the Spanish succession (*q.v.*). At the beginning of the year 1701 he was sent into Italy to oppose his old antagonist Catinat. He achieved a rapid success, crossing the mountains from Tirol into Italy in spite of almost insurmountable difficulties (*Journal d. Militärwissensch. Verein*, No. 5, 1907), forcing the French army to retire behind the Oglio, where a series of reverses led to Catinat's recall. Villeroi, Catinat's successor, ventured to attack Eugène at Chiari, and was repulsed with great loss. The French were forced to abandon the whole of the Mantuan territory and to take refuge in Cremona. By means of a stratagem, Eugène penetrated into the city during the night, at the head of 2,000 men, and though he could not hold the town, carried off Villeroi as a prisoner. The French army was then largely reinforced under the able command of Vendôme, and the campaign was ended by the sanguinary battle of Luzzara (Aug. 1, 1702) in which each party claimed the victory. The armies went into winter quarters, and Eugène returned to Vienna, where he was appointed president of the council of war. He was then sent against the insurgents in Hungary. After the collapse of the revolt, he was sent to Bavaria, where, in 1704, he made his first campaign along with Marlborough. Similarity of tastes, views and talents soon established between these two great men a rare friendship which contributed to the success of the allies. The first victory (Aug. 3, 1704) was that of Höchstadt or Blenheim (*q.v.*) where the English and imperial troops vanquished one of the finest armies that France had ever sent into Germany.

But in Eugène's absence, Vendôme, who commanded the French army in Italy, had obtained various successes against the duke of Savoy, who had once more joined Austria. The emperor recalled Eugène and sent him to Italy. After a variety of marches and counter-marches, in which both commanders displayed signal ability, the two armies met at Cassano (August 16, 1705). Prince Eugène received two severe wounds which forced him to quit the field; this accident decided the fate of the battle, and for the time suspended the prince's march towards Piedmont. Vendôme, however, was recalled, and his successor, La Feuillad, was helpless against Eugène who appeared before the entrenched camp at Turin, which place the French were now besieging with an army 80,000 strong. Prince Eugène had only 30,000 men; but on Sept. 7, 1706 he attacked the French army in its entrenchments and gained a victory which decided the fate of Italy. In the heat of the battle Eugène received a wound, and was thrown from his horse. He was rewarded by the government of the Milanese, of which he took possession with great pomp on April 16, 1707. He was also made lieutenant-general to the emperor Joseph I. The attempt which he made against Toulon in the course of the same year failed completely. The prince now returned to Vienna, where he was received with great enthusiasm. The Emperor immediately despatched Eugène to Holland, and to the different courts of Germany, in order to forward the necessary preparations for the campaign of the following year, 1708 (*see* SPANISH SUCCESSION, WAR OF THE).

Early in the spring of 1708 the prince assumed the command of the German army in Flanders. The campaign was opened by the victory of Oudenarde (*q.v.*). The French immediately abandoned the Low Countries, and made no attempt to prevent Eugène's army, covered by that of Marlborough, making the siege of Lille. After the capture of Lille, Eugène and Marlborough proceeded to the Hague, and negotiations were opened for peace, but proved fruitless. In 1709 France placed Marshal Villars, her best living general, in command. The bloody victory of Malplaquet (*q.v.*), was so dearly bought that the allies broke off the campaign and went into winter quarters. Eugène was sent on a mission to the king of Prussia. He then returned to Flanders, where, excepting the capture of Douai, Bethune and Aire, the campaign of 1710 presented nothing remarkable. On the death of the emperor Joseph I. in April 1711, Prince Eugène, in concert with the empress, sought to secure the crown to the archduke, who afterwards ascended the imperial throne under the name of Charles VI. In the same year Marlborough fell from favour with Queen Anne. Prince Eugène immediately repaired to London, in the hope of

restoring Marlborough's credit and re-attaching England to the coalition. The mission failed, and the emperor had to make the campaign of 1712 with the aid of the Dutch alone. Nevertheless, Eugène resolved, at whatever cost, to penetrate into Champagne; and began operations by making himself master of Quesnoy. But the Dutch, having been surprised and beaten in the lines of Denain, he was obliged to raise the siege of Landrecies, and to abandon the project of invading France. Abandoned first by England and then by Holland, the emperor still wished to continue the war in Germany; but Eugène was unable to relieve either Landau or Freiburg, both of which capitulated. Seeing the Empire thus laid open to the armies of France, and the Austrian hereditary states exposed to invasion, the prince counselled peace. He was entrusted with full powers to negotiate and concluded peace at Rastadt on March 6, 1714. After his return to Vienna, Eugène exchanged the government of the Milanese for that of the Austrian Netherlands.

In the spring of 1716 the emperor having concluded an offensive alliance with Venice against Turkey, appointed Eugène to command the army of Hungary; and at Peterwardein he gained (Aug. 5, 1716) a signal victory over a Turkish army of more than twice his own strength. The pope sent the victorious general the consecrated hat and sword which the court of Rome was accustomed to bestow upon those who had triumphed over the infidels. Eugène won another victory in this campaign at Temesvár. In 1717, Eugène laid siege to Belgrade, where he had to deal with the garrison of 30,000 men and a relieving army of 200,000, while his own force was only about 40,000 strong. On the morning of Aug. 16, 1717 he ordered a general attack, which resulted in the total defeat of the enemy with enormous loss, and in the capitulation of the city six days afterwards. The prince was wounded, for the thirteenth time. The popular song "Prinz Eugen, der edle Ritter," commemorates the victory of Belgrade. In 1718, after some fruitless negotiations, he again took the field, but the treaty of Passarowitz (July 21, 1718) concluded hostilities at the moment when the prince had well-founded hopes even of reaching Constantinople, and dictating a peace on the shores of the Bosporus.

As the government of the Netherlands, up to 1724 held by Eugène, had now been bestowed on a sister of the emperor, the prince was appointed vicar-general of Italy, with a pension of 300,000 florins. His personal relations with the emperor were not so cordial as before, and he suffered from the intrigues of the Spanish or anti-German party. On discovering the conspiracy of Tedeschi and Nimptsch in 1719, the prince threatened to lay down all his offices if the conspirators were not punished. During the years of peace between the Treaty of Passarowitz and the War of the Polish Succession, Eugène occupied himself with the arts and with literature, and corresponded with many of the most eminent men in Europe. Austria attacked France against the advice of Eugène (1734). Nevertheless, he was appointed to command the army destined to act upon the Rhine; if it could not prevent the capture of Philipsburg after a long siege, it at least prevented the enemy from entering Bavaria. Eugène, who was now 71, no longer possessed his former vigour, and he welcomed the peace concluded on Oct. 3, 1735. He died at Vienna on April 21, 1736, leaving an immense inheritance to his niece, the princess Victoria of Savoy.

Of a character cold and severe, Prince Eugène had almost no other passion than that of glory. He died unmarried, and seemed so little susceptible to female influence that he was styled a Mars without a Venus. That he was one of the great captains of history is universally admitted. The special characteristics of his generalship were imagination, fiery energy and a tactical resolution which was rare indeed in the 18th century. His almost invariable success raised the reputation of the Austrian army to a point which it never reached either before or since his day. War was with him a passion. Always on the march, in camps, or on the field of battle during more than fifty years, and under the reigns of three emperors, he had scarcely passed two years together without fighting. Yet his political activity was not inconsiderable and his advice was always sound and well-considered; while in his government of the Netherlands, which he exercised through the marquis de Prié, he set himself resolutely to oppose the many wild schemes, such as Law's Mississippi project, in which the times were so fertile. He took keen interest in literature and art. His palace in Vienna, and the Belvedere near that city, his library, and his collection of paintings were renowned.

Bibliography.—A. v. Arneth, *Prinz Eugen* (3 vols., Vienna, 1858; 2nd ed., 1864); H. v. Sybel, *Prinz Eugen von Savoyen* (Munich, 1868); Austrian official history, *Feldzüge des Prinzen Eugen von Savoyen* (Vienna, 1877–93, 21 vols.); Keym, *Prinz Eugen von Savoy* (3rd ed., 1899); von Landmann, *Prinz Eugen, Die Begründung der Grossmachtstellung Oesterreich-Ungarns* (1905). The political memoirs attributed to Prince Eugène (ed. Sartori, Tübingen, 1812) are spurious; *see* Böhm, *Die Sammlung der hinterlassenen politischen Schriften des Prinzen Eugens* (Freiburg, 1900).

EUGENE, a city of western Oregon, U.S.A., at the head of navigation on the Willamette river, 125m. S. of Portland; the county seat of Lane county and the seat of the State university. It is at the intersection of Federal highways 28 and 99; is served by the Oregon Electric and the Southern Pacific railways; and has a municipal airport. The population in 1920 was 10,593 (94% native white). The city lies at the edge of a broad fertile prairie, at the foot of a ridge of low hills, with the peaks of the Coast Range visible in the distance. It is the trading and shipping centre for the agricultural, stock-raising and lumbering territory extending from the Cascades to the coast, and has manufacturing industries which in 1925 produced goods valued at $3,906,013. The University of Oregon and the Eugene Bible university (Disciples, established in 1895) are located here. There is fine fishing at many points near the city. Eugene was settled in 1854 and incorporated in 1864.

EUGENICS, a word coined by the late Sir Francis Galton in 1885 and derived from the Greek εὐγενής, "well born." The latest definition of the term given by Galton runs as follows: "Eugenics is the study of agencies under social control which may improve or impair the racial qualities of future generations either physically or mentally." It is well established that men are what they are, partly on account of the inborn or racial qualities derived from their parents, and partly on account of their surroundings. In the fashioning of men both the nature of the material and of the workmanship applied to it affect the final product. The word eugenics is used to cover any proposals or plans for the improvement of the racial qualities of human beings. Therefore eugenic proposals aim at social improvement. They differ fundamentally from other projects having the same object in that they are concerned with the improvement of the human material and not of the surroundings. But they are not alternative to these projects. Improvement of the material and improvement of the surroundings should go on at the same time. A good result will only be achieved where good workmanship is applied to good material. While the word eugenics is used to mean plans for racial improvement, it is also used for the study of the part played by racial qualities in making men what they are. Galton introduced the word "study" into his definition though the definition as a whole makes it apparent that he was thinking of such studies as would be the foundation of plans. There is a distinction between the pure study of natural phenomena in and for itself and the study of how to apply the knowledge so gained for certain purposes. Whether or not eugenics is properly held to be a pure as well as an applied science, it remains true that the necessary knowledge must be available before any application can be attempted. It is in fact a mere matter of terminology whether we speak of a pure science of eugenics and also of an applied science of eugenics, or whether we regard eugenics wholly as an applied science. In any case those interested in eugenics must acquaint themselves with the results achieved by workers in certain fields of pure science and to them we turn.

Eugenic proposals must be based in the first place upon such knowledge as we possess of the part played by inborn qualities in making men what they are. It is evident that they do play some part. In the United States of America the surroundings of negroes are much the same as those of white men and yet they are sharply marked off from one another owing, it is to be inferred, to differences in racial qualities. We may study identical twins who

are derived from the division of a single fertilized cell at an early stage of development. Identical twins have therefore the same inherited qualities and differences between them must be due to differences in their surroundings. Again we may study the inmates of orphanages. They form the reverse case. They are no more alike in inborn qualities than persons chosen at random from the public at large and they have been subjected to the same environment for varying periods of years. Other methods of approach are available. As a result of such studies we reach the general conclusion that the differences between men are to no small extent the result of inborn differences. This conclusion is founded upon the facts that identical twins remain closely alike in spite of diversity of experience, that orphan children tend only slightly to grow alike in spite of similarity of experience and upon other evidence. This statement should not be misunderstood. Some differences between men are wholly the result of different experiences. Thus a child may be rendered mentally deficient by an accident at birth. But at least three quarters of all mentally deficient children have mentally deficient relatives and may be supposed to have inherited the condition. What the statement means is that, when we investigate the causes of the innumerable differences between men in respect of intelligence, temperament character, health, physique and other characteristics, which we observe between those whom we meet, we find that, while almost any kind of difference can be wholly produced by differences in the environment, most differences in part, many in large part, are due to inherited differences. Inborn characters are thus of great importance and they are derived from the parents. The study of the precise manner in which they are derived is the study of heredity. This study has been greatly advanced in the present century and we now understand the mechanism of inheritance. While the recently acquired knowledge is of great importance, when we are concerned with particular problems, for the purposes of a general review it merely explains what was known before. It has long been common knowledge that like tends to produce like, that tall parents tend to have tall children, able parents able children, and so on. We now know how this comes about. We have therefore the position that those who differ from their fellow men in exhibiting greater ability or stature than the average do so mainly because of the possession of certain inborn qualities and that the offspring of such persons will more often than not be abler or taller than the average.

It is to students of certain branches of biology that we look for knowledge of matters such as those we have just discussed. This knowledge is not sufficient for the making of proposals to improve racial qualities. It is necessary to have information upon other subjects, which lie within the field of sociology or social science, and among these subjects that which first claims attention is the distribution of racial qualities within the population. Men differ profoundly in respect of their inborn endowments and it might be that all those, or the majority of those, endowed with ability above a certain level, or with physical strength above a certain standard, are to be found in certain areas, in certain occupations or in certain classes. On the other hand inborn qualities might be so distributed that the average representative of those following each occupation, of the members of each social class or of the inhabitants of every locality had approximately similar endowments. Little is known as yet regarding the distribution of physical qualities though there is reason to believe that the average miner and agricultural labourer are physically stronger than the average working man. More is known about the distribution of those inborn mental qualities which can be measured by the use of intelligence tests. These tests have been widely used of late in Great Britain and America, and many investigators have employed them to throw light upon the distribution of intelligence within the population. In 1912 13,595 school children between the ages of 11 and 13 were tested in Northumberland and the intelligence quotient of each child ascertained. The intelligence quotient is independent of age and an intelligence quotient of more or less than 100 is indicative of an intelligence above or below normal. The occupations of the fathers were known and the children may be classified by these occupations.

Occupations of Fathers and Intelligence of Children in Northumberland

Occupations of Fathers	*Average I.Q. of Children*
Professional	112·2
Managerial	110·0
Higher commercial	109·3
Army, navy, police, postmen	105·5
Shopkeeping	105·0
Engineering	102·9
Foremen	102·7
Building	102·0
Metal workers, shipbuilders	100·9
Miscellaneous industrial workers	100·6
Miners and quarrymen	97·6
Agriculture (all classes)	97·6
Low grade occupations	96·0

It will be noticed that in general the higher economic or social position of the parents the higher the intelligence quotient of the children. Numerous other investigations point to the same conclusion. There are three points to be observed. Firstly, it is only what is to be expected from a knowledge of the social conditions. There is a mechanism which, working through free places, scholarships and the opening generally of chances to bright children, results in a sifting out of the abler among each generation who find a place in a higher economic class than that of which their parents were members. Since the children of those thus promoted will tend to inherit the intelligence of their parents, it would be astonishing if the members of the higher economic classes were not more intelligent on the average than the members of the lower economic classes. Secondly, it should be observed that the only established differences between the average representative of the social classes are in respect of that aspect of intelligence which can be measured by tests. Social and occupational groups may differ in respect of temperamental and emotional qualities and also in respect of physical endowment. We may suspect such differences because the temperament and physique of a man is not without influence in determining his place in society; but we have no definite information on this subject. Thirdly, it does not follow that, because the members of a certain social class are on the average more highly endowed with some inborn quality, they are better in any ethical sense than members of other classes.

It is also necessary to study the contribution to the next generation made by persons with different inborn qualities. In this manner light can be thrown upon the problem whether the racial qualities of the population are changing. The direct method is to select those known to be endowed with qualities different from those possessed by the average number of the population and to ascertain whether the rate of contribution to the next generation made by the former is greater or less than that made by the latter. Many investigations of this kind have been made especially in the United States. It has been repeatedly shown that those with more than average ability contribute less than the average number of children to the next generation. It has not been proved that the mental defectives as a class contribute more than their share. This method can as a rule only be employed in enquiries of limited scope. The problem can be approached indirectly by the employment of statistics such as are collected by the census authorities. The questions asked at the English Census of 1911 were so framed that the families could be allocated to social groups according to the social class to which the head of the family belonged. Eight groups were set up. The wage earners in the textile, mining and agricultural industries were placed in classes VI., VII. and VIII. respectively. The rest of the population was distributed between five classes as follows: class I., upper and middle; class II., intermediate; class III., skilled; class IV., intermediate; class V., unskilled. The results of so doing are set out in the table on next page.

The important figures are those giving the number of children surviving per 100 families in each class and it will be seen that the lower the social class the larger the number of surviving children. As we have seen there is evidence that the higher the class the greater is the average degree of intelligence. From this it is to be deduced that the changes in progress in the endowment of the population as a whole in respect of intelligence are in the direction of a lowering of the level. Since we do not know

England and Wales, 1911. Marriages where the wife had not attained the age of 45 years at census. Total and effective fertility and child mortality classified by social status (as indicated by husband's occupation) for all durations of marriage.

	Social class.							
	1.	2.	3.	4.	5.	6.	7.	8.
Children born per 100 families	190	241	279	287	337	238	358	327
Children dead per 1,000 born	116	147	167	173	206	200	213	131
Children surviving per 100 families	168	205	232	237	268	191	282	284

whether these social classes differ in their temperamental and physical endowment, it is not possible to say whether this process is also bringing about changes in the average endowment of the population in these respects.

Lastly before plans for racial improvement can be made it is necessary to gain some knowledge of the factors which influence the size of family. This is so because, while most proposals may contemplate prohibition of reproduction by certain persons, some proposals aim at stimulating or discouraging reproduction in certain groups. It is now generally agreed that the most important immediate cause of smaller families in certain classes is the greater use of family limitation. But the enquiry must be pushed further back and an attempt made to ascertain why family limitation is more employed by some classes than others. For this there are many reasons. The knowledge of methods of family limitation is not equally spread among all classes. Wage earners receive their maximum income early in life and are therefore not under any inducement to postpone marriage as are the professional classes who may only reach their maximum income when 40 years of age or more. The education of children is more of an expense to professional parents than to working-class parents and the children are less of a support to their parents in old age among the professional than among the working classes. These and other reasons may account for the different rates of reproduction between the classes. Unless the reasons for these conditions are understood effective proposals cannot be made for changing the situation. Again, it cannot be foretold what effects proposals made with quite other immediate objects are likely to have. Thus family endowment is widely advocated in order to alleviate poverty. It is very desirable to be able to estimate the effect of such a measure upon the size of such families.

On the basis of knowledge of this nature plans for racial improvement may be made. Stress is at times laid on evidence of racial deterioration and proposals often have as their immediate object the prevention of race deterioration. It is necessary to emphasize the urgent need and abundant opportunity for racial improvement. There are large numbers of persons who by reason of defective inborn endowment are unable to lead full lives and are a burden to themselves and others. Thus in 1925 the number of children in England and Wales certified as mentally defective amounted to about 33,000 or 6·7 per 1,000 of children in average attendance at public elementary schools. It is generally acknowledged that all mentally defective children have not been certified and that the proportion probably reaches 10 per 1,000. Poverty, crime, drunkenness, disease and other social problems are intensified by defective inborn equipment. There is ample opportunity because there are persons who are generously endowed both physically and mentally, and it is possible to bring up the average endowment of the race to somewhere near their level. Human history is largely the story of attempts by man to bring his surroundings under control. But if he wishes to bring his destiny under control he must turn his attention to the control of human material as well as to the control of human surroundings. He must attempt to govern his own racial evolution. Attempts to do this are in line with all that inspires man to improve his surroundings. They do, however, depart somewhat from other proposals in that of necessity they contemplate restrictions upon the very intimate human relationship of marriage. But it may be pointed out that this relationship is already directly affected by restrictions upon marriage by persons below a certain age or between persons within certain degrees of blood relationship and is also indirectly affected by many kinds of social legislation such, for instance, as that concerning housing or taxation. Eugenic proposals therefore contemplate the extension of an existing principle rather than the introduction of any new principle in the field of social organization.

Eugenic proposals aim at (1) the prevention of reproduction by persons of definitely defective types and (2) the encouragement of reproduction by persons of sound stock. (1) The marriage of defective persons can be prohibited. The marriage of mentally defective persons is prohibited in Russia. Again in several of the United States of America marriage is prohibited on account of one or more of the following conditions: insanity, feeble mindedness, epilepsy, criminality and alcoholism. There is no such prohibition in Great Britain. Prohibition of marriage may not prevent reproduction, especially by the mentally defective, and therefore segregation and sterilization are sometimes recommended. Segregation is now practised to some extent in all civilized countries to safeguard the defectives and the public, but not with the deliberate intention to prevent reproduction. Over 50,000 mentally defective persons are now segregated or under supervision in Great Britain. But segregation is expensive and is not likely to be applied to the less seriously afflicted who can wholly or partly support themselves. Therefore sterilization is advocated in some quarters. In 1926 sterilization laws had been enacted in 23 of the 48 United States, and over 6,000 operations had been performed. It has also been proposed that as a preliminary to the issue of a marriage licence certificates should be exchanged between the parties concerned setting out certain facts relating to family and personal history. When the licence is issued an approved statement laying down in simple language what is known of the laws of inheritance might be handed to the parties. Legislation of the latter kind would not be restrictive but it might educate young persons in regard to their responsibilities and induce certain persons to refrain from reproduction. (2) Proposals for encouraging reproduction among the fit by legal action are mainly confined to amending the system of taxation so that the amounts levied on married couples with children should be materially less than the amounts levied on the unmarried and the childless. It is also hoped to rouse among the fit a sense of their responsibility as bearers of desirable traits which should lead them to desire to perpetuate these traits. It will be observed that the action so far taken and the proposals most widely advocated aim at preventing reproduction among the unfit rather than encouraging reproduction among the fit. Regarding proposals of the former kind three points may be noticed. It is not difficult to obtain a general consensus of opinion as to what constitutes unfitness though opinions may differ as to what degree of unfitness should form a bar to marriage. Secondly there is abundant evidence that desirable qualities are not especially associated with certain undesirable traits. It is not the case that genius is associated with insanity or mental ability with physical debility. Therefore fear that the cutting off of defective persons would tell against the production of genius is baseless. Such cutting off would result in a raising of the general level of the racial qualities of the population and would increase the chances of the birth of a genius. Thirdly it can be shown that the prevention of reproduction by the unfit would be effective within a relatively short time. This may be illustrated for mental defect. If it is supposed that mental defect is inherited as a recessive quality and that it is scattered at random among the population, it can be demonstrated that, starting with a frequency of 100 defectives per 10,000 of the population, it would be reduced by prohibition of marriage among those showing the defect to 82·6 per 10,000 in one generation, to 69·4 in the next generation and to 59·2 in the third generation. But the assumptions upon which the calculation is based are very unfavourable. It is almost certain that restriction of reproduction would reduce the amount of mental defect with much greater rapidity. It is most unlikely, for instance, that mental defect is equally distributed throughout the population and, to the extent to which it is concentrated in certain strains, the swifter will be

the reduction of the incidence of defect. So far as proposals to encourage reproduction are concerned, it is evident that it is much more difficult to define the fit than the unfit. Such proposals usually go no further than aiming at the removal of burdens so far as possible which rest upon those of sound stock and discourage them from contributing their share to the next generation.

During the present century organizations have been founded to promote research into eugenic problems and to conduct propaganda in favour of eugenic proposals. Much of the research work upon which eugenic proposals must be founded lies in the field of established sciences. There are, however, other fields of research. Such is the case, for instance, with regard to investigations into the distribution of inherited qualities within the population. Research institutes in England and America have been founded to investigate these and other problems. The Eugenics Record Office, of which Dr. C. B. Davenport is head, was founded in 1910. It is a section of the Department of Genetics of the Carnegie Institution of Washington and is situated at Cold Spring Harbour (N.Y.). Sir Francis Galton (d. 1911) founded by a bequest in his will a chair of Eugenics at University college, London. Professor Karl Pearson was appointed to this chair.

It is now becoming recognized that, valuable as these research institutions may be, they cannot collect some of the most important data without Government assistance. The Government could conduct periodically a census of the mental and physical qualities of all school children. It might be advisable to set up a special Government department to advise upon or conduct the collection of this information. Such a department has been founded in Sweden. In 1922 the Swedish State Institute of Race Biology was set up at Uppsala. It is controlled by a council of six members nominated by the Crown. The institute is primarily concerned with research. It is contemplated, however, that it may be called upon to advise as to legislation. Societies for the promotion of eugenic proposals exist in every country. The aim of these societies is to popularize eugenics by placing before the public concrete eugenic proposals.

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(A. M. C.-S.)

EUGÉNIE (MARIE-EUGÉNIE-IGNACE-AUGUSTINE DE MONTIJO) (1826–1920), wife of Napoleon III., emperor of the French, daughter of Don Cipriano Guzman y Porto Carrero, count of Teba, subsequently count of Montijo and grandee of Spain, was born at Granada on May 5, 1826. Her mother was a daughter of William Kirkpatrick, United States consul at Malaga, a Scotsman by birth and an American by nationality. Her childhood was spent in Madrid, but after 1834 she lived with her mother and sister chiefly in Paris, where she was educated, like so many French girls of good family, in the convent of the Sacré Coeur. When Louis Napoleon became president of the republic she appeared frequently with her mother at the balls given by the prince president at the Elysées. In Nov. 1852 mother and daughter were invited to Fontainebleau, and in the picturesque hunting parties the beautiful young Spaniard, who showed herself an expert horsewoman, was greatly admired. Three weeks later, on Dec. 2, the Empire was formally proclaimed, and during a series of fêtes at Compiègne, which lasted eleven days (Dec. 19–30), the emperor became more and more enamoured. Early in January he made a formal proposal of marriage. In a speech from the throne on Jan. 22, he formally announced his engagement, and justified what was considered a mésalliance. The marriage was celebrated with great pomp at Notre Dame on Jan. 30, 1853. On March 16, 1856 the empress gave birth to a son, who received the title of prince imperial. She was the mirror of fashion for all Europe. By her beauty, elegance and charm of manner she contributed largely to the brilliancy of the imperial régime, and when the end came, she was, as the official *Enquête* made by her enemies proved, one of the very few who showed calmness and courage in face of the rising tide of revolution. The empress acted three times as regent during the absence of the emperor,—in 1859, 1865 and 1870,—and she was generally consulted on important questions. When the emperor vacillated between two lines of policy she generally urged on him the bolder course; she deprecated everything tending to diminish the temporal power of the papacy, and she disapproved of the emperor's liberal policy at the close of his reign. On the collapse of the Empire she fled to England, and settled with the emperor and her son at Chislehurst. After the emperor's death she removed to Farnborough, where she built a mausoleum to his memory. The ex-Empress found a faithful friend in Queen Victoria, whose own family bereavements deepened her sympathy with Eugénie. In 1879 her son was killed in the Zulu War, and in the following year she visited the spot and brought back the body to be interred beside that of his father. At Farnborough, and in a villa she built at Cap Martin on the Riviera, she continued to live in retirement, following closely the course of events, but abstaining from all interference in French politics. She died in Madrid on July 11, 1920, while on a visit to the queen of Spain, who was her favourite god-daughter.

EUGENIUS I., pope from 654 to 657. Elected on the banishment of Martin I. by the emperor Constans II., and at the height of the Monothelite crisis, he showed greater deference than his predecessor to the emperor's wishes, and made no public stand against the patriarchs of Constantinople, though he held no communication with them.

EUGENIUS II., pope, a native of Rome, succeeded Pascal I. in 824. He was the candidate of the nobles, and the clerical faction brought forward a competitor. But the monk Wala, the representative of the emperor Lothair, succeeded in securing the election of Eugenius. Lothair, however, took advantage of this opportunity to redress many abuses in the papal administration, to vest the election of the pope in the nobles, and to confirm the statute that no pope should be consecrated until his election had the approval of the emperor. A council which assembled at Rome passed enactments for the restoration of church discipline, took measures for the foundation of schools and chapters, and decided against priests wearing secular dress or engaging in secular occupations. Eugenius died in 827.

EUGENIUS III. (Bernardo Paganelli), pope from Feb. 15, 1145 to July 8, 1153, native of Pisa, was abbot of the Cistercian monastery of St. Anastasius at Rome when he succeeded Lucius II. Immediately after his election, the Roman senators demanded the pope's renunciation of temporal power. He refused and fled to Farfa, where he was consecrated. By treaty of Dec. 1145 he recognized the republic under his suzerainty, substituted a papal prefect for the "patrician" and returned to Rome. The celebrated schismatic, Arnold of Brescia, however, again headed the party opposed to the temporal power of the papacy, re-established the patricianate, and forced the pope to leave Rome. In Jan. 1147 Eugenius journeyed to France to further preparations for the Second Crusade and to seek aid in the constant feuds at Rome. After holding synods at Paris, Reims and Trier, he returned to Italy in June 1148, excommunicated Arnold of Brescia in a synod at Cremona, and thenceforth endeavoured to recover his see. Negotiations between Frederick Barbarossa and the Romans enabled Eugenius to return to Rome in Dec. 1152, where he died in the following July. Eugenius exhibited the stoic virtues of monasticism and was reverenced for his personal character. His tomb in St. Peter's acquired fame for miraculous cures, and he was pronounced blessed by Pius IX. in 1872.

See his letters in Migne, *Patrol. Lat.*, vols. 106, 180, 182, and in *Bibliothèque de l'École des Chartes*, vol. 57 (Paris, 1896); the life by Cardinal Boso in J. M. Watterich, *Pontif. Roman. vitae*, vol. 2; and the life by John of Salisbury in *Monumenta Germaniae historica. Scriptores*, vol. 20; J. Langen, *Gesch. der römischen Kirche von Gregor VII. bis Innocenz III.* (Bonn, 1893); F. Gregorovius, *Rome in the Middle Ages*, vol. 4, trans. by G. W. Hamilton (1900–02); Hefele, *Conciliengeschichte*, Bd. 5, 2nd ed.; Jaffé-Wattenbach, *Regesta pontif. Roman.* (1885–88); M. Jocham, *Gesch. des Lebens u. der Verehrung des seligen Papstes Eugen III.* (Augsburg, 1873); B. Kugler, *Analekten zur Gesch. des zweiten Kreuzzugs* (Tübingen, 1878–83).

EUGENIUS IV. (Gabriel Condulmieri or Coldumario), pope March 3, 1431 to Feb. 23, 1447, was born at Venice. He entered the Celestine order, and his uncle, Gregory XII., appointed him bishop of Siena, papal treasurer, protonotary, cardinal-priest of S. Marco e St. Clemente, and later cardinal-priest

of S. Maria in Trastevere. The most important feature of Eugenius's pontificate was the struggle between pope and council. In July 1431 his legate opened the council of Basle but, distrustful of its purposes and moved by the small attendance, the pope issued a bull in Dec. 1431, dissolving the council. The council refused to dissolve, renewed the revolutionary resolutions by which the council of Constance had been declared superior to the pope, and cited Eugenius to appear at Basle. A compromise was arranged by Sigismund, by which the pope recalled the bull of dissolution, and, reserving the rights of the Holy See, acknowledged the council as oecumenical (Dec. 15, 1433). The struggle with the council broke out anew. Eugenius at length convened a rival council at Ferrara on Jan. 8, 1438 and excommunicated the prelates assembled at Basel. The latter then formally deposed him as a heretic, and in Nov. 1439 elected Amadeus VIII., duke of Savoy, antipope under the title of Felix V. The conduct of France and Germany seemed to warrant this action, for Charles VII. had introduced the decrees of the council of Basel, with slight changes, into the former country through the pragmatic sanction of Bourges (July 7, 1438), and the diet of Mainz had deprived the pope of most of his rights in the latter country (March 26, 1439). At Florence, whither the council of Ferrara had been transferred, a temporary union with the Greeks was effected in July 1439. Eugenius signed an agreement with the Armenians on Nov. 22, 1439, and with a part of the Jacobites in 1443; and in 1445 he received the Nestorians and Maronites. He tried to stem the Turkish advance, pledging one-fifth of the papal income to the unfortunate crusade of 1443. Meanwhile the adviser of his rival, Felix V., made peace with him in 1442. The pope's recognition of the claims to Naples of King Alphonso of Aragon withdrew the last important support from the council of Basle, and enabled him to enter Rome in Sept. 1443, after an exile of nearly ten years. His victory over the council and his efforts in behalf of church unity contributed greatly to break down the conciliar movement and restore the papacy to the position it had held before the Great Schism. Eugenius laboured to reform the monastic orders, and was a devotee of art and learning. He died on Feb. 23, 1447.

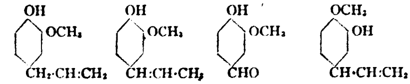
See L. Pastor, *Hist. of the Popes*, vol. 1, trans. by F. I. Antrobus (1899); M. Creighton, *Hist. of the Papacy*, vol. 3 (1899); F. Gregorovius, *Rome in the Middle Ages*, vol. 7, trans. by G. W. Hamilton (1900–02); Hefele, *Conciliengeschichte*, Bd. 7, 2nd ed.; H. H. Milman, *Latin Christianity*, vol. 8 (1896); G. Voigt, *Aus den Annaten-Registern der Päpste Eugen IV., Pius II., Paul II. u. Sixtus IV.*, ed. by K. Hayn (Cologne, 1896).

EUGENOL, an odoriferous principle, the chief constituent of oil of cloves, and occurring in many other essential oils. Structurally it is *allyl guaiacol*, $C_{10}H_{12}O_2$. It can be synthetically prepared by the reduction of coniferyl alcohol,

$$(HO)(CH_3O)C_6H_3{\cdot}CH{:}CH{\cdot}CH_2OH,$$

which occurs in combination with glucose in the glucoside coniferin, $C_{16}H_{22}O_8$. It is a colourless oil boiling at 247° C, and having a spicy odour. By the action of alkalis it is converted into iso-eugenol, which on oxidation yields vanillin, the odorous principle of vanilla (*q.v.*). This transformation of allyl phenols into propenyl phenols is very general. The amount of eugenol in oil of cloves can be estimated by acetylation in presence of pyridine or by absorption in normal potassium hydroxide solution in a cassia flask. *Chavibetol*, an isomeride of eugenol, occurs in the ethereal oil obtained from *Piper betle*.

The structural relations are:



Eugenol Iso-eugenol Vanillin Chavibetol

EUGIPPIUS or **EUGYPIUS** (*c.* 455–*c.* 538), abbot of Lucullanum near Naples, was born at Carthage and studied in Rome under St. Severin, whose biography he wrote. He also compiled *Thesaurus Augustinianeus*. His *opera* are edited in the *Corpus Script. Eccl. Lat.* vol. ix. and in Migne's *Patrol. Lat.* vol. 62.

EUHEMERUS (EUEMERUS, EVEMERUS) (*fl. c.* 300 B.C.), Greek mythographer, born at Messana, Sicily (others say at Chios, Tegea or Messene in Peloponnese), and lived at the court of Cassander. He is chiefly known by his *Sacred History* (Ἱερὰ ἀναγραφή), a philosophical romance, based upon archaic inscriptions which he claimed to have found during his travels in Greece. In this work he for the first time systematized an old Oriental (perhaps Phoenician) method of interpreting the popular myths, asserting that the gods of popular worship had been originally heroes and conquerors. The word "euhemeristic" is consequently applied to such explanations of primitive myths. Euhemerus was a firm upholder of the Cyrenaic philosophy, and by many ancient writers he was regarded as an atheist. His work exists only in a few fragments of the Latin trans. by Ennius.

See Raymond de Block, *Évhémère, son livre et sa doctrine* (Mons, 1876); G. N. Némethy, *Euhemeri relliquiae* (Budapest, 1889); Ganss, *Quaestiones Euhemereae* (Kempen, 1860); O. Sieroka, *De Euhemero* (1869); Susemihl, *Gesch. der griech. Litteratur in der Alexandrinerzeit*, vol. i. (Leipzig, 1891).

EULALIUS (d. 423), anti-pope in 418 in opposition to Boniface I. (*q.v.*). The rivalry led to the first interference of the temporal authorities in papal elections, and Eulalius was ultimately banished to Campania.

See *Liber Pontificalis*, vol. i. ed. Duchesne (Paris, 1886) and Jaffé, *Regesta Romanorum Pontificum*, vol. i. (Leipzig, 1885).

EULENBURG, BOTHO, GRAF ZU (1831–1912), Prussian statesman, son of Botho Heinrich, Graf zu Eulenburg-Wicken, president of the chamber of deputies 1855–58, was born at Wicken on July 31, 1831. He held various administrative positions before he succeeded, in 1878, his cousin Count Friedrich Eulenburg (*q.v.*) as minister of the interior. He resigned in 1881. In 1892 he was prime minister of Prussia for a few months, returning to the ministry of the interior in August. In 1894 he came into conflict with the imperial chancellor Caprivi (*q.v.*) over the bill for the amendment of the criminal code. In October, the emperor William II., who was on a visit to the Eulenburgs at their country seat, suddenly dismissed the chancellor. Eulenburg was also dismissed. He entered the Prussian Upper House in 1899. Eulenburg died at Berlin on Nov. 5, 1912.

EULENBURG, FRIEDRICH, GRAF ZU (1815–1881), Prussian statesman, was born at Königsberg on June 29, 1815. He entered the diplomatic service in 1852, and, after holding various European appointments, was sent on a mission to the Far East, where he concluded commercial treaties with Japan (Jan. 24, 1861) and with China (Sept. 2, 1861). On his return he became minister of the interior, and supported Bismarck in his insistence on the necessity of expenditure on armaments in Prussia. After 1866 he organized relations with the newly-acquired provinces of Prussia, Hanover, Hesse-Cassel, Frankfurt, Schleswig-Holstein duchies and Lauenburg. He resigned in 1878 when Bismarck refused to sanction his proposals for town and parish administration. Count Eulenburg died on June 2, 1881, at Berlin-Schöneberg.

See his *Ostasien 1860 bis 1862 in Briefen*, edit. Count Philipp zu Hertefeld-Eulenburg (1900), and his *Zehn Jahre innere Politik 1862 bis 1872* (1872).

EULENBURG-HERTEFELD, PHILIP ZU, PRINCE AND COUNT (1847–1921), German diplomat, was born Feb. 12, 1847 in Königsberg. He fought in the campaigns of 1866 and 1870–71 with the *Gardes du Corps*, and in the latter campaign won the iron cross for valour. But his heart was not in the fighting traditions of his family, and in 1877 he gladly abandoned the military for the diplomatic service. Appointed in 1881 third secretary at the German embassy in Paris, where he became the intimate friend of the later chancellor, Prince Bülow, Eulenburg was transferred a year later to Munich. From 1888 he was minister to the grand ducal court at Oldenburg; then in 1890 was promoted to Stuttgart, but in the same year was sent to Munich. In 1893 the emperor offered him the choice of the ambassadorships at London, Paris or Vienna. Eulenburg chose the latter post, where he remained until his resignation from the service in 1902 owing to continued ill-health. Afterwards he lived in retirement—broken

only by his trial in 1908 on charges of homo-sexuality—at his castle of Liebensberg until his death on Sept. 17, 1921.

For more than 30 years the intimate friend and trusted adviser of the emperor, William II., Eulenburg might well have aspired to the highest office in the State. Indeed, in the summer of 1894, he was openly spoken of as Hohenlohe's successor in the chancellorship, but he lacked both the political ambition and physical strength that would have enabled him to grasp the prize. Instead, he was instrumental in securing it for his friend Prince Bülow. Although his influence was not openly perceptible, Eulenburg during the first half of the Emperor William II.'s reign was one of the powers behind the throne in Germany. Alone among the Kaiser's immediate entourage, Eulenburg perceived the dangers of the "new course" along which that monarch was guiding Germany. And he alone had the courage to warn his imperial friend of the impending disaster. A wit and poet, a musician and architect, an able diplomat and brilliant *causeur*, Eulenburg was amongst the most interesting and most gifted personalities in the Germany of the late 90's and early years of the present century.

Bibliography.—He wrote a volume of reminiscences, mainly of his early life and the Bismarck family, which was posthumously published under the title of *Aus 50 Jahren* (1923). His biography, in great part an attempted vindication of his moral character, was written by his friend and literary executor Prof. J. Haller under the title *Aus dem Leben des Fürsten Philipp zu Eulenburg-Hertefeld* (1924).
(I. F. D. M.)

EULENSPIEGEL (Ulenspiegel), **TILL,** the name of a popular German figure, and the title of a German chapbook of the beginning of the 16th century. The oldest extant text of the book was printed at Strasbourg in 1515 (*Ein kurtzweilig lesen von Dyl Vlenspiegel geboren vss dem land zu Brunsswick*), and is in High German, but the original was undoubtedly Low Saxon. Its hero, Till Eulenspiegel or Ulenspiegel, the son of a peasant, was born at Kneitlingen in Brunswick at the end of the 13th or at the beginning of the 14th century and died, according to tradition, at Mölln near Lübeck in 1350. He is locally associated with the Low German area extending from Magdeburg to Hanover, and from Lüneburg to the Harz Mountains. The jests and practical jokes ascribed to him were collected—if we may believe a statement in one of the old prints—as early as 1483. He is the wily peasant who exercises his wit and roguery on the tradespeople of the towns, above all, on the innkeepers; but priests, noblemen, even princes, are also his victims. His jests are often pointless, more often brutal; he indulges, when opportunity offers, in scurrility and obscenity. The satire of the chapbook turns on class distinctions, and it might be described as the retaliation of the peasant on the townsman who in the 14th and 15th centuries had begun to look down upon the country boor as his inferior. *Eulenspiegel* was early translated into Dutch, French, English, Latin, Danish, Swedish, Bohemian and Polish. In England, "Howleglas" (Scottish, *Holliglas*) was long a familiar figure; his jests were adapted to English conditions, and appropriated in the collections associated with Robin Goodfellow, Scogan and others. Ben Jonson refers to him as "Howleglass" and "Ulenspiegel" in his *Masque of the Fortunate Isles, Poetaster, Alchemist* and *Sad Shepherd.*

Bibliography.—The Strasbourg edition of 1515 (British Museum) has been reprinted by H. Knust in the *Neudrucke deutscher Litteraturwerke des 16. und 17. Jahrh.* No. 55–56 (1885) and by E. Schroeder (1911); that of 1519 by J. M. Lappenberg (1854). Some ten further editions appeared in the first half of the 16th century at Cologne, Erfurt, Strasbourg and Augsburg. Johann Fischart published an adaptation in verse, *Der Eulenspiegel Reimensweiss* (Frankfurt, 1571), K. Simrock a modernization in 1864. The earliest translation was that into Dutch; it is undated, but may have appeared as early as 1512 (facsimile reprint, The Hague, 1898). This served as the basis for the first French version: *Ulenspiegel, de sa vie, de ses oeuvres et merveilleuses aduentures par luy faictes, etc.* (1532). Reprint, ed. by P. Jannet (1882). It was followed by upwards of 20 French editions. C. de Coster's *La légende et les aventures d'Ulenspiegel* (Brussels, 1912; Eng. trans. 1918) is a modernization of the legend. The first complete English translation bears the title: *Here beginneth a merye Jest of a man called Howleglas, etc.* printed by Copland in three editions, probably between 1548 and 1560. Reprint by F. Ouvry (1867). There was, however, a still older English edition (1518?), of which the British Museum possesses fragments (reprinted by F. Brie, *Eulenspiegel in England,* 1903). In 1720 appeared *The German Rogue, or the Life and Merry Adventures of Tiel Eulespiegle. Made English from the High-Dutch;* and an English illustrated edition, adapted by K. R. H. Mackenzie in 1880 (repr. in *Broadway Translations*). On Eulenspiegel in England, *see* C. H. Herford, *Studies in the Literary Relations of England and Germany in the Sixteenth Century* (1888), pp. 242 ff., and F. Brie's work referred to.
(J. G. R.)

EULER, LEONHARD (1707–1783), Swiss mathematician, was born at Basel on Apr. 15, 1707. His father, a good mathematician, was a Lutheran pastor. In 1723 he graduated at Basel, where he studied geometry under Jean Bernoulli, at that time one of the first mathematicians in Europe, and became a close friend of his sons, Daniel and Nicolas. He then took up theology and oriental languages, and medicine. In 1727 on the invitation of Catherine I., Euler joined his friends in St. Petersburg, where he became professor of physics in 1730 and three years later of mathematics, in succession to Daniel Bernouilli. The severity of the climate and close application to study affected his health and in 1735 he lost the sight of one eye. In 1741 Euler went to Berlin at the command of Frederick the Great, and during the next 25 years contributed many memoirs to the Prussian Academy. During this period he continued to contribute memoirs to the academy of St. Petersburg, and in 1766 he obtained, though with difficulty, permission to return to Russia. Soon afterwards a cataract formed in his left eye, which left him almost blind; with the help of his sons and of Krafft and Lexell, however, he continued his labours. In the next seven years he sent in 70 memoirs to the Academy, and left in his papers some 200 more. He died of apoplexy on Sept. 18, 1783.

Importance of His Work.—Euler's greatest work was done in pure mathematics, and he must be regarded as one of the founders of the modern science. In his *Introductio in analysin infinitorum* (1748), of which a full analysis is given in Cantor's *Geschichte der Mathematik* (vol. iii.), he provided an introduction to pure analytical mathematics. In the first part he gave the bulk of the matter to be found in treatises on algebra, the theory of equations and trigonometry; the second was devoted to analytical geometry. "In the algebra he paid particular attention to the expansion of various functions in series, and to the summation of given series; and for the first time we find the rule laid down that an infinite series cannot be safely employed unless it is convergent" (W. W. R. Ball, *Short History of Mathematics*). Euler treated trigonometry as a branch of analysis. He introduced (at the same time as Thomas Simpson) the abbreviations now used for the trigonometric functions and made use of the symbols ϵ and π. In the second he made many investigations which were new in his time; he discussed the general equation of the second degree in three dimensions, and classified the surfaces represented by it; he showed that the conic sections were represented by the general equation of the second degree in two dimensions.

His next important works were the *Institutiones calculi differentialis* (1755) and the *Institutiones calculi integralis* (1768–70), which may be said to be the first complete and accurate treatises on the calculus of that time. Beta and Gamma Functions and other original investigations were contained in these works. His *Methodus inveniendi lineas curvas maximi minimive proprietate gaudentes* (1744) is an earlier attempt to elaborate the calculus of variations afterwards perfected by Lagrange. His *Anleitung zur Algebra* (1770; translated and extended by Lagrange 1795) is in two parts, the first treating of determinate and the second of indeterminate algebra.

But though Euler's most important work was done in pure mathematics he was a man of wide culture, interested in many branches of applied mathematics and science. He made important contributions to astronomy, hydrodynamics and optics. His *Theoria motuum lunae* (1772) was based on earlier work of his on the subject. It was completed under terrible difficulties. His house had been burned down and some of his papers destroyed; he was nearly blind, and had to carry all the elaborate computations involved in his head. The complicated work on lunar motion in this treatise formed the basis of the lunar tables subsequently constructed by Mayer. His researches in optics were collected by him in the three vols. of his *Dioptrica* (1771).

A general view of the principal facts of mechanics, optics, acoustics and physical astronomy is provided in his *Lettres a une princesse d'Allemagne sur quelques sujets de physique et de philosophie* (1768–72), written for the use of the princess of Anhalt-Dessau.

A catalogue of Euler's works was drawn up by Fuss, the secretary of the St. Petersburg Academy, which issued some of his papers under the title *Opera Postuma* in 1862. A complete edition of his works was begun in 1926. *See* M. Cantor, *Geschichte der Mathematik* (1906).

EULER NUMBERS or **EULERIAN NUMBERS,** are the coefficients of the expansion:

$$\sec x = \frac{1}{\cos x} = 1 + A_1x^2 + A_2x^4 + A_3x^6 + \cdots.$$

They were so named by the German mathematician Scherk after the man who first discovered their significance in analysis. Although not of such wide application as the Bernouilli numbers, they are interesting on account of their intimate connection with the former, and of their various theoretical properties. They are also used in the summation of certain series. The first nine of these numbers were computed by Euler (*q.v.*). The ninth was found to be erroneous by Rothe, who gave the correct value. H. F. Scherk (1825) computed six more, Glaisher extended the list to 27, and S. A. Joffe computed 23 more, making 50 in all.

Euler used the recurrent formula

$$\frac{A_n}{1} - \frac{A_{n-1}}{2!} + \frac{A_{n-2}}{4!} - \frac{A_{n-3}}{6!} + \cdots = 0,$$

and independent representations in the form of determinants have been given by Glaisher:

$$E_n \quad \begin{vmatrix} \frac{1}{2!} & 1 & \cdots & 0 & 0 \\ \frac{1}{4!} & \frac{1}{2!} & \cdots & 0 & 0 \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & 1 & 0 \\ \cdot & \cdot & \cdots & \frac{1}{2!} & 1 \\ \frac{1}{2n!} & \frac{1}{2n-2!} & \cdots & \frac{1}{4!} & \frac{1}{2!} \end{vmatrix}$$

and by Haussner as follows:

$$E_n = \begin{vmatrix} 1 & 1 & 0 & \cdots & 0 \\ 1 & \binom{4}{2} & 1 & \cdots & 0 \\ 1 & \binom{6}{2} & \binom{6}{4} & \cdots & 0 \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ 1 & \binom{2m-2}{2} & \binom{2m-2}{4} & \cdots & 1 \\ 1 & \binom{2m}{2} & \binom{2m}{4} & \cdots & \binom{2m}{2m-2} \end{vmatrix}$$

The following formula does not seem to have been given in the memoirs on the subject,

$$E_n = 2n! - B_1(2n-2)! + B_2(2n-4)! + \cdots.$$

where B represents the sum of the products of the squares of the first $n-i+1$ odd numbers taken as products i at a time with repetitions, *e.g.*,

$$\begin{aligned} E_n = 8! &- 6!(1^2+3^2+5^2+7^2) \\ &+ 4!(1^2\cdot 3^2 + 1^2\cdot 5^2 + 3^2\cdot 5^2) \\ &- 2!(1^6 + 1^4\cdot 3^2 + n^2 3^4 + 3^6) + 1. \end{aligned}$$

Binet made the very interesting observation that the nth Eulerian number is equal to the number of permutations that can be formed of $2n$ elements, $a_1, a_2, a_3 \ldots a_{2n}$, such that the index of any element is either larger or smaller than each of the two adjacent indices, *e.g.*, out of the 24 permutations of the four elements, a_1, a_2, a_3, a_4, the following satisfy the above condition:

$$\begin{matrix} a_2 & a_3 & a_1 & a_4 \\ a_3 & a_1 & a_4 & a_2 \\ a_4 & a_2 & a_3 & a_1 \\ a_1 & a_4 & a_2 & a_3 \\ a_2 & a_1 & a_4 & a_3 \end{matrix}$$

totalling 5 distinct permutations, and hence $E_2 = 5$.

Of the theoretical properties of the Eulerian numbers the following are of interest:

1. Every Eulerian number is a positive odd integer.
2. The sum of any two successive Eulerian numbers is divisible by 3.
3. When n is even, $E_n + 1 \equiv 0 \pmod{3}$
4. When n is odd, $E_n - 1 \equiv 0 \pmod{3}$
5. E_n always ends in 1 or 5.

The first 10 Euler numbers are 1, 5, 61, 1385, 50521, 2702765, 199360981, 19391512145, 2404879675441, 370371188237525; and E_{50} is a number of 127 figures.

Bibliography.—Haussner, *Zur Theorie der Bernouillischen und Eulerschen Zahlen*, Göttinger Nachrichten (1894); Walther Fender, *Zur Theorie von verallgemeinerten Bernouillischen und Eulerischen Zahlen* (Leipzig, 1911); S. A. Joffe, "Calculation of the First Thirty-two Eulerian Numbers from Central Differences of Zero," *Quarterly Journal of Pure and Applied Mathematics* (1916–17) and "Calculation of Eighteen More Eulerian Numbers from Central Differences of Zero," *ibid.* (1917–20); H. F. Scherk, *Mathematische Abhandlungen* (1825). (J. Gi.)

EUMENES, the name of two rulers of Pergamum.

1. Eumenes I. succeeded his uncle Philetaerus in 263 B.C. The only important event in his reign was his victory near Sardis over Antiochus Soter, which enabled him to secure possession of the districts round his capital. (*See* Pergamum.)

2. Eumenes II., son of Attalus I., was king of Pergamum 197–159 B.C. During the greater part of his reign he was a loyal ally of the Romans. He materially contributed to the defeat of Antiochus of Syria at the battle of Magnesia (190), and as a reward for his services the Thracian Chersonese and all Antiochus's possessions as far as the Taurus were bestowed upon him. Although he supported the Romans in the war against Macedonia, he displayed so little energy and interest that he was suspected of intriguing with the enemy. Nothing, however, came of these negotiations, whatever may have been their real object; and Eumenes, in order to avert suspicion, sent his congratulations to Rome by his brother Attalus after the defeat of Perseus (168). Attalus was received courteously but coldly; and Eumenes in alarm set out to visit Rome in person, but on his arrival at Brundusium was ordered to leave Italy at once. He never regained the good graces of the Romans, who showed especial favour to Attalus on his second visit to Rome, probably with the object of setting him against Eumenes; but the ties of kinship proved too strong. The last years of his reign were disturbed by renewed hostilities against Prusias of Bithynia and the Celts of Galatia, and probably only his death prevented a war with Rome. Eumenes, although physically weak, was a shrewd and vigorous ruler and politician, who raised his little state from insignificance to a powerful monarchy. During his reign Pergamum became a flourishing city, where men of learning were always welcome, among them Crates of Mallus, the founder of the Pergamene school of criticism. The greatest monument of his liberality was the foundation of the library, which was second only to that of Alexandria.

See Livy xxxix. 51, xlii. 11–16; Polybius xxi.–xxxii.; Appian, *Syriaca;* Livy, *Epit.* 46; Cornelius Nepos, *Hannibal,* 10.

EUMENES (*c.* 360–316 B.C.), Macedonian general, was a native of Cardia in the Thracian Chersonesus. He was employed as private secretary by Philip II. of Macedon, and later by Alexander the Great, whom he accompanied into Asia. In the

division of the empire on Alexander's death, Cappadocia and Paphlagonia were assigned to Eumenes; but as they were not yet subdued, Leonnatus and Antigonus were charged by Perdiccas to put him in possession. Antigonus, however, disregarded the order, and Leonnatus in vain attempted to induce Eumenes to accompany him to Europe. Eumenes joined Perdiccas, who installed him in Cappadocia. When Craterus and Antipater, having reduced Greece, determined to pass into Asia and overthrow Perdiccas, their first blow was at Cappadocia. Craterus and Neoptolemus, satrap of Armenia, were defeated by Eumenes (321); Neoptolemus was killed, and Craterus died of his wounds. After the murder of Perdiccas in Egypt by his own soldiers, the Macedonian generals condemned Eumenes to death, and charged Antipater and Antigonus with the execution of the order. Eumenes fled to Nora, on the confines of Cappadocia and Lycaonia, where he defended himself for more than a year. Antipater left the regency to his friend Polyperchon over the head of his son Cassander, who entered into an alliance with Antigonus and Ptolemy against Polyperchon, supported by Eumenes, who had escaped from Nora. In 318 Antigonus marched against him, and Eumenes withdrew east to join the satraps of the provinces beyond the Tigris. After two indecisive battles in Iran, Eumenes was betrayed by his own soldiers to Antigonus and put to death. He was an able soldier, who did his utmost to maintain the unity of Alexander's empire in Asia; but his efforts were frustrated by the generals and satraps, who hated and despised the "secretary" and "foreigner."

See Plutarch, *Eumenes;* Cornelius Nepos, *Eumenes;* Diod. Sic. xviii., xix.; Arrian, *Anabasis,* vii.; Quintus Curtius x. 4. 10; Justin xiii. 8; also MACEDONIAN EMPIRE.

EUMENIDES, ancient goddesses, also called *Semnai* ("reverend ones") worshipped at the foot of the Areiopagus at Athens, at Colonus, and in places outside Attica. Their cult closely resembled that of Gē (earth), and they were probably earth-spirits, largely concerned with fertility, but having also certain moral and social functions. By and after Aeschylus (q.v.) they were generally identified, although wrongly, with the Erinyes (q.v.). (From Gr. εὐμενής, kindly.)

See L. Farnell, *Cults of the Greek States,* v., p. 440.

EUMENIUS (*c.* A.D. 260–311), one of the Roman panegyrists, was born at Augustodunum (*Autun*) in Gallia Lugdunensis. He was of Greek descent. He became *magister memoriae* (private secretary) to Constantius Chlorus. In 296 Chlorus determined to restore the famous schools (*scholae Maenianae*) of Autun, and appointed Eumenius to the management of them. There is no doubt that Eumenius was a heathen, not even a nominal follower of Christianity. Nothing is known of his later years; but he must have lived at least till 311, if the *Gratiarum Actio* to Constantine is by him. Of the 12 discourses included in the collection of *Panegyrici Latini* (ed. E. Bährens, 1874), the following are probably by Eumenius: (1) *Pro restaurandis* (or *instaurandis*) *scholis,* delivered (297) in the forum at Autun before the governor of the province. Its chief object is to set forth the steps necessary to restore the schools to their former state of efficiency, and the author lays stress upon the fact that he intends to assist the good work out of his own pocket. (2) An address (297) to the Caesar Constantius Chlorus, congratulating him on his victories over Allectus and Carausius in Britain. (3) A panegyric on Constantine (310). (4) An address of thanks (311) from the inhabitants of Autun to Constantine for remission of taxes and other benefits. (5) A festal address (307) on the marriage of Constantine and Fausta. All these speeches, with the exception of (1), were delivered at Augusta Trevirorum (Trèves), whose birthday is celebrated in (3). Eumenius was far the best of the orators of his time, and in his restraint and moderation superior to most of the writers of imperial panegyrics.

There are treatises on Eumenius by B. Kilian (Würzburg, 1869), S. Brandt (Freiburg-im-Breisgau, 1882), and H. Sachs (Halle, 1885); *see* also Gaston Boissier, "Les Rhéteurs gaulois du IVe siècle," in *Journal des savants* (1884).

EUMOLPUS. The priestly clan of the Eumolpidae at Eleusis (*see* MYSTERY) claimed descent from a certain Eumolpus ("good or strong singer;" *i.e.,* priest who can chant his litanies clearly and well), an obvious personification of their hereditary functions. As might be expected in the case of so shadowy a figure, his legend fluctuates greatly, so much so that three Eumolpi have been assumed, quite unnecessarily, however. (1) Being a "sweet singer," he is naturally connected with Thrace, the country of Orpheus (*q.v.*). He is son of Poseidon and Chione ("Snow-girl"), daughter of Boreas; after sundry adventures he becomes king in Thrace, is invited to help the Eleusinians in their war with Erechtheus (*q.v.*), and is killed in the war. (2) As one of the originators of the Eleusinian mysteries, he is an Eleusinian, a son of Earth, father of *Kērux,* the mythical ancestor of the *Kērukes* (*see* MYSTERY), taught the mysteries by Demeter herself. (3) Since Orpheus and all his following were closely connected with mysteries of all sorts, Eumolpus is son, father or pupil of Musaeus. Further confusion is introduced by his being sometimes called son, not father, of *Kērux,* possibly a reflection of some old dispute over precedence between the two clans. As a priest, he purifies Heracles from the blood of the Centaurs, and also initiates him; as connected with the Orphic circle, he is a culture-hero, maker of various advances in the useful and fine arts. His tomb was shown both at Eleusis and in Athens.

See Engelmann in Roscher's *Lexikon s.v.* (authorities).

EUNAPIUS, Greek sophist and historian, was born at Sardis, A.D. 347. At Athens he became a favourite pupil of Proaeresius the rhetorician, and later taught rhetoric. Initiated into the Eleusinian mysteries, he was admitted into the college of the Eumolpidae and became hierophant. He was the author of *Lives of the Sophists* (Βίοι φιλοσόφων καὶ σοφιστῶν), still extant, and a continuation of the history of Dexippus (*q.v.*). Of the latter only excerpts remain, but the facts are largely incorporated in the work of Zosimus. It embraced the history of events from A.D. 270–404. The *Lives of the Sophists* is valuable as the only source for the history of contemporary neo-Platonism. Both works are marked by hostility to Christianity.

The *Lives* was edited by J. F. Boissonade (1822), with notes by D. Wyttenbach and by W. C. Wright with an Eng. trs. in Loeb series (1922); history fragments in C. W. Müller, *Fragmenta Hist. Graecorum,* iv.; *see* also Uberweg, *Grund. der gesch. der phil.* pt. I. (1926).

EUNOMIUS (d. *c.* 393), a leader of the extreme or "anomoian" Arians, sometimes called Eunomians, was born at Dacora, Cappadocia, early in the 4th century. He studied at Alexandria and was ordained deacon at Antioch. Through Eudoxius he was appointed bishop of Cyzicus in 360, but Eudoxius was compelled, by command of the emperor, Constantius II., to depose him from the bishopric a year later because of his extreme Arian views. Eunomius went to Constantinople and then to Chalcedon, whence in 367 he was banished to Mauretania for harbouring the rebel Procopius. He was recalled, however, before he reached his destination. In 383 the emperor Theodosius banished him to Halmyris in Moesia. He afterwards resided at Chalcedon, at Caesarea in Cappadocia, from which he was expelled by the inhabitants for writing against their bishop Basil, and lastly at Dacora. The influence of his writings was so much dreaded by the orthodox, that more than one imperial edict was issued for their destruction (*Cod. Theod.* xvi. 34). Consequently his commentary on the epistle to the Romans, mentioned by the historian Socrates, and his epistles, mentioned by Philostorgius and Photius, are lost. His first apologetical work (Ἀπολογητικός) written *c.* 360 or 365, has been recovered from the celebrated refutation of it by Basil, and is in J. A. Fabricius, *Bibl. Gr.* viii. Of a second apology written before 379 (Ὑπὲρ ἀπολογίας ἀπολογία), there are only quotations in a refutation by Gregory of Nyssa. The exposition of faith (Ἔκθεσις τῆς πίστεως), demanded by Theodosius, has been edited by Valesius in his notes to Socrates, and by Ch. H. G. Rettberg in his *Marcelliana.*

The teaching of the Anomoians, led by Aetius and Eunomius, starting from the conception of God as ὁ ἀγέννητος, argued that between the ἀγέννητος and γέννητος there could be no *essential,* but at best only a *moral,* resemblance. According to Socrates (v. 24), Eunomius, instead of baptizing in the name of the Trinity, baptized in the name of the Creator and into the death of Christ. The Eunomian heresy was formerly condemned by the council

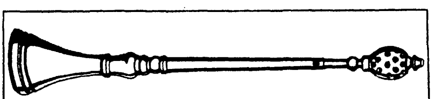
of Constantinople in 381.

See C. R. W. Klose, *Geschichte und Lehre des Eumonius* (Kiel, 1833); F. Loofs in Hauck-Herzog, *Realencyk.*; Whiston's *Eunomianismus redivivus* contains an English translation of the first apology. *See* also ARIUS.

EUNUCH, a castrated human male. From remote antiquity among the Orientals, as also at a later period in Greece, eunuchs were employed to take charge of the women, or generally as chamberlains. Their confidential position in the harems of princes frequently enabled them to exercise an important influence over their royal masters, and even to raise themselves to stations of great trust and power (*see* HAREM). Hence the term eunuch came to be applied in Egypt to any court officer, whether a *castratus* or not. The common idea that eunuchs are necessarily deficient in courage and in intellectual vigour is amply refuted by history. Herodotus states that in Persia they were especially prized for their fidelity; and they were frequently promoted to the highest offices. The capacity of eunuchs for public affairs is strikingly illustrated by the histories of Persia, India and China; and considerable power was exercised by the eunuchs under the later Roman emperors. The hideous trade of castrating boys to be sold as eunuchs for Muslim harems has continued to modern times, the principal district whence they are taken being north-central Africa (Bagirmi, etc.). The Italian practice of castrating boys in order to train them as adult soprano singers ended with the accession of Pope Leo XIII. Voluntary eunuchs who emasculated themselves, or caused the operation to be performed on them, for the avoidance of sexual sin or temptation, appeared in early Christian ages, its votaries acting on the texts Matt. xix. 12, v. 28–30. Origen's case is the most celebrated example, and by the 3rd century there had arisen a sect of eunuchs, of whom Augustine says (*De haeres.* c. 37), "*Valesii et seipsos castrant et hospites suos, hoc modo existimantes Deo se debere servire.*" (The Valesii castrate themselves and their guests, thinking thereby to serve God.) A sect of the kind exists in Russia, whose practice is expressed in their name of Skopzi.

EUNUCH FLUTE or ONION FLUTE, a wind instrument in use during the 16th and 17th centuries, producing music akin to the comb-music of the nursery, and still manufactured as a toy (*mirliton*). It consists of a wooden tube widening out slightly to form a bell and closed at its upper end by means of a very fine membrane. The mouthpiece, a simple round hole, is pierced a couple of inches below the membrane; into this hole the performer sings, his voice setting up vibrations in the membrane, which thus intensifies the sound and changes its timbre to a bleating quality.

EUONYMUS, in botany, a genus of deciduous or evergreen shrubs or small trees of the staff-tree family (*Celastraceae*). It comprises upwards of 100 species, widely distributed in the north temperate zone, and represented in Great Britain by *E. europaeus*, the spindle-tree. It is a shrub or small tree growing in copses or hedges, with a grey smooth bark, four-angled green twigs, opposite



BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

EUNUCH FLUTE, A 16TH CENTURY INSTRUMENT, THE MOUTHPIECE OF WHICH WAS CLOSED BY A PIECE OF PARCHMENT OR SKIN, GIVING IT A CURIOUS BLEATING TIMBRE

leaves and loose clusters of small greenish-white flowers. The ripe fruit is a pale crimson colour and splits into four lobes exposing the bright orange-coloured seed. Besides the spindle-tree, which has become naturalized in the eastern United States, the genus is represented in North America by *E. americanus* (strawberry bush), *E. obovatus* (creeping strawberry bush), *E. atropurpureus* (wahoo), and *E. occidentalis* (western wahoo). Numerous species are in cultivation, among which are *E. japonicus*, a handsome evergreen often with variegated leaves, and *E. repens*, a hardy climber for walls, especially the var. *vegetus*, which bears profuse persistent fruits. The flowering was said to foretell plague.

EUPALINUS, of Megara, a Greek architect, who constructed for the tyrant Polycrates of Samos a tunnel under a hill to bring water to the city. This aqueduct still exists, and is one of the most remarkable constructions in Greece. (*See* AQUEDUCTS.)

EUPATORIA, a seaport on the west coast of the Crimean A.S.S.R., 20 m. north-west of Simferopol, on a sandy promontory on the north of Kalamita Bay, in lat. 45° 15′ N., long. 33° 23′ E. The town is also known as Kozlov. Pop. (1926) 23,341. This number includes many Jews, the Karaite sect having their principal synagogue here. Of its numerous ecclesiastical buildings three are of interest—the synagogue of the Karaite Jews; one of the mosques, which has fourteen cupolas and was built (1552) after the plan of St. Sophia in Constantinople; and the Greek Catholic cathedral (1898). The roadstead has a sandy bottom, and is exposed to violent storms from the north-east. It is connected by a branch line with the main north to south railway. The trade is principally in cereals, skins, cow-hair, felt, tallow and salt. Its industries include the making of machines and chemical products, and the preparation of salt and of dried fish. Eupatoria has some repute as a sea-bathing resort.

According to some authorities it was near this spot that a military post, *Eupatorium*, was established in the 1st century A.D. by Diophantus, the general of Mithridates the Great, king of Pontus. Towards the end of the 15th century the Turks built the fortress of Gezleveh on the present site, and it became the capital of a khanate. It was occupied by the Russians under Marshal Münnich in 1736, and in 1771 by Prince Dolgorukov. Its annexation to Russia took place in 1783. In 1854 the Anglo-French troops were landed in the neighbourhood of Eupatoria, and in February 1855 the town was occupied by the Turkish forces.

EUPATORIUM, a numerous genus of plants of the family Compositae, comprising more than 500 species, nearly all American and found chiefly in tropical South America, the West Indies and Mexico. They are mostly perennial herbs, a few are annuals, and many tropical species are shrubby or tree-like. The leaves are usually opposite and the flowers are borne in rayless heads disposed usually in flat-topped clusters. Of the few Old World species, one, *E. cannabinum*, the hemp-agrimony, occurs in Great Britain. Upwards of 60 species are found in the United States and Canada, widely distributed but mostly in the eastern, southern and south-western States, very few occurring on the Pacific coast. Representative North American species are *E. perfoliatum*, boneset (*q.v.*); *E. purpureum*, Joe-Pye weed; *E. urticaefolium*, white snake-root; and *E. coelestinum*, mist-flower. Various tropical forms are in greenhouse cultivation and several hardy species are grown as border plants.

EUPATRIDAE, the ancient nobility of Attica (the Greek word means "sons of noble fathers"). Tradition ascribes to Theseus, whom it regards as the author of the *synoecism* (συνοικισμός), the union of Attica round Athens as a political centre, the division of the Attic population into three classes, *Eupatridai*, *Geōmoroi*, and *Dēmiourgoi*. The Eupatridae are described as the autochthonous population (*see* AUTOCHTHONES), the dwellers in the city, the descendants of the royal stock. After the time of the *synoecism* the nobles were obliged to reside in Athens, now the seat of government; and at the beginning of Athenian history the noble clans form a class which has the monopoly of political privilege. It is possible that in very early times the Eupatridae were the only full citizens of Athens.

The exact relation of the Eupatridae to the other two classes has been a matter of dispute. It seems probable that the Eupatridae were the governing class, the recognized nobility, the *Geōmoroi* the country inhabitants of all ranks, and the *Dēmiourgoi* the commercial and artisan population. It seems certain from the little known of the early constitutional history of Athens that the Eupatridae represented the only nobility that had any political recognition in early times. The political history of the Eupatridae is that of a gradual curtailment of privilege. They were at the height of their power in the period during the limitation of the monarchy. They alone held the two offices, those of polemarch and archon,

which were instituted during the 8th century B.C. to restrict the powers of the kings. In 712 B.C. the office of king (βασιλεύς) was itself thrown open to all Eupatrids (*see* ARCHON). They thus had the entire control of the administration and were the sole dispensers of justice in the State. At this latter privilege, which perhaps formed the strongest bulwark of the authority of the Eupatridae, a severe blow was struck (*c.* 621 B.C.) by the publication of a criminal code by Draco (*q.v.*), which was followed by the more detailed and permanent code of Solon (*c.* 594 B.C.), who further threw open the highest offices to any citizen possessed of a certain amount of landed property (*see* SOLON), thus putting the claims of the Eupatridae to political influence on a level with those of the wealthier citizens of all classes. By the middle of the 6th century the political influence of birth was at an end.

The name Eupatridae survived in historical times, but the Eupatridae were then excluded from the cult of the *Semnai* at Athens, and also held the hereditary office of "expounder of the law" (ἐξηγητής) in connection with purification from the guilt of murder. Isocrates says of Alcibiades that his grandfather was a Eupatrid and his grandmother an Alcmaeonid, which suggests that in the 5th century the Eupatrids were a single clan, like the Alcmaeonids, and that the name had acquired a new signification. This "Eupatrid" clan seems to have traced its origin to Orestes, "the benefactor of his father." *See* also AREOPAGUS, ARCHON.

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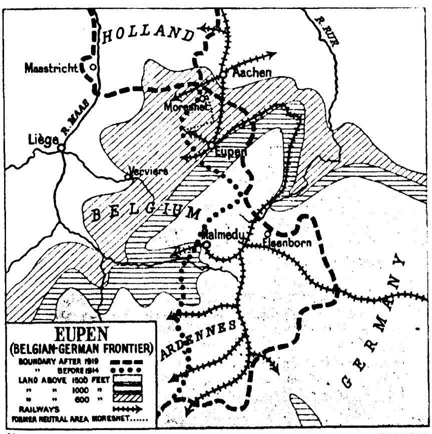
EUPEN AND MALMÉDY, two districts acquired by Belgium from Rhenish Prussia in 1919, with the small district of Moresnet. The latter, by an oversight in the Treaty of Vienna in 1815 was not assigned to either Belgium or Prussia, and part of it



MAP SHOWING BELGIAN-GERMAN FRONTIER BEFORE 1914 AND AFTER 1919

therefore remained neutral territory between the two countries. It comprised little over 3,000 inhabitants (census of 1910).

Prior to 1914 the boundary of Germany overlooked the valley of the right bank tributaries of the Meuse. The cession of Malmédy took the frontier eastward to the watershed between the feeders of the Meuse and those of the Moselle and Rhine, while the cession of Eupen removed the frontier from the vicinity of Verviers to that of Aachen. These changes transferred to Belgium important sections of the German railway system which had been developed near this frontier.

Eupen and Malmédy contain some 60,000 persons of whom less than one-sixth are Walloon and French-speaking, and five-sixths German. It was contended at the Peace Conference that these inhabitants had been systematically Prussianized since 1815. It seems true that the majority spoke French before that date, and were, in origin, Walloons. The conference therefore declined to sanction a plebiscite, but the inhabitants were permitted to express their opinions in registers for six months after the ratification of the treaty, Jan. 10, 1920. The League of Nations, to which the case was referred, ultimately assigned the areas to Belgium. By a decree of March 6, 1925, Eupen and Malmédy were joined to the province of Liége.

The Allied Powers (reply to the German observations on the draft treaty, June 16, 1919) based the fate of these areas on grounds other than those of self-determination. Eupen and Malmédy had been made a basis for German militarism, and had a close economic connection with Belgium. Moresnet, which had valuable woods, was assigned to Belgium "in partial compensation for the destruction of Belgian forests."

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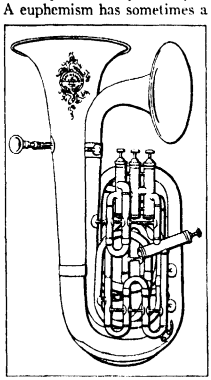
EUPHEMISM, a figure of speech in which an unpleasant or coarse phrase is replaced by a softer or less offensive expression. A euphemism has sometimes a metaphorical sense, as in the substitution of the word "sleep" for "death."



BY COURTESY OF CARL FISCHER
THE EUPHONIUM, THE HIGHEST PITCHED MEMBER OF THE FAMILY OF BRASS WIND-VALVE INSTRUMENTS KNOWN AS TUBAS

EUPHONIUM, a modern brass wind instrument, known in military bands as euphonium and in the orchestra as tuba. The euphonium consists of a brass tube with a conical bore of wide calibre ending in a wide-mouthed bell; it is played by means of a cup-shaped mouthpiece. The sound is produced as in the bombardon, which is the bass of the euphonium, by the varied tension of the lips across the mouthpiece, whereby the natural open notes or harmonics are obtained. The intervening notes of the chromatic scale are obtained by means of valves or pistons. The quality of tone is rich and full, blending well with that of the trombone. (*See* BOMBARDON.)

EUPHORBIA, in botany, a large genus of plants from which the family Euphorbiaceae takes its name. It includes about 750 species and is of almost world-wide distribution. It is represented in Great Britain and North America by the spurges—small, generally smooth, herbaceous plants with simple leaves and inconspicuous flowers arranged in small cup-like heads (*cyathia*). The cyathium is characteristic of the genus, and consists of a number of male flowers, each reduced to a single stamen, surrounding a central female flower which consists only of a stalked pistil; the group of flowers is enveloped in a cup formed by the union of four or five bracts, the upper part of which bears thick, conspicuous, gland-like structures, which in exotic species are often brilliantly coloured, giving the cyathium the appearance of a single flower (*e.g.*, the so-called Poinsettias). Another characteristic is the presence of a milky juice, or latex, in the tissues of the plant. In one section of the genus the plants resemble cacti, having a thick succulent stem and branches with the leaves very small or reduced to a small wart-like excrescence, with which is generally associated a tuft of spines (a reduced shoot). These occur in the warmer parts of the world and are essentially dry country or desert vegetation.

EUPHORBIACEAE, in botany, a large family of flowering plants, containing 220 genera with about 4,000 species, chiefly tropical, but spreading over the whole earth with the exception of the arctic and cold alpine zones. They are represented in Great

Britain and North America chiefly by the spurges (*Euphorbia*, *q.v.*) (fig. 1), which are herbaceous, but the greater number are woody, often trees. The large genus *Euphorbia* shows great variety in habit; many species, like the English and most North American spurges, are annual herbs, others form bushes, while in the desert regions of tropical Africa and the Canary Islands species occur resembling cacti, having thick fleshy stems and leaves reduced to spines. Another large genus, *Phyllanthus*, contains small annual herbs as well as trees, while in some species the leaves are reduced to scales, and the branches are flattened, forming phylloclades. The leaves also show great variety in form and arrangement, being simple and entire as in the English spurges, or deeply cut as seen in *Ricinus* (castor-oil) and *Manihot* or palmately compound (*Hevea*). The majority contain a milky juice or latex in their tissues which exudes on cutting or bruising. In *Hevea*, *Manihot* and others the latex yields caoutchouc. The flowers are unisexual; male and female flowers are born on the same, as occurs in the spurges, or on different plants, as in dog's mercury. Their arrangement shows considerable variation, but the flowers are generally grouped in crowded definite partial inflorescences, which are themselves arranged in spikes or stand in the axils of the upper leaves. These partial inflorescences are generally unisexual, the male often containing numerous flowers while the female flowers are solitary. The partial inflorescence (*cyathium*) of *Euphorbia* (fig. 1) resembles superficially a hermaphrodite flower. It contains a central terminal flower, consisting of a naked pistil; below this are borne four or five bracts which unite to form a cup-shaped involucre resembling a calyx; each of these bracts subtends a small cyme of male flowers each consisting only of one stamen. Between the segments of the cup are large oval or crescent-shaped glands, often brightly coloured, forming petal-like structures.

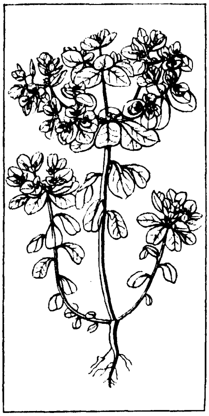


FIG. 1.—A SPURGE, EUPHORBIA HELIOSCOPIA, SHOWING GENERAL HABIT OF GROWTH
The cells of the plant contain latex, a milky-looking fluid

The form of the flower shows great variety. The most complete type occurs in *Wielandia*, a shrub from the Seychelles Islands, in which the flowers have their parts in fives, a calyx and corolla being succeeded in the male flower by 5 stamens, in the female by 5 carpels. Generally, however, only 3 carpels are present, as in *Euphorbia; Mercurialis* has minute apetalous flowers with 3 sepals, followed in the male by 8 to 20 stamens, in the female by a bicarpellary pistil. In many genera the corolla is absent. The most reduced type of flower is that described under EUPHORBIA. The stamens are sometimes more or less united (monadelphous), and in castor-oil (*Ricinus*) are much branched. The ovary generally contains three chambers, and bears three simple or more often bipartite styles; each chamber contains one or two pendulous ovules, which generally bear a cap-like outgrowth or *caruncle*, which persists in the seed.

As the stamens and pistil are borne by different flowers, cross-pollination is necessary. In *Mercurialis* and others with inconspicuous flowers pollination is effected by the wind, but in many cases insects are attracted to the flower by the highly-coloured bracts, as in many *Euphorbias* and *Dalechampia*, or by the coloured calyx as in *Manihot;* the presence of honey is also frequently an attraction, as in the honey-glands on the bracts of the cyathium of *Euphorbia*. The fruit is generally a capsule which splits into three divisions (*cocci*), separating from the central column, and splitting lengthwise into two halves. In the manchineel (*Hippomane Mancinella*) of Central America the fruit is a drupe like a plum, and in some genera berries occur. In the sandbox tree (*Hura crepitans*) of tropical America the ovary consists of numerous carpels, and forms when mature a capsule which splits with explosive violence into a number of woody cocci. The seeds contain abundant endosperm and a large embryo.

Several members of the family are of economic importance. *Manihot utilissima*, manioc or cassava (*q.v.*), is one of the most important tropical food-plants, its thick tuberous root being rich in starch; it is the source of Brazilian arrowroot. Caoutchouc or india-rubber is obtained from species of *Hevea, Mabea, Manihot* and *Sapium*. Castor-oil (*q.v.*) is obtained from the seeds of *Ricinus communis*. The seeds of *Aleurites triloba* and *Sapium sebiferum* also yield oil. Resin is obtained from species of *Croton* and *Euphorbia*. Many of the species are poisonous; *e.g.*, the South African *Toxicodendron*, one of the most poisonous plants known. Many, such as *Euphorbia, Mercurialis, Croton, Jatropha, Tragia*, have been, or still are, used as medicines. Species of *Codiaeum* (*q.v.*), *Croton, Euphorbia, Phyllanthus, Jatropha* and others are used as ornamental plants in gardens.

The box (*Buxus*) and a few allied genera, formerly included in Euphorbiaceae, are now generally regarded as forming a distinct family, Buxaceae, differing from Euphorbiaceae in the position of the ovule in the ovary-chamber and in the manner of splitting of the fruit.

EUPHORBIUM, an acrid dull-yellow or brown resin, consisting of the concreted milky juice of several species of *Euphorbia*, cactus-like perennial plants indigenous to Morocco. It dissolves in alcohol, ether, and turpentine; in water it is only slightly soluble. It consists of two or more resins and a substance euphorbone, $C_{20}H_{36}O$ or $C_{15}H_{24}O$. In former times euphorbium was valued in medicine for its drastic purgative and emetic properties.

EUPHORBUS, son of Panthus, a Trojan hero, slain by Menelaus (*Iliad*, xvii. 1–60). Pythagoras, in support of his doctrine of the transmigration of souls, declared that he had once been this Euphorbus. (Horace, *Odes*, i. 28. ii.; Diog. Laert. viii. i.)

EUPHORION, Greek poet and grammarian, born at Chalcis in Euboea about 275 B.C. He spent much of his life in Athens, where he amassed great wealth. About 221 he was invited by Antiochus the Great to the court of Syria. He assisted in the formation of the royal library at Antioch, of which he held the post of librarian till his death. He wrote mythological epics, amatory elegies, epigrams and a satirical poem (Ἀραί "curses"). Prose works on antiquities and history are also attributed to him. His elegies were esteemed by the Romans; they were imitated or translated by Cornelius Gallus and also by the emperor Tiberius.

Fragments in Meineke, "De Euphorionis Chalcidensis vita et scriptis," in his *Analecta Alexandrina* (1843); for another fragment of about 30 lines see *Berliner Klassikertexte*, v. i. (1907).

EUPHRANOR, of Corinth (dated by Pliny in 364 B.C.), a Greek artist who excelled both as a sculptor and as a painter. In Pliny we have lists of his works; among the paintings, a cavalry battle, a Theseus, and the feigned madness of Odysseus; among the statues, Paris, Leto with her children Apollo and Artemis, Philip and Alexander in chariots. Unfortunately we are unable among existing statues to identify any as copies from works of Euphranor (for attempts to do so *cf.* Six in *Jahrbuch*, 1909, 7 ff., and Furtwängler, *Masterpieces* pp. 348 ff.). He appears to have resembled Lysippus, in his preference for bodily forms slighter than those usual in earlier art, and in his love of heroic subjects. He wrote books on proportion and colour.

EUPHRATES (Shatt al Fara, Frat su) the largest river of western Asia, and the western of the two streams which flow through Mesopotamia into the Persian gulf. It may be divided into three divisions, an upper, middle and lower, the first extending as far as Samsat, the second to Hit, and the third to its junction with the Tigris at Kurna, the united stream thus formed being known as the Shatt al Arab (*q.v.*). Pliny writing in the first century A.D. says that the Euphrates originally had its own mouth (*see* MESOPOTAMIA: *Geology*) and within historical times the lower course of the river has changed considerably. The shore line at the end of glacial times appears to have been near Hit. Below this point the river has tended to move westwards, the old channel

in Sumerian times corresponding more or less to modern Shatt al Nil, while to-day the river shows a tendency, so far more or less overcome, to desert its bed which passes the ruins of Babylon, the Hilla branch, and to follow a yet more westerly channel, the Hindiya branch. The importance of these changes to human history have been very considerable (*see* MESOPOTAMIA: *Ancient Geography*). Owing to the fact that the Euphrates floods in spring, just before the burning heat of the summer, it has been necessary to use it for perennial irrigation. The tendency has been to dig canals at low water; during flood the river has tended therefore to carry silt into the irrigation canals and often to desert its bed with disastrous results. Most of the changes in the stream appear to have been the result of man's action, followed by the natural flooding of the river. The history of the river has gradually resulted in its becoming less useful to man as it moved westwards from the Tigris, and made the emptying of the canals supplied by the Euphrates (but running into the Tigris) more and more difficult. Measures of conservation have been undertaken since Sumerian times, but these measures have been continually frustrated by the action of riparian owners, who disregarding the efforts alike of Rim-sin and Alexander, have persisted in raising the water level by dikes and have neglected to keep the minor channels deep.

In addition to this westward movement the river since glacial times has been continually pushing its delta southward, combining with other streams, to form first lakes, then marshes and finally dry land (for further details, *see* MESOPOTAMIA: *Geography*).

The Upper Division.—The upper Euphrates consists of two arms, the Kara su (Western Euphrates), the more northerly branch, and the Murad su (Eastern Euphrates). These two streams flow from the Armenian plateau along shallow valleys uniting west of Arabkir, and after cutting through the Taurus flow down from the foothills into Mesopotamia. The *Kara su,* considered by the Arab geographers as the main stream, and formerly the eastern boundary of the Roman Empire rises in Dumlu Dagh, north-north-west of Erzerum at an altitude of 8,625 ft., and flows south-east to the plain of Erzerum. From this point it flows west-south-west through a narrow valley to Erzingan, being joined by the Ovajik su on the right bank, the Tuzla su on the left, and the Merjan and the Chanduklu on the right. From this point the river flows south-west through a rocky gorge to Kemakh, at which point it is crossed by a bridge and receives the Kumur su. Between Avshin and Pingan, where it is crossed by a bridge, it flows through a canyon about 1,000 ft. deep. Below it is joined on the right bank by the Chalta Irmak. From this point its gorge, until it joins the Murad su, is famous for its wild scenery and precipitous walls. The Kara su is a rapid stream of considerable size and is navigable downstream for rafts below Erzingan. It communicates by a low and easy pass with the Aras (Araxes) valley and from this point westwards a road runs which has formed both an ancient trade route and a ready means of access for invading barbarians from the east.

The *Murad su,* although longer and of greater size, has never formed a highway of communication, owing partly to the smallness of its valley below Mush, and has acquired less historical fame. It rises at a height of 11,500 ft. on the northern side of Ala Dagh, south west of Diadin. From this point it flows west to the Arishkerd plain, where it is joined by the Sharian su. Through the trough formed by the two valleys passes the trade route from Erzerum to northern Persia. The river then runs through the mountains to the south and has two tributaries, the Patnotz on the left bank and the Khinis su on the right. It flows in a double bend in a general southwesterly direction through the plain of Bulanik to the plain of Mush, where it is joined by another river usually known as Kara su (the name means black water and is applied to several rivers) which rises near Lake Van. Below Mush its valley is much contracted; it runs west-south-west through a rocky gorge into which flows the Gunig su (on its right bank) as far as Palu. From this point the valley is more open. About ten miles east-north-east of Kharput the Peri su, which drains the Dersim, a mountainous region between the two main branches of the Euphrates, and is the most important tributary of the Murad su, falls into it.

The length of the Murad su to its junction with the Kara su is 415 miles, the length of the latter being 275 miles. From this point the Euphrates flows in a southwesterly direction past the lead mines at Keban Maden, where it is crossed by a ferry, 120 yd. across, on the road from Kharput to Sivas. It then runs in a great bend round the Musher Dagh, and is joined by the Kuru Chai, down whose valley the road from Malatia to Sivas runs, and the Tokhma su. Shortly below the ferry it enters a deep gorge and runs through the Taurus range in a rapid fall, the course of the river being much interrupted by rapids. It runs south east, close to the source of the western Tigris, and then turns at right angles and flows south-west leaving the mountains a few miles above Samsat (Samosata), the distance from the junction of the main two rivers to the latter town being 115 miles.

The Middle Division.—The middle division of the river, from the mountains above Samosata to the old shore line at Hit, is a little over 700 miles. The valley bed here is a few miles wide and covered with a bed of alluvium. The country is treeless and open and though sparsely populated it is to a certain extent irrigated, within the actual zone of the valley itself. Two methods of irrigation are used, the more modern is the draw well, where a skin is lowered into the water and raised by oxen. The more ancient method is however of greater importance because of the obstacles which it sets to navigation. The method used is the construction of great wheels, like those used on some of the rivers of China. These wheels carry earthen vessels which pick up a small proportion of the water and discharge into aqueducts carried on arches, which form a serious obstacle in the path of the stream. Much of the valley is to-day desolate and the desert approaches to the rocky edge of the valley sides. In ancient times the valley appears to have been inhabited as far as the mouth of the Khabur, the principal towns being on the left bank. To-day however from Birijik southwards the river is very desolate and little known, the principal towns, which are Samsat, Birijik, Kalaat en Nidjin, Meskene, Rakka, Madan, Dier ez Zor, Ana and Hit, being all on the right bank except Birijik and Rakka, the latter however is at the confluence of a tributary stream. A caravan road runs along this bank, and there are posts along the road, but the whole scenery is one extremely desolate. This feeling of desolation is enhanced by the geological strata through which the river has cut its valley. They consist of marls and gypsum, overlaid with sandstone and topped with breccia or conglomerate. In places the erosion has produced curious flat-topped hills, sometimes rising a hundred or more feet above the river. Above Deir ez Zor the river has cut through a dike of basalt, along the south side of the extension of which the road runs west from Deir to Tadmor.

This now desolate stretch of the river was of great importance historically. It separated for long the Assyrian and Hittite empires, and was the dividing line between the western and eastern satrapies of the Persian Empire, while at various times it formed the boundary of the Roman Empire. During the Mongol tenure of Mesopotamia it formed a fortified frontier against the Mongols. The ancient ruins along this frontier are numerous and important. Samsat is built on the site of Samosata, the capital of the Seleucid kings of Commagene; it is situated at an old crossing point of the river, and the old road from Susa to Sardis probably passed through it. A little lower down the river, at the point where the Sanjeh (Σίγγας) joins the main stream, stands the Rum-Kaleh, an ancient castle on a high rock defending another ancient crossing; 25 m. south of this point is Birijik (ancient Birtha, the Apamea Zeugma), the point at which the main road from east to west crosses the river, as it has done for many centuries. The point is only just over a hundred miles from the Mediterranean at an altitude of 628 feet. From this important caravan centre the river runs sluggishly southwards past Jerablus (Carchemish), which lies close to the junction of the Sajur (Sagara), to Meskene, close to which are the ruins of Barbalissus, now a short distance from the river, but formerly a river port for the overland trade with Aleppo. At this point the river road turns westwards and crosses the desert to Aleppo. Six miles below this again is another important crossing point Thapsacus (modern Kalaat Dibse). This was

probably the most important of all the passages of the river in this region. It formed the point for the starting of caravans in ancient times. Cyrus here crossed the river and it was this passage which was used by Alexander. At this point the river takes a sharp bend to the east. From here onwards there are a succession of ancient towns. A few miles below Thapsacus there lies on the west bank the Kalaat Jaber (Dausera), while on the opposite bank is the more ancient Siffin (Roman Sephe). Below this again is another Roman frontier post, Sura, on the west bank, and 20 m. south of this, but away from the river, the ruins of Reseph. Below Sura (but on the other side of the river) are the ruins of Heraklea (Haragla). At the point where the Belikh, an important tributary joins the Euphrates, is the site of Nicephorum (modern Rakka) called Callinicus in Seleucid and Roman times and at one time the capital of Harun al Raschid. The Belikh (Bilechas) is a river of some importance in antiquity, on whose banks are Urfa (Edessa *q.v.*) and Harran (Carrhae). Below Rakka, at the point already mentioned where the river cuts through a basaltic dike, are two great ruins: on the left bank Zelebiya, on the right Halebiya (Zenobia), which are situated about 26 m. above Deir-ez Zor. Below Deir the river opens out into a large plain and runs through two channels. This point has also been a ford of considerable importance and today is the meeting point of the western road, which goes by Palmyra, and the eastern road to Mosul, in addition to the up and down river road. The site is one of great antiquity and there are numerous ancient mounds. Below Deir the Khabur joins the left bank of the Euphrates, flowing from the foothills to the north. This stream, which has one important tributary the Jaghijagh (Mygdonius) was the frontier of the Roman empire from the time of Diocletian. At this point are the ruins of the Roman Circesium (Assyrian Sirki), modern Al-Buseira. The fortress on the opposite bank, Salahiya (Ad-Daliye of Arab times) lies a little below. Between this point and Deir, on an old canal are the ruins of the Arab fort of Rahba.

Although some doubts have been raised there seems every probability that the Khabur is identical with the Araxes of Xenophon (called Saccoras by Ptolemy) and the distance given by Xenophon, of fifty parasangs between Thapsacus and Araxes, is a fair estimate of the actual distance. All this northerly region must have been until the time of the Mongols, or even later fairly highly populated and prosperous, both on the evidence of archaeology and the statements of ancient authors. It seems probable that the change is due entirely to the devastating effect of the Mongol invasion.

Below this point the region has always been desolate, although along the river in ancient and modern times there were a series of small towns and villages. Below Salahiya on the eastern side of the river are the ruins of Al Irsi and below this again, at a point where two great wadis mark the course of a former tributary from the Syrian plateau, is an unidentified town built of unbaked brick. At this point there is a sharp bend to the east as far as Ana, above which town are a series of rapids. Ana is an ancient town, probably originally Sumerian; it lay on islands of the stream, where there are today a series of ruins, mostly of Persian and Arab date. The whole nature of the river changes at this point, the valley is very constricted, leaving very little alluvial ground for cultivation, while there are numerous islands in the stream. The vegetation also changes. Although the date palm grows as far north as Deir, here it becomes common and in favoured spots palm groves are found, while the olive, characteristic of the Mediterranean regions, entirely disappears. Side by side with the change in flora the presence of one ruin at least of crude brick, shows that we are definitely approaching the true Mesopotamian zone.

Between Ana and Hit there are four ancient sites, possibly old river guard posts. Haditha, in ancient times Baia Malcha, was an important town under the Abbasids; Al Uzz may probably be identified with the ancient Auzura (Uzzanesopolis) and Jibb Jibba, a site whose ancient name has not been identified. Olabu lies on the now uninhabited island of Telbeis. The neighbourhood of Hit is remarkable for the bitumen lakes, which supplied material for cementing bricks in ancient times and was and is still used for caulking boats. The region has been known from time immemorial as a place where there was an ooze of petroleum and it is possible that it may prove a fertile oil field.

The whole of the region of the middle Euphrates is marked by a long series of ancient sites. In classical times it was comparatively thickly populated and the descriptions of Xenophon suggest that the country was fertile and contained much game. Until the Mongol invasion this prosperity continued, and indeed there is reason to believe that it attained its greatest prosperity under the Abbasid caliphs.

The Lower Division.—The lower division of the Euphrates extends from Hit to the junction with the Tigris, just below Kurna. Throughout this region the river runs through bare flat alluvium in a south-easterly direction, with little traces of any rock except just above Hilla and at Warka. At Hit the river is about 250 yd. across. From this point onwards the river decreases in size, as it receives no tributaries and much of its water is used for irrigation or dissipated in swamps. The speed of the main stream is slow, not normally exceeding a mile per hour and often falling to a quarter of this velocity except where the stream is held up by floating bridges, as at Ramadi, Feluja, Mussaib, Hilla, Diwaniya and Samawa. From Hit to Museyib there is a single channel. Between the latter town and Samawa the Euphrates divides into two branches: the more westerly, which carries most of the water, the Hindiya branch; the more easterly the Hilla branch. At Feluja the river approaches most closely to the Tigris, but from that point onwards the two streams are widely separated and enclose the great alluvial plain of ancient Sumeria.

All this region is extensively irrigated and the canals supplied by the river form an important part of its topography. Of these canals the largest is the Cherra Saaheh (Khandak Sabur). This great canal ran all along the edge of the alluvial plain from below Hit to the Persian gulf. It was protected by a series of guard posts and is of great antiquity; it was reconstructed in the time of Nebuchadrezzar, but its original date is unknown. The majority of the canals however are on the left bank, and originally tailed into the Tigris. Above Ramadi, a small town which forms the crossing place of the modern mail service across the desert, the Dujail flows across the plain and into the Tigris between Ukbara and Baghdad. Below this the Sakhlawiya, which follows closely the course of an ancient canal, leaves the Euphrates near Anbar and joins the Tigris at Baghdad. This canal had within the last sixty years been navigable for steamers. Below this again the Abu-Ghuruayb (Sarsar) crosses the plain and tails into the Tigris between Baghdad and Ctesiphon. The Nahr al Mali, sometimes called to-day the Radhwaniya canal, a little lower down joins the Tigris below Ctesiphon. Below this the Cutha canal Harl Ibrahim crosses the narrow strip between the rivers. It will be seen from an enumeration of this series how important to Mesopotamia the close position of the two rivers is and what profound changes have been effected by the alteration of the bed of the Euphrates lower down the stream.

Below Museyib the river has from ancient times divided into two branches, the Hindiya and the Hilla branch. The ancient channel however seems to have flowed still more to the east, past a series of ancient sites of which the most important are Kish and Nippur, below which it again divided into two channels. (*See* MESOPOTAMIA: *Ancient Geography.*) The two modern branches join again near Samawa, 110 m. lower down. Between 1865 and 1890 the main stream shifted its course into the western branch. The Hilla branch was threatened with complete desiccation. A new Hindiya barrage was erected and a regulator was built on the Hilla branch to ensure a proper distribution of the water. Considerable progress is being made in this region in restoring the ancient irrigation system. The Shatt al Nil, a canal which probably followed more or less the ancient stream bed, is once more in use and is irrigating a large amount of land; it runs quite close to the ancient city of Kish. Near Diwaniya there is also another large canal.

On the Hindiya branch there are no important towns, on the Hilla branch is Hilla itself, lying on both sides of the river, the

two banks being connected by a bridge of boats; below is Diwaniya. At Samawa the two branches reunite and flow to Nasariyeh. From this point onwards the Euphrates is lower than the Tigris. Nasariyeh probably marks the spot where at one time the two rivers joined. The Shatt al Hai, which flows along the old bed of the Tigris, even to-day carries a good deal of Tigris water into the Euphrates and was carrying the main stream certainly down to 2000 B.C. From this point onwards it flows through marshy land and eventually joins the Tigris at Kurna. From this point onwards the united streams are known as the Shatt al Arab (*q.v.*).

From Hilla onwards there are no ancient sites on the present course of the Euphrates, though Ur is close to the stream. Considerable discussion has taken place concerning the place where the Euphrates flowed into the sea in ancient times. There is absolutely no doubt that the ancient texts definitely state that Eridu was on the edge of salt water. If it be argued that it was on the edge of a lake this lake must have been salt, unless we are to disregard the ancient statements. Campbell Thomson's discovery of fresh water mussels has been put forward as proving that the ancient texts must be disregarded. His account however does not disprove that the mussels in the earliest stratum were in situ and had not been used for food. Some sea shells were also found, which may equally well have been used for food. In later times the abundance of fresh water shells on the surface shows that the area must have been a large lake. There is further evidence of numerous lacustrine lakes along the Euphrates; in classical times there was one as high up as Karbala. To-day such lakes as exist have become marshes. The river is however still young and has not yet firmly established itself in its channel. The deposition of silt will probably in time accomplish this. The point however is an important one, for naturally on the amount of silt which the river can deposit on its way to the sea will greatly depend its power of adding to its delta at the mouth.

Navigation.—Although high water may be said to extend from Dec. to June, the river does not begin to rise high till the end of March, attaining its maximum about the end of May, and its minimum at the end of November. In ancient times there seems to have been considerable traffic on the river, practically all down stream. Much of the modern traffic, both in the forms of the boats and in methods of navigation, does not differ very much from the ancient methods. From Meskene to Hit the local traffic is carried downstream in flat bottomed boats. Much of the river is interrupted by rapids and navigation is difficult except at high water. Below Hit the river can be navigated by steamers with a draught of under 5 feet. The width of the stream varies between 150 and 500 yd., with a current of 5 m. an hour, draining to 1½ at low water. The discharge at Hit varies from 4,000 cu. metres a second to as low as 270. The observations on the Hindiya branch are too few to furnish a just estimate; no continuous navigation can be carried on in the Hilla branch. In the Hindiya branch there are locks planned to take vessels drawing 5 ft. at low water, but at the barrage and Samawa at certain times only 2 ft. is available. South of Samawa, between this town and Nasariyeh the river flows in a firm bed and a minimum of 5 ft. is always available and there are no obstacles to navigation. Below this point the river is no longer navigable except in flood time.

The main channel below Suk esh Sheyuk no longer carries any large amount of water and the Euphrates discharges through the Hammar lake to the Shatt al Arab at Kurmat Ali. During the World War certain efforts were made to dredge the old channel and to cut through the bar at Chubaish, but these were discontinued and a large expenditure would no doubt be necessary to make navigation possible along the whole stream. Sir W. Willcocks proposed to use the river purely as a drain for the water used for irrigation from the Tigris. Considerable divergence of opinion has been expressed on this point, and some authorities have considered that the river might be used for both purposes, although considerable works might have to be undertaken. In the lower reaches of the river no doubt considerable maintenance charges would be needed. It has been considered that, if the obstacles up stream were removed and a different method of irrigation employed, the upper reaches could be used for up stream as well as down stream navigation, which in time might be commercially profitable.

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(L. H. D. B.)

EUPHRONIUS, a distinguished Athenian potter and vase painter of the end of the sixth and beginning of the fifth century B.C. (*see* GREEK ART and CERAMICS). Several vases with his signature are preserved. The name of the artist who decorated the vases which Euphronius signed as potter is not known, but he has been named the Panaitios painter from the inscriptions "fair Panaitios" which occur on his works. Among the best known vases decorated by Euphronius as painter are the crater with Heracles and Antaeus (Louvre) and the Kylix with Heracles and Geryon (in Munich). (*Cf.* J. D. Beazley, *Attische Vasenmaler,* pp. 58 ff. and 165 ff., 1925.)

EUPHROSYNE (*fl. c.* 470), a virgin of Alexandria, who, to escape marriage, disguised herself as a man and became a member of a monastic community. In his grief her father came to her for religious instruction, but she did not reveal her identity until just before her death. Her feast is celebrated in the Roman Church on Jan. 16, and in the Greek Church on Sept. 25.

EUPHUISM, the peculiar mode of speaking and writing brought into fashion in England towards the end of the reign of Elizabeth by the vogue of the fashionable romance of *Euphues,* published in 1578 by John Lyly. As early as 1570 Ascham in his *Schoolmaster* had said that "Euphues" (*i.e.*, a man well endowed by nature, from the Gr. εὖ, φυή well, growth) is "he that is apt by goodness of wit, and applicable by readiness of will, to learning, having all other qualities of the mind and parts of the body that must another day serve learning." Lyly adopted this word as the name of the hero of his romance, and it is with him that the vogue of Euphuism began. He addressed himself to "the gentlewomen of England," and he had the audacity, in that grave age, to say that he would rather see his books "lie shut in a lady's casket than open in a scholar's study." Lyly was 26 when he published in 1579 the first part of *Euphues: the Anatomy of Wit:* a second part, entitled *Euphues and his England,* appeared in 1580.

For a comprehension of the nature of Euphuism it is necessary to remember that the object of its invention was to attract and to disarm the ladies by means of an ingenious and playful style, of high artificiality, which should give them the idea that they were being entertained by an enthusiastic adorer, not instructed by a solemn pedagogue. For 50 years the romance of *Euphues* retained its astonishing popularity. As late as 1632 the publisher, Edward Blount (1560?–1632), recalling the earliest enthusiasm of the public, wrote of John Lyly, "Oblivion shall not so trample on a son of the Muses, and such a son as they called their darling. Our nation are in his debt for a new English which he taught them. *Euphues and his England* began first that language. All our ladies were then his scholars, and that beauty in Court, which could not parley Euphuism, was as little regarded, as she which, now there, speaks not French." Among those who applied themselves to this "new English," was Queen Elizabeth herself, styled by J. R. Green "the most affected and detestable of Euphuists."

Euphuism did not attempt to render the simplicity of nature. On the contrary, in order to secure refinement, it sought to be as affected, as artificial, as high-pitched as possible. Its most prominent feature was an incessant balancing of phrases in chains of antitheses, thus:— "Though the tears of the hart be salt, yet the tears of the boar be sweet, and though the tears of some women be counterfeit to deceive, yet the tears of many be current to try their love." Another of the main characteristics of Euphuism was the incessant use, for purposes of ornament, of similes taken from fabulous records of zoology, or relating to mythical birds, fishes or minerals. This was a feature which was excessively admired. That lady was considered most proficient in Euphuism who could keep up longest these chains of similes taken out of fabulous

natural history. Alliteration was also a particular ornament of the Euphuistic style, as: "The bavin, though it burn bright, is but a blaze," but the use of this artifice by Lyly himself was rarely exaggerated; for instances of its excess we turn to his imitators.

The earliest instance of the word "Euphuism" which has been traced occurs in a letter written by Gabriel Harvey in 1592, when he speaks of a man, who would be smart, as talking "a little Euphuism." Dekker, in the *Gull's Hornbook* of 1609, uses the word as an adjective, and denounces "Euphuised gentlewomen." When the practice was going out of fashion we find it thus severely stigmatized by Michael Drayton, a poet who had little sympathy with the artificial refinement of Lyly. In an elegy, printed in 1627, Drayton refers to the merit of Sir Philip Sidney, who recalled English prose to sanity, and

"did first reduce
Our tongue from Lyly's writings then in use,
Talking of stones, stars, plants, of fishes, flies,
Playing with words and idle similes,
As th' English apes and very zanies be
Of everything that they do hear and see,
So imitating his ridiculous tricks
They spake and writ, all like mere lunatics."

This severe censure of Euphuism may serve to remind us that hasty critics have committed an error in supposing the *Arcadia* of Sidney to be composed in the fashionable jargon.

Lyly found in Greene, Lodge, Dickenson, Nicholas Breton and others, enthusiastic disciples who had learned all the formulas of Euphuism, and could bring them forth as fluently and elegantly as he could himself. Nevertheless the trick wore out, with the taste that it had created, by the close of the reign of James I.

Critics have not failed to insist, on the other hand, that a species of Euphuism existed before *Euphues* was thought of. It has been supposed that a translation of the familiar epistles, or, as they were called, the "Golden Letters," of a Spanish monk, Antonio de Guevara, led Lyly to conceive the extraordinary style which bears the name of his hero. Between 1574 and 1578 Edward Hellowes (fl. 1550–1600) translated into a very extravagant English prose three of the works of Guevara. Earlier than this, in 1557, Sir Thomas North had published a version of the same Spanish writer's *Reloj de Principes* (The Dial of Princes), a moral and philosophical romance not without a certain likeness in plan and language to *Euphues*.

See Landmann, *Der Euphuismus* (1881); Arber's edition of *Euphues* (1869); R. W. Bond's *Complete Works of Lyly* (1902).

EUPOLIS (*c.* 446–411 B.C.), Athenian poet of the Old Comedy, flourished in the time of the Peloponnesian War. He is said to have been drowned by Alcibiades, whom he had attacked in one of his plays, but it is more likely that he died fighting for his country. He is ranked by Horace (*Sat.*i.4.1) along with Cratinus and Aristophanes, as the greatest writer of his school. He was reputed to equal Aristophanes in the elegance of his style and Cratinus in his command of satire. Although he was at first on good terms with Aristophanes, their relations later became strained, and they accused each other of plagiarism. Of the 17 plays attributed to Eupolis, with which he won the first prize seven times, only fragments remain. Of these the best known were: the *Kolakes*, directed against the spendthrift Callias (*q.v.*); *Marikas*, an attack on Hyperbolus, the demagogue; the *Baptai*, against Alcibiades and his clubs. The *Demoi* and *Poleis* were political, dealing with the desperate condition of the state and with the allied (or tributary) cities.

Fragments in T. Kock, *Comicorum Atticorum fragmenta*, i. (1880).

EUPOMPUS, the founder of the great school of painting which flourished in the 4th century at Sicyon in Greece. He was eclipsed by his successors, and is chiefly remembered for the advice which he is said to have given to Lysippus to follow nature rather than any master.

EURASIAN, a term originally used in India to denote children born of Hindu mothers and European (especially Portuguese) fathers. Following the geographical employment of the word Eurasia to describe the whole of the great land mass of Europe and Asia, Eurasian is used of persons born of parents representing the races of the two continents.

EURE, a department of north-western France, formed in 1790 from a portion of the old province of Normandy, together with the countship of Evreux and part of Perche. Pop. (1926) 308,445. Area, 2,330 sq.m. It is bounded north by the department of Seine Inférieure, west by Calvados, south-west by Orne, south by Eure-et-Loir, and east by Seine-et-Oise and Oise. Eure is a dissected plateau sloping from a height of 800 ft. in the south-west to the Seine in the north. Forests cover about one-fifth of the department. The rivers include a portion of the Seine in the north-east, receiving the Andelle and the Epte on the right, and the Eure with its feeders the Avre and the Iton, and the Risle with its tributary the Charentonne, on the left. The Eure and the Risle rise in Orne. The climate is mild, but moist and variable. The soil is for the most part clayey, resting on a bed of chalk, and is, in general, fertile and well tilled. Wheat, oats, colza, flax and beetroot are grown. There is much pasturage, supporting numbers of cattle and sheep, and especially of the celebrated Norman horses. Fruit is very abundant, especially apples and pears, from which much cider and perry are made. The mineral products of Eure include freestone, marl, lime and brick-clay. The chief industries are the spinning of cotton and wool, and the weaving, dyeing and printing of fabrics of different kinds. Turnery, cotton-bleaching, metallurgy, tanning, and the manufacture of glass, paper and wind instruments are also carried on. Coal and raw materials for its industries are the chief imports of Eure; its exports include cattle and horses, poultry, eggs, butter, grain and manufactured goods. The department is served chiefly by the Ouest-État railway; the Seine, Eure and Risle provide 87 m. of navigable waterway. Eure is divided into the following arrondissements (containing 36 cantons, 700 communes):—Evreux, Les Andelys and Bernay. The capital of the department is Evreux, which is the seat of a bishopric of the ecclesiastical province of Rouen. The department belongs to the III. Army Corps (Rouen) and to the *académie* (educational division) of Caen. Its court of appeal is at Rouen.

Evreux, Les Andelys, Bernay, Louviers, Pont-Audemer, Verneuil, Vernon and Gisors are the principal towns of the department. At Gaillon there are remains of a celebrated château of the archbishops of Rouen (*see* LOUVIERS). Pont de l'Arche has a fine Gothic church, with stained-glass windows of the 16th and 17th centuries; the church of Tillières-sur-Avre is a graceful specimen of the Renaissance style. The churches of Conches (15th or 16th century) and of Rugles (13th, 15th and 16th centuries), and the château of Beaumesnil (16th century) are also of architectural interest.

EURE-ET-LOIR, an inland department of north-western France, formed in 1790 of portions of Orléanais and Normandy. Pop. (1926) 255,213. Area, 2,293 sq.m. It is bounded N. by the department of Eure, W. by Orne and Sarthe, S. by Loir-et-Cher, S.E. by Loiret, and E. by Seine-et-Oise. The Perche in the south-west and the Thimerais in the north-west are districts of hills and valleys, woods, lakes and streams. The level cornland of Beauce occupies the east and south. The department is drained northward by the Eure (tributaries Vègre, Blaise and Avre), and southward by the Loir (tributaries Conie and Ozanne). The air is pure, the climate mild, dry and not subject to sudden changes. The soil is either clay intermixed with sand or porous calcareous earth, and is on the whole fruitful. Wheat and oats are highly cultivated on the Beauce. Barley, beetroot and other vegetables, including good asparagus, are grown. Cider apples are produced abundantly in the Perche. A large number of cattle and sheep are raised and also draught horses in the Perche. Bee-farming is commonly carried on. The department produces building-stone, lime, grindstones and brick-clay. The manufactures are not extensive; but there are flour- and saw-mills, tanneries and leather-works, copper and iron foundries, starch-works, dye-works, distilleries, breweries and potteries; and agricultural implements, cotton and woollen goods, and yarn, hosiery, boots and shoes, sugar, felt hats and paper are made. Eure-et-Loir exports the products of its soil and live-stock; its imports include coal, wine and wearing apparel. It is served by the railways of the Ouest-Etat, the Etat and the Orléans company, but it has no navigable waterways. The department has Chartres for its capital, and is divided into the

arrondissements of Chartres, Châteaudun and Dreux. There are 24 cantons and 426 communes. Eure-et-Loir forms the diocese of Chartres (province of Paris), and belongs to the académie (educational division) of Paris and the region of the IV. Army Corps (Le Mans). Its court of appeal is at Paris.

Chartres, Dreux, Châteaudun, Nogent-le-Rotrou and Anet are the more noteworthy places in the department. At Bonneval the lunatic asylum occupies the 18th century buildings of a former Benedictine abbey. The abbey church belonged to the 13th century, but only a gateway flanked by two massive towers is left. The château of Maintenon, 16th and 17th centuries, was presented by Louis XIV. to Madame de Maintenon, by whom additions were made. St. Lubin-des-Joncherets has a handsome church of the 11th century, in which there are 16th century stained-glass windows.

EUREKA, a city of California, U.S.A., 294m. N. by W. of San Francisco, on Humboldt bay, 2m. from the ocean; a port of entry, the county seat of Humboldt county and the most western city in the United States. It is on the Redwood highway; is served by the Northwestern Pacific railway; and is a division point for the Pickwick stages, operating over the highway from San Francisco to Grant's Pass, Oregon. The population was 12,923 in 1920 (24% foreign-born white), and was estimated locally at over 19,000 in 1928. Eureka is in a magnificent stand of redwood timber. Enormous quantities of redwood lumber are made in the saw-mills, and shipped largely to San Francisco, Hawaii, Australia and the Orient. Humboldt bay is the largest landlocked harbour between San Francisco and the Columbia river. Its traffic in 1927 amounted to 670,540 tons, valued at $24,927,773. At Arcata, on the northern arm of the bay, is the Humboldt State teachers' college. The Hoopa Valley Indian Reservation is 53m. N.E. by highway. When Humboldt county was organized (1853) Eureka was already the centre of an important lumber trade, chiefly in spars. The city was incorporated and became the county seat in 1856.

EUREKA SPRINGS, a city of north-western Arkansas, U.S.A., in the Ozark mountains, 1,500–2,000ft. above sea-level; one of the county seats of Carroll county. It is served by the Missouri and North Arkansas railway. The resident population was 2,429 in 1920, but there is a transient population averaging 3,500 daily in summer, and half as many throughout the year. Eureka Springs is one of the oldest health and pleasure resorts of the Ozarks. It is built on the slopes and crests of several mountains, streets and buildings rising terrace-like one above another. There are two bath-houses, a well equipped hospital, numerous hotels, apartment houses and furnished cottages. The springs are held in trust by the city for the free use of the public. The water is radio-active; varies in temperature from 57° to 64° F; contains 28·5 cu.in. of gaseous matter per gallon and 6 to 9 grains of solids held in solution, and is especially beneficial in diseases of the kidneys. There is good fishing in the neighbouring streams, and Lake Lucerne, fed by springs, is a beautiful resort 2m. distant. The first settlement here was made in 1879 and the city was chartered in 1880.

EURHYTHMICS is the term applied generally to the use of harmonious bodily movement as a form of artistic expression, and specifically to Dalcroze's system of musical education which is founded on a rhythmical discipline of bodily movements for the expression of time values. The present article is restricted to the latter sense. (*See* DANCING.)

History.—Émile Jaques Dalcroze (b. 1865) studied music at the Geneva Conservatoire and under Delibes in Paris and Bruckner and Fuchs in Vienna. In 1892 he was appointed professor of harmony at Geneva Conservatoire. His experience as a teacher suggested to him that the conventional professional training of musicians was radically wrong in that it ignored the relation of technical training to the inner consciousness of the student. He argued that the student should begin not by specializing on any instrument, but by developing his musical faculties as a basis for specialized study. Such a training could only be secured by awakening the sense—natural, though often latent—of the ultimate bases of music, viz., tone and rhythm.

As the sense of tone can be developed only through the ear, Dalcroze gave special attention to vocal work; and then, noticing that when the students themselves beat time to their singing the work became much more real, he wrote a series of "gesture songs," which were performed by his pupils with surprising ease. This suggested the idea which is the essence of the Dalcroze method, viz., the training of the body in such a way as to make movement not merely an accompaniment of music, but a means of expressing it.

About 1905 Dalcroze began to consider the possibility of applying his method not only to the special education of musicians but as part of the general elementary education of children. Accordingly he worked out a system of pedagogic eurhythmics, which has been widely adopted in schools throughout Europe and America.

Outline of the Method.—The Dalcroze method consists of three parts: (*a*) rhythmic movement, (*b*) ear training and (*c*) improvization (practical harmony). Of these the first is the essence of the Dalcroze method and is fundamentally new. The second is closely linked with the first and necessary to the pupil. The third is necessary to the teacher.

In the system of exercises upon which the method is based, *time* is shown by movements of the arms, and *time-duration, i.e.,* note-values, by movements of the feet and body. In the early stages of the training this principle is clearly observed; later it may be varied in many ingenious ways—for instance, in what is known as plastic counterpoint the actual notes may be represented by movements of the arms, while the counterpoint in crotchets, quavers or semiquavers is given by the feet.

In the series of movements to represent note-values the crotchet is taken as the unit—this is represented by a step; higher values, from the minim to the note of 12 beats, are represented by a step with one foot and a movement or movements with the other foot or with the body, but without progression; *e.g.,* a minim by one step and a knee bend, a dotted minim by a step and two movements without progression, a note of 12 beats by a step and 11 movements. Thus for each note in the music there is one step, one progression in space, while at the same time the note, if of greater length than a crotchet, is analysed into crotchets. Notes of shorter duration than a crotchet, *i.e.,* quavers, triplets, etc., are expressed also by simple steps.

The whole training aims at developing the power of rapid physical reaction to mental impressions. These latter are more commonly obtained through the ear, chiefly from the music played; naturally, however, the teacher needs at times to give commands during an exercise. For this purpose he generally uses the word "hopp," chosen for its clear incisiveness. Before each exercise it is clearly stated what the word is to represent in that particular case, *e.g.,* omit one beat, omit one bar, beat time twice as fast as with the arms, etc.; often the word will be used in series in an exercise, each "hopp" meaning some additional change. As the command generally falls on the second half of the beat preceding the one in which the change is to be made, very rapid intellectual and physical response is necessary, especially if the music be at all quick. Exercises of this class soon give the power of rapid muscular innervation and inhibition, and are of extraordinary value in education, quite apart from their purely rhythmic side. (P. B. I.)

EURIPIDES (*c.* 484–407), the third of the great Greek tragedians, apart from his success as a playwright—he held the stage for 600 years—is a figure of much significance in human history. The date of his death can be fixed. He produced the *Orestes* in 408 B.C., but was dead before Aristophanes began writing the *Frogs* (produced Jan. 405 B.C.) and before the Dionysia of March 406, when we hear that Sophocles, in the Proagon, brought his Chorus on without garlands in mourning for his great rival. His year of birth, however, as usual with famous men in antiquity, seems to have been a matter of conjecture. One tradition groups the three tragedians round the battle of Salamis in 480 B.C.: Aeschylus fought in the ranks, Sophocles danced in the Boys' Chorus, Euripides was born. This has the air of a Hellenistic literary "combination," more convenient to the memory than strictly historical. More authentic perhaps is the date given by

the Parian Marble, 484 B.C.; though, since that chronicle (inscribed 264 B.C.) puts for 484: "Euripides born; Aeschylus' first victory," and for 455 "Aeschylus' death; Euripides' first production," this dating also may be a "combination." At any rate he must have been over 20 by the time of that first production; and this may be the ground of the statements of Philochorus that he was "more than 70," and Eratosthenes that he was "75" when he died.

Euripides has had always a chequered fate. During his life he was famous throughout Greece, but won only four first prizes out of 22 competitions. He was incessantly assailed by the comedians, especially by Aristophanes in the *Acharnians* (423), the *Thesmophoriazusae* (411), which is largely made up of parodies of Euripides, and the *Frogs* (405), which contains an elaborate comparison of his art with that of Aeschylus. Yet an obvious liking and admiration enter into the ridicule, and the attacks are not quite consistent with one another. He is too realistic, dressing his exiled kings in rags; he is too romantic, with his disguised princes and inspired princesses. His heroes talk the language of common life: his diction is all tragic tags. He is an unbeliever, rejecting the gods and worshipping Aether or Intelligence; he is an unintelligible mystic with his doctrine that "Life is not life." He is too austere; he is dangerously immoral. His lyrics are parodied—and beautifully parodied—partly for metrical licences, partly for their extreme melodiousness. The fact is that Euripides, as Aristophanes repeatedly says, was essentially σοφός, and σοφία was a word of wide range. His intellect broke the bounds of custom not in one direction but in many.

Similarly in modern times he is apt to be treated almost as a personal enemy by the type of scholar which dreads unorthodoxy or which dislikes elaborate clarity (σαφήνεια) of style: while by another he is idealized for the most various and contradictory reasons: as a rationalist, a realist, a mystic; as the inventor of romance; as a dramatist who ought to have written in prose, as a great lyric poet who cared little for drama. Elmsley remarks that he is "marvellously addicted to contradicting himself"; Swinburne calls him "a botcher"; Schlegel treats him as the wrecker of Greek classic poetry; while Aristotle, in spite of serious criticisms in detail, calls him "the most tragic of the poets." Milton profoundly admires him, and Goethe asks indignantly whether all the nations of the world since his time have produced one playwright worthy to hand him his slippers.

This striking discord of opinion goes back to a discord in the poet himself. Euripides was a child of that great intellectual awakening which made 5th century Athens a new era in the history of mankind. There arose after the Persian War a widespread realization of the value of σοφία, "wisdom" or "knowledge," with its companion ἀρέτη, "virtue," and concomitantly a whole generation of "educators" or *Sophistae,* ready to make men wise in all the varieties of wisdom: science, music, art, poetry, history, philosophy or politics. Euripides is said to have been a pupil of Anaxagoras, who had proved the existence of air as a substance, taught that the sun was not a god but a mass of incandescent metal, incredibly large; that the order in the universe was produced by Mind or Thought (Νοῦς). He was a close friend of Protagoras who confessed that he knew nothing about the gods; studied the principles of language and of human society; emphasized the distinction between Nature (Φύσις) and Custom (Νόμος) and the extreme relativity of all human judgements. And we are told that Socrates himself never went to the theatre unless there was a play by Euripides; then he would walk as far as the Pairaeeus to see it.

Thus Euripides belonged to the *sophoi,* and his *sophia* startled the old-fashioned Athenian now in one way and now in another. At the same time the art at which he worked was the most rigid and old-fashioned of all the great arts. A painter or sculptor or lyric poet was, comparatively speaking, free. But a tragedian could choose neither his form nor his subject. He must compose in a traditional pattern, based on a religious ritual and exhibited on the festival of Dionysus under the presidency of his priest; his subject is always some traditional story of heroes or gods, and is mostly a representation of the origin of some religious rite, the Torch-race at the Prometheia, the Burial of Ajax at the Aianteia, the mourning service for Hippolytus, etc.

The clash is obvious. Indeed to an Englishman there is danger of overemphasizing it. For we must remember that questions of personal belief or unbelief mattered little in the ancient world. Religion was chiefly a matter of ritual or practice, and Euripides himself held, probably as an ancestral privilege, the positions of "fire-bearer" and "cup-bearer" in the worship of the Delian Apollo. Nevertheless there was evidently a certain conflict between the poet's audacious questioning and original mind and the stately and antique art-form in which he laboured.

Qualities of his Art.—As an artist he seems to have liked formality. In Sophocles we can see a movement towards naturalness in language and composition. There is sometimes elision at the end of the verse; there is variety in the length of speeches in dialogue; there is much colloquial idiom. In Euripides there is a return to formality. With all his variety of invention and his resolute sincerity in the treatment of character, he keeps more closely even than Aeschylus to the art-form imposed by the ancient Dionysiac ritual (*see* DRAMA: *Greek*). His matter, so to speak, is not conventionalized, but his form is. Each play, as a rule, opens with one solitary figure, generally supernatural or half-supernatural, in the darkness before dawn, speaking a prologue. One thinks of the *prorrhesis* spoken by the hierophant before a sacred ceremony. Artistically this serves an important purpose. It makes the atmosphere and starts the play in extreme dignity and quiet. Thereafter carefully, by set stages, the action quickens, rises to climax after climax, and then sinks again to calm in the last scene. That last scene is often like the first. In about half the plays it contains the epiphany (generally on a *machina* in the air) of a god or goddess who calms the strife, explains or half-explains the mystery, reconciles the combatants, of the play itself, and by foretelling the future fates of the characters gradually brings the performance down from the stir of drama to the calm of narrative. This peaceful end, or καταστροφή, was almost essential in Greek art. Later ages, which liked a bustling first scene and a "strong curtain" have been puzzled by the prologue and *deus ex machina,* and have imagined that they were mere mechanical expedients by which an unskilful dramatist contrived to "cut the knots" of his story. The view is unhistorical and untenable; in scarcely any case is the theophany really used to "cut a knot": in some cases (e.g., *Iph. Taur.* 1,394 ff.) a difficulty is invented in order to give an excuse for the theophany.

Another element in the ritual of the dying Year God, is highly developed in Euripides, viz., the messenger who announces the πάθος. His entrance is carefully prepared, so as to keep us hanging on his words. His speech is a formal recitation, constructed on rhetorical principles and highly effective on the stage, but with no attempt at "naturalness." The scenes of dialogue, again, are formal. There is seldom any ordinary conversation. (The one fragment of prose from the blinded Thracian in the Hecuba [1,091 ff.] seems to aim not at realism but at an artistic shock.) There are scenes in which long speech answers long speech, each closed by two formal lines of Chorus with an effect like a chord of music; and there are scenes in which single line answers single line, like the clashing of swords. This highly wrought form was part of the poet's σοφία.

Most significant of all, the Chorus, which in Aeschylus' earliest plays occupied half the performance and was reduced by Sophocles in the *Oedipus Rex* to less than one-fifth, increases again in the later plays of Euripides, both in length and in importance. In the *Troades* and *Bacchae* the Chorus is practically protagonist. By realistic standards of course the Chorus is grotesquely undramatic, and Sophocles had tactfully minimized its obtrusiveness. By other standards it is not only the rock out of which tragedy was hewn, it has a beauty and dramatic power which are all its own. Euripides uses it for all it is worth, casting aside verisimilitude for the sake of something greater.

The Chorus is sometimes described as "an ideal spectator." This means that it is there to express, in music and yearning of the body, an emotion which is not the emotion of one particular person at one moment of the play but something more impersonal

and eternal. Examples would be the Ocean Spirits in Aeschylus' *Prometheus,* expressing the anguish of the world; the Bacchae of Euripides with their mystic worship; the Trojan women, like "half-heard voices of an eternal sorrow"; or the Old Men who dream dreams in the *Heracles.* The Chorus in Euripides often seems to float, as it were, between earth and heaven. Sometimes they bring comfort to us from that world of music where "metaphor, as we call it, is the very stuff of life"; at times by some intensity of emotion they are shaken into personal life and feeling: as when at the child-murder in the *Medea* they beat vainly against the barred door.

This strictness of convention in part emphasizes the conflict of which we have spoken, in part it lifts the poetry above it. The conflict is by no means all to the bad. The artistic flaw was often compensated by a gain in depth, in observation and in passion. Euripides' revolt against custom took various forms. At one time he would make a strangely ingenious and adventurous plot (*Telephus**, *Ph. Aul.*); at another he would raise problems of morality or religion (*Bellerophontes**, *Cressae**, *Heracles*); he would make use, austere by our standards but fuller than any previous dramatist, of the motive of love (*Andromeda**, *Hippolytus*), sometimes in abnormal forms (*Cretes**, *Aeolus**); he would study the intrigues and vindictiveness of political strife (*Orestes, Andromache*); or again he would deal with the wrongs and revenges of woman, or the madness of war (*Medea, Troades*). Sometimes he would take a heroic story as it stood, and show not its heroic quality but its barbarity (*Electra*).

This variety of creative imagination explains, so far as it needs explanation, the great variety of philosophic statements or *gnomae* which can be found in Euripides, and which cause him to be such a frequent source of quotations. There is of course no inconsistency in making one hero, when staggered by the injustice of the world, exclaim: "There are no gods!" (frag. 286), and another, in a different situation, comment on the folly of the man who denies the gods. But Euripides does seem to take the full licence of a dramatist in letting his thoughts run strongly first in this direction and then in that. A dramatist illustrates his problems; he is not bound to commit himself to a decision about them.

His Life.—An anonymous and shapeless *Life and Race of Euripides* is found, in varying forms, in some of the mss. It is derived from earlier sources, notably from a *Life* by Satyrus, an Aristotelian of the later 3rd century B.C., and an *Attic Chronicle* by the rather earlier antiquarian, Philochorus. A considerable fragment of Satyrus discovered on a papyrus in 1911 enables us to see how unhistorical most of the anecdotic tradition is. Much of it is made up simply of the inventions of comedy treated as facts. Thus, the plot of the *Thesmophoriazusae* (in which the women at their secret festival plot to murder Euripides, because he has so "shown them up" on the stage and he sends his hirsute father-in-law disguised among them as a spy) is seriously repeated as history by Satyrus, Gellius, and the *Life.* Equally fictitious must be the story that he had two wives, like his own Neoptolemus, and that both deceived him, like his own Aerope. In the *Thesmophoriazusae,* produced when he was 73, he is still married to his first wife, Melitê, and there is no hint of matrimonial trouble. Neither need we believe that he was torn in pieces by hounds, like Actaeon, or by wild women, like Pentheus. We know from Philochorus that his mother Cleito, was "of very high family"; but for some reason it was a recognized joke to say she was a greengrocer and sold inferior greens. This may come from a much-quoted line in *Melanippe the Wise**: "It is not my word but my mother's word," the said mother being an authority on magic herbs and simples. Turn the heroine's mother into the poet's mother, and the potent herbs into "wild cabbages," and the fable is made.

For reliable information even Philochorus, our best authority, must have been poorly off. He had no collection of letters and papers, like a modern biographer. He would have the public records of the plays performed at Athens year by year; he might find a few mentions of Euripides in odd inscriptions. If he wrote about 300 B.C. there was no one living who could remember a man who died in 406 B.C. There might at most be men of 70 whose fathers had spoken to Euripides and whose grandfathers had known him well. Such memories as we have are all about the poet's old age, and all very external. He wore a long beard and had moles on his face. He lived much alone and hated society. He had crowds of books and did not like women. He lived in Salamis, in a cave with two openings and a beautiful sea view, and there you could see him "all day long, thinking to himself and writing, for he simply despised anything that was not great and high."

*An asterisk denotes a lost play.

He was the son of Mnesarchus or Mnesarchides, a merchant, and born at Phlya, a village in the centre of Attica, a seat of temples to Demeter, Dionysus and the Dread Goddesses, and a mystery cult of Eros. If born in 484, he would be about eight when the ruined walls of Athens were rebuilt after the Persian invasion; at 12 he may have seen Aeschylus' *Persae;* at 17 he pretty certainly saw that poet's *Seven against Thebes* and was much influenced by it. In 466 he began his military service with garrison duty in frontier forts, and while his spear and shield were still new received the news of the massacre of 10,000 Athenian settlers by the Thracian tribes of the Strymon. No wonder one of his earliest plays was about *Rhesus,* the Thracian hero.

His First Plays.—We hear that he was an athlete; he won prizes both in Athens and Eleusis. He also painted; and paintings by his hand were found by later antiquarians in Megara. His first play was performed in 455 B.C., on the *Daughters of Pelias**, who were led by Medea to kill their father when trying to rejuvenate him. His first victory was in 442 with a play of unknown name. Two plays, however, have come down to us which seem to belong to an earlier date. The *Cyclops* is a satyr-play and the only complete specimen of its class, though we may now compare it with the papyrus fragments of Sophocles' *Ichneutae.* A satyr-play is neither tragedy nor comedy: it has the general tone, form and diction of tragedy, but the Chorus are satyrs and one of the characters must belong to the "comic" rather than the "tragic" tradition —*i.e.*, to the Kômos, or revel, rather than the Lament—like the Cyclops himself, or the drunken Heracles, or the thief Hermes. The *Cyclops* is a gay and fantastic piece, based on Homer's story of Odysseus' escape from the Cyclops' cave. Shelley's translation well catches the spirit of it.

The *Rhesus* has come down to us in a peculiar condition and is generally considered spurious. However it is known that Euripides did write a *Rhesus,* and tradition says he was "very young" at the time, which might account for the peculiarities of style in the extant play and particularly for its imitation of Aeschylus. It is a young man's play, full of war and adventure, spies in wolf-skins and white chargers and chivalry. On the other hand there are marks of lateness in the use of four actors and the free treatment of the Chorus; and something very like the later Euripides in the exquisite final scene, where the Muse weeps for her slain son. The *Rhesus* cannot possibly be a work of the late or middle period of Euripides; the style proves that. But it might be a youthful play, as tradition says, worked over by one or more later hands. The working-over indeed is certain from the fact that we know of three versions of the opening scene.

Alcestis.—In the year 438 appeared the romantic tetralogy *Cressae** (or *Women of Crete*), *Alcmaeon in Psophis**, *Telephus** and *Alcestis.* The *Alcestis,* still extant, took the place of a satyr-play as fourth in the tetralogy, and may be called pro-satyric in style and plot. Admetus has been granted the right, when his day of death comes, to escape if he can find a willing substitute. His old parents refuse to die for him; his young wife Alcestis consents and dies. Heracles passing the house on his travels is given hospitality, and is already revelling and crowned with flowers when he learns what has happened. He goes out into the night to wrestle with Death and rends his prey from him. We have here one "comic" character, the revelling Heracles, and a touch of the fantastic in the scenes between Thanatos and Apollo, Admetus and Pheres. The death of Alcestis is an obvious poetic theme, and most tenderly treated, but it is like Euripides to raise pointedly the question of Admetus' conduct in asking her to die. His self-satisfaction is broken down in a biting scene between him and the

*An asterisk denotes a lost play.

old father who had refused to die for him, but at least had not shifted his own fate on to another. As he returns to his empty house he cries: "At last I understand."

The other plays of this tetralogy also show the romantic style—*i.e.*, an admixture of adventure, variety and love interest with the strict theme of tragedy. The hero of the *Alcmaeon** is the son of that Eriphyle who had betrayed her husband to death for the sake of a magic necklace with a curse upon it. Alcmaeon kills his mother, seeks purification from the king of Psophis and is betrothed to his daughter Arsinoë, to whom he gives the necklace. But the whole earth is polluted by his mother's blood, and he wanders on till he comes to the alluvial islands at the mouth of the Achelous, which are untainted because they had not existed at the time of his sin. He settles there and marries Achelôus' daughter. She demands the necklace, and he returns to get it from Arsinoe, who discovers why he wants it, and has him murdered on his road back.

In the *Cressae** the princess Aërope secretly loved a young soldier; her angry father cannot bring himself to kill her, but gives her to a Greek sailor to throw into the sea. The sailor helps her to escape to Greece. The story itself is a common ballad motive and offends no one as long as it is not made too real. But it seems that Euripides did make it too real, and Aërope's songs of love were remembered against him even after his death. The *Telephus** was apparently seen by Aristophanes, then a boy of 16, and made an impression on him which he never forgot. Telephus, king of Mysia, had been wounded by Achilles and, when the wound would not close, was told by an oracle "the wounder shall heal." Consequently he goes disguised as a beggar to the enemy's country, to the heart of the Greek army and Agamemnon's palace. He is discovered; but snatches the baby Orestes from the cradle and threatens to dash him on the ground unless the Greeks will hear him. They consent; and he pleads the cause of himself and his country, and convinces them. The parodies in Aristophanes, *Acharnians* lay stress on the "gift of the gab" possessed by Telephus, on his hair-breadth escapes, and, curiously enough, on the rags and wallet of his beggar's disguise. It is hard to see how else he could have been dressed, if he was to be disguised at all, but apparently the treatment was a little more realistic, or less purely symbolical, than the audience of 438 B.C. expected. Later we find even Sophocles dressing the outcast Philoctetes in rags.

Medea.—Up to this time the chief notes of Euripides' work were variety, invention, romance and scenic effect; his analytic and destructive power of thought had hardly shown itself. The next play that we possess is the *Medea*. It appeared in 431 B.C. with the *Philoctetes**, *Dictys** and a satyr-play *The Reapers**. The *Medea* was placed by the judges at the bottom of the list, and thereafter took its place as one of the consummate masterpieces of Greek tragedy. It begins where the *Daughters of Pelias** ended. Jason has fled with Medea to Corinth, which is ruled by an old king, Creon, with a daughter but no son to succeed him. The famous Jason will exactly do as a son-in-law, if only he will discard the mad barbarian woman who is ruining him. Jason consents. Creon orders Medea to instant exile, but she obtains one day's grace . . . to make arrangements for her children. She uses it for her revenge. There is a wonderful scene with Jason, the man still held back by some conventional courtesy from telling the woman how he hates her, and offering to provide her generously with everything in the world except the one thing she needs, and she torturing him because he will not love her. Eventually she sees that the way to break him is to make him childless. She sends her two children to bear a gift to the new bride. It is a crown and robe, a gift from her divine ancestor, the Sun, which she has steeped in burning poison. The bride dies in agony together with her father who has tried to save her. Medea kills her two children behind the barred door of her house, against which the women of the Chorus beat in vain. Jason finds her laughing over the bodies. She loves her own pain since it means that he shall have happiness no more, and the daughter of the Sun sails away on her dragon chariot.

*An asterisk denotes a lost play.

The play is remarkable not merely for its concentrated passion, but for its daring and realistic psychology. The case for barbarian against Greek and for woman against man, with all its madness as well as its reason, is marvellously stated. More than one woman now in Broadmoor has killed her child for the same motive as Medea. The Aristotelian Dicaearchus says that Euripides based his play on the *Medea* of Neophron, a writer of unknown date. There would be nothing improbable in this. All heroic or legendary subjects were treated again and again. But the lines that are quoted from Neophron's *Medea* seem clearly to be modelled on Euripides, and not vice versa.

Hippolytus.—The *Hippolytus*, produced in 428 B.C., did win the first prize, besides establishing itself in permanent fame and inspiring Seneca and Racine to some of their finest work. The plot is a variant of a theme found in an ancient Egyptian "novel" and in the Pentateuch; the wife who falls in love with the chaste youth, and, when rejected, slanders him. Theseus—not here the ideal democratic king, but the stormy adventurer of the poets—had in his youth conquered the Amazons and ravished their virgin queen. She died leaving a son like herself, Hippolytus, who rejects the love of woman and lives in mystic communion with the virgin goddess, Artemis. Some 20 years later Theseus wedded Phaedra, daughter of Minos, and she by the evil will of Aphrodite against Hippolytus, fell in love with him. She concealed her love and was trying to starve herself to death, when her old nurse discovered the secret and told Hippolytus under an oath of secrecy. He contemptuously rejected her. Phaedra, in a rage of fear, writes a false accusation against Hippolytus and hangs herself; Hippolytus, charged by Theseus with the crime, will not break his oath, and goes out to exile and death under his father's curse.

The story is treated by Euripides with wonderful power and purity. The strife of superhuman forces in the background, Aphrodite speaking the prologue and Artemis bringing peace at the end, seems to make the human beings more sympathetic and their fate typical of an eternal conflict. The play, as we have it, is said to have been re-written. The first version seems to have told the story of the "novel" straightforwardly, with a shameless heroine who personally declares her love to Hippolytus, and, to judge from Seneca's imitation, with other strong theatrical effects. In the extant play Phaedra never speaks a word to Hippolytus. It looks as if we had here a rare phenomenon; a second treatment of a theme which, instead of keying everything higher and adding to the stage effects, deliberately aimed at restraint and *Sophrosyne*. To Comedy, however, any stick was good enough to beat Euripides with. We find repeated attacks on one phrase: spoken by Hippolytus: *ἡ γλῶσσ' ὀμώμοχ', ἡ δὲ φρὴν ἀνώμοτος* ("'Twas but my tongue, 'twas not my heart that swore"). The line is a passing flash of indignation at the trap in which he has been caught, and when the time comes he keeps his oath at the cost of his life. Yet it is cited as a wicked sophistry! The extant play has the second name of *Stephanêphoros*, "The Wreath-bearer," from the wreath which Hippolytus lays on the altar of Artemis; the first was called ὁ Καλυπτόμενος, "who veils himself," though as a matter of fact Hippolytus does that in our play also (l. 946).

Andromache.—The *Andromache* is said by the scholiast to have been produced "about the beginning of the Peloponnesian War," a date which would suit the style and metre. No "*Andromache* of Euripides" was recorded in the official Lists of Performances at Athens, and Callimachus found the play inscribed with the name of "Democrates," a person otherwise unknown. It would seem, therefore, that for some reason Euripides gave his play to another man to produce, as Aristophanes sometimes did. The situation is moving, and some scenes and lyrics effective; but the play, as a whole rather unsatisfactory. (The scholiast's phrase *τὸ δρᾶμα τῶν δευτέρων* is obscure.) Neoptolemus, son of Achilles, who had taken Andromache, the widow of Hector, as his concubine, has put her away on his marriage to Hermione, daughter of Helen, but still likes and trusts her. Hermione is childless and suspects Andromache of bewitching her. Her old betrothed, Orestes, still loves her; and her father, Menelaus—represented as a villain—is possibly in league with him. Neoptole-

mus being away at Delphi, Andromache and her child are about to be murdered by Menelaus, but are saved by the old Peleus. Menelaus retreats, leaving Hermione in despair, when Orestes, who has been waiting on the borders for this moment, suddenly appears and gets her to fly with him. "She need never fear Neoptolemus again!" The meaning of these words presently appears, when a Messenger comes from Delphi announcing the murder of Neoptolemus by Orestes and his men. Old Peleus, broken with grief, is comforted by the appearance of Thetis *ex machina,* one of the most beautiful of these divine epiphanies.

Hecuba.—Before Aristophanes' *Clouds* in 423, and perhaps after the purification of Delos in 426 (l. 455 ff.), came the *Hecuba.* The play shows the transformation of Hecuba, by the cruelties and treacheries of war, from a stately barbarian queen into a sort of devil. Her daughter Polyxena, the most beautiful of all Euripides' virgin martyrs, is sacrificed on Achilles' tomb to satisfy a superstitious mob. (It shows the beginning of a new note of bitterness in Euripides that the two Athenian heroes, the sons of Theseus, amid all these horrors, did what? They quarrelled, but both were for the murder!) Her other daughter, Cassandra, the virgin prophetess, has been taken for Agamemnon's slave. But the worst is that her youngest son, Polydorus, whom she had sent for safety away from the war to her guest-friend Polymestor, king of Thrace, has been murdered by the Thracian for his gold. Having persuaded Agamemnon to stand aside, Hecuba inveigles Polymestor and his two children into her room among her women: they kill the children and then blind the father, and the eyeless barbarian crawls back shrieking to Agamemnon for help. Legend told that Hecuba, maddened with suffering, was transformed into a sort of hell-hound with fiery eyes, whom sailors saw at night round the hill where she was stoned. The prophesies of the dying Thracian speak of this, and in the fury of the scene it seems credible, just as Medea's dragon-chariot does.

Two Patriotic Plays.—As against the bitterness of the *Hecuba* we may note two patriotic plays, the *Heraclidae,* dating early in the war and the *Suppliant Women,* about the Peace of Nicias (421 B.C.). In the *Heraclidae* the children of Heracles hunted by the tyrant Eurystheus, and led by Heracles' old companion, Iolaus, take refuge in Athens. The king, Demophon, son of Theseus, defies the overbearing Argive herald and undertakes to protect them. An oracle, however, has declared that a virgin of royal birth must die if they are to be saved. One of the daughters of Heracles, Macaria, overhears the discussion of this and offers herself. Iolaus says, "No: lots must be drawn," but she prevails on him. She is led out to die, and Iolaus, despairing and unarmed, takes down the sacred armour hanging in a temple, and prays to be made young for one day. The prayer is granted and the battle won. (The *Heraclidae* seems to have come down to us in a mutilated condition. It is very short: there is no account of Macaria's death, and some passages quoted from it by ancient writers are not found in our text.)

The *Suppliant Women* also opens with a scene of supplication. The mothers of the Seven Argive Chieftains slain before Thebes, led by Adrastus, have found Aethra, King Theseus' mother, at her prayers beside the altar of Eleusis, and have surrounded her with a chain of suppliant branches which she dares not break. They ask that Theseus shall recover for burial the bodies of their sons, whom the Thebans have flung out to dogs and birds. Theseus at first refuses. The Argives did wrong to make war; he will not risk war for their sake. At last: "Women in sorrow call thee, and men dead," says Aethra, and he yields.

Patriotic plays are generally too shallow and boastful to make good literature. But it is interesting to see what qualities the patriot boasts about. Euripides idealizes Athens as the helper of the oppressed, the champion of Hellenism and true piety; but also as the city of enlightenment. For when the putrefying bodies are recovered from the field, the old practice would have been, first, to treat them as polluted and let only slaves tend them, and next to lay them before their mothers so as to increase the weeping; Theseus tends them and "shows them love" himself, and he keeps the mothers away from the hideous sight. It is the Hellenism or humanity of Athens that Euripides loved, and her failure in that is the cause of his quarrel with her. It is strange to observe that he seems at this time to have favoured Alcibiades as a leader. A phrase about "a shepherd young and noble" in the *Suppliant Women* (l. 190) may be meant to suggest him: the play commends his pro-Argive policy, and the ode for his Olympian victory in 420 B.C., which Plutarch read, was said to be the work of Euripides.

Heracles.—The same note is struck in the later part of the *Heracles* (called in the Aldine edition Ἡρακλῆς Μαινόμενος, *Hercules Furens*). That play opens with a suppliant scene: in the absence of Heracles his wife and children are left in Thebes in the power of the tyrant Lycus ("Wolf"), who is determined to extirpate the whole race. They have fled to an altar, hoping to stay there till Heracles' return, but Lycus proceeds to burn them out. They get leave to perform the funeral rites for the children, and have done so—a terrible omen—when at last Heracles appears. He saves them; but the deliverer is strangely excited and boastful and unlike himself. The Elders of the Chorus see in a dream a vision of Madness descending upon him. It comes: he murders his wife and children, and then, finding what he has done, is about to kill himself, when Theseus arrives. He hides his face and warns Theseus to keep away and avoid the pollution; but in a moment his friend's arms are round him and the shrouding mantle drawn off. Theseus persuades him that the great Heracles, the saviour of Hellas, must not die, but fulfil in spite of suffering whatever further tasks life may have in store. The scene is remarkable both in its treatment of the problem of suicide and in showing again Euripides' conception of the "wisdom" of Athens, typified as usual by Theseus.

The *Heracles* is noteworthy in two other ways: for its plain and outspoken denial of current myths:

> Say not there be adulterers in heaven,
> Nor prisoner gods and gaoler. Long ago
> My heart hath known it false and will not alter.
> God, if he be God, lacketh naught: all these
> Are dead unhappy tales of minstrelsy.
> (*Her.* 1341 ff.; *cf. I. T.* 385 ff.)

(*ἀοιδῶν οἵδε δύστηνοι λόγοι*). And secondly for a wonderful lyric about youth and age, claiming that, while all else passes, poetry does not. The poet had now, it seems, reached the age of 60 and was a *Geron,* relieved of military service. "I care not to live if the Muses leave me; may their garlands be about me for ever! Even yet the age worn minstrel can turn Memory into song." *Ἔτι τοι γέρων ἀοιδὸς κελαδεῖ μναμοσύναν.* The prayer was granted, but granted at a heavy price. His poetry remained with him undimmed, but it was a cause of strife with the city he loved and a proclamation of his broken hopes. Thucydides and all our other authorities testify to the growing corruption of life wrought by the Peloponnesian War, and the increasing savagery of the democratic war-party.

Ion.—The *Ion* is sometimes described as a glorification of Apollo and of Athens. If so, why is Apollo the villain of the piece, why are the legends of Athens made barbaric, her shrines unclean and her legendary princess a polluted woman? Why does the hero explain that he would sooner be a slave at Delphi, where one is not jostled off the pavement by the scum of the earth, than a free man in Athens "a city full of terror," where good men dare not speak?

The princess Creusa, ravished by Apollo, had laid her babe in the cavern where she had met him. She came again and the child was gone. Later she married a foreigner, Xuthus. Having no children the pair went to Delphi to consult the god. There Creusa meets the foundling Ion—really her own son whom Apollo had saved—and the two are strangely attracted to one another. She intends to ask Apollo what he has done with her child, but in the meantime Xuthus has questioned the god and is made to believe that Ion is his own illegitimate son. He proposes inventing some lie to deceive his wife and adopting the boy. An old household slave, devoted to Creusa, tells her of this plot. Betrayed by god and man, she cries out her story against the Holy Place. She may be disgraced for ever, but at least she will drag down this devil who sits crowned with flowers and singing to the lyre, while the

woman he has ravished goes mad and his child is torn by wild beasts! In the horror-stricken silence which follows there is none to advise her but the old slave. He wrings from her the whole story, and then calls for revenge. "Burn down the god's temple!" She dare not. "Poison Xuthus!" No; he was good to her when she was so unhappy. "Kill the bastard!" Yes; she will do that. The attempt is made but fails; Ion is revealed as Creusa's own son and the general confusion more or less satisfactorily cleared up, not by Apollo, who dares not show his face, but by Hermes who comes on his behalf. The Ion is the most ironic of the extant plays, and perhaps the most blasphemous. Many heroes in Greek legend were born of the love of a god for a mortal woman and their stories could be beautiful in the hands of Aeschylus or Pindar; but they were generally treated by Euripides in anything but a sympathetic spirit: *e.g.,* in the *Auge**, *Melanippe**, *Danae**, *Alope**.

The year 416 was to bring to a head the discord between Euripides and his city. In that year occurred an event of very small military or political importance, to which nevertheless Thucydides devotes 26 closely written chapters: the unprovoked siege of the small neutral island of Melos followed by massacre and enslavement. The whole case is argued out in Thucydides; its utter wickedness clearly exposed, and cynically justified by the Athenians. The next chapter begins the Sicilian expedition and the ruin of Athens.

The Trojan Women.—Euripides, apparently stirred by the same indignation as Thucydides, produced in the following spring an extraordinary tragedy, the *Trojan Women.* It represents the capture of Troy, the proudest triumph of legendary Greece, seen through the eyes of those who knew most about it, the conquered women. We see first, in the darkness, the gods of Troy, re-inforced by the offended Athena, waiting their hour. The captured women creep out from their huts; the Greek herald comes to announce how the slaves are to be distributed and to take Cassandra, the mad priestess, to Agamemnon's bed. Hecuba and the other women are filled with horror, but Cassandra herself is happy, seeing everything through a mist of vision, including her own ghastly death and that of "her bridegroom." Meantime Andromache, made slave to Neoptolemus, is planning how to win favour with her masters so that her child Astyanax may be allowed eventually to return and re-build Troy, when the herald comes back. He must take the child. The Greeks have decreed its death. The scene is perhaps the most harrowing in Greek tragedy. A scene between Menelaus and Helen, whom he longs to kill, and yet dares not, shows the conqueror as miserable as the conquered, and more contemptible. The body of Astyanax is brought back and decked for burial by his grandmother, the dead child and the very old woman being all that is left of the great city. In the finale come scenes of almost mystical grandeur. Hecuba cries first to the gods, who care not at all. Then to the dead, who did at least care and love, but cannot help. With no hope, no illusion anywhere, Hecuba faces That-Which-Is, and finds somewhere in the very intensity of Troy's affliction a splendour that cannot die. She looks on the burning city and tries to hurl herself into the flames, but is held back. With a crash the great tower falls; the Greek trumpet sounds through the darkness calling the women to the ships; and they go forth to their slavery.

The two plays that were produced with this tremendous tragedy seem to have led up to it: *Alexandros**, showing the curse upon Troy that came through sparing the fire-brand, "the seed of wrath"; and *Palamedes**, showing the curse upon the Greeks, who believed the liar and slew the innocent.

Two Romantic Plays.—The *Troades* is sometimes spoken of as introducing a period of gloom or pessimism in Euripides, but this is an exaggeration. One result of the "bad years" of the Sicilian expedition was a turn towards fantasy and romance, of which the most famous example is Aristophanes' *Birds.* In 414–412 comes the *Iphigenia in Tauris,* a delightful play in which the tragedy lies largely in exile and homesickness and the romance in lyrics of the sea. Iphigenia, about to be sacrificed at Aulis, was saved by Artemis and carried off to be her priestess among the savage Tauri, who sacrifice strangers. After many years two Greek youths are found on the shore and brought to the Priestess to be consecrated for death. (They are really her brother Orestes with his friend Pylades, who have been sent by Apollo's command to bring to Athens the statue of the goddess.) Much moved, she questions the strangers about Greece, and tries vainly somehow to show pity for them. She can save the life of one, if he will bear a letter for her to Greece; Orestes in a beautiful scene constrains Pylades to go. But to whom is the letter to go? "To Orestes." So the truth is revealed, but the danger remains. Eventually a plot is made for the three to deceive the king, get the statue to sea, and fly together. They have practically escaped when the wind changes and drives them back. But Athena, *ex machina,* makes Thoas forgive them and institutes the ritual connected with Iphigenia at Brauron.

*An asterisk denotes a lost play.

The *Iphigenia* seems to have had such a success that, since there was no opportunity for a long "run," the poet used a similar plot again next year in the *Helena.* He follows the old story of Hesiod that it was not Helen herself who was taken to Troy, but only her *eidolon* or image. (Helen was the Spartan marriage-goddess; and the rape of an image of the marriage-goddess was a known ritual in places where the marriage ceremony consisted in a carrying-off of the bride, as in Sparta.) The real Helen, an innocent and devoted wife, has been all the time in Egypt. First there was a good king who kept her for her husband, then came a bad king who wanted her for himself. She takes refuge at an altar. Meantime Menelaus, having taken Troy and suffered shipwreck, comes to the Palace. He and Helen meet; there are explanations and mutual amazement; and eventually the two escape by a plot very similar to the plot in the *Iphigenia.* There are charming lyrics in the *Helena* and the plot is ingenious; but as a whole it is unsatisfactory. It looks as if Euripides had been groping, with inadequate resources, towards a style of fanciful and unreal play—something like *Twelfth Night* or *A Midsummer Night's Dream*—for which the form of Greek tragedy was not suited. It is hard where it should be tender, and strikes us as absurd when it is meant to be miraculous or astonishing.

Much more successful, apparently, was the *Andromeda**, a romantic story of the rescue of the heroine by Perseus, when she was exposed to be devoured by the sea-monster. The fragments have a rare charm, and Lucian has a pleasant story of a tragedy fever that fell on the folk of Abdera and set them walking as if in a dream muttering verses of the *Andromeda**, by that time 500 years old!

Electra.—About the same date, or slightly earlier, came a play of a very different sort, the *Electra,* dubbed by Schlegel "the meanest of Greek tragedies." It treats the same theme as Aeschylus' *Choephoroe* and Sophocles' *Electra,* but in a different spirit. It may be described as a study of a heroic bloodfeud from the point of view of a civilized man. The vengeance of Orestes and Electra upon their mother and her paramour had been treated by Aeschylus as a problem of clashing duties. His hero obeys the god's command, but the horror of it unseats his reason. Sophocles treats the story in a Homeric or "heroic" spirit, with no qualms of conscience and no madness. Euripides studies closely what sort of children they could have been who would so nurse their hatred for years and at last work out their mother's murder. His Electra is a mixture of heroism and broken nerves, a lonely woman eating her heart in ceaseless broodings of hate and love, both unsatisfied. Orestes is a youth bred among the false dreams of exile and now swept away by his sister's more passionate will; haunted also, as Orestes traditionally was, by the shadow of madness. The same psychological study is applied to Clytemnestra. Most remarkable is the scene after the mother-murder when the brother and sister reel out from the house "red-garmented and ghastly" and break into an agony of remorse. The play ends with an appearance of the heavenly horsemen, Castor and Polydeuces, who definitely pronounce the deed of vengeance to be evil, speak words of pity for mankind and go forth on their eternal duty, which is not to punish but to save.

*An asterisk denotes a lost play.

Phoenissae.—The *Phoenissae*, or *Women of Tyre* (?410 B.C.) is an experiment of a different kind. It is the longest Greek tragedy and covers the longest stretch of story. Some critics have described it as "a whole trilogy in one play"; others as "epic rather than dramatic." It is written in a large and heroic style; but, in the manner of this period, it shows a background of clashing hatreds, ambitions and revenges, against which we see standing out one man's self-sacrifice and a mother's and a sister's love.

Polynices is besieging Thebes. Eteocles is king: the blind Oedipus lives imprisoned in the vaults of the palace. Jocasta speaks the prologue. After a scene in which Antigone looks from the wall on the enemy host, as Helen did in the *Iliad*, a disguised man with drawn sword enters looking for Jocasta. It is Polynices, whom she has begged to come and be reconciled with his brother. The brothers meet, but part in increased anger, and the battle begins. Creon consults the prophet Teiresias, who says that Thebes will be saved if Menoiceus, Creon's son, dies. Creon desperately arranges for Menoiceus to escape; the boy feigns consent, but as soon as his father's back is turned, rushes up a tower of the city and throws himself into the dragon's den. A messenger comes to Jocasta with news of the battle. The Argives are repulsed. Her sons are safe, but—the truth is forced from him—just about to engage in single combat. The mother, with Antigone, makes her way out through the army to separate the brothers, but too late. They have already slain each other in a "meadow of wild lotus," where she too kills herself with one of the swords. Creon, who takes over the government, proclaims that the body of Polynices shall be left unburied, that the accursed Oedipus shall be cast out of the land, and that the princess Antigone shall marry his son Haemon. Antigone defies him, and goes out to exile with her blind father, away from the brutalities of men, to the untrodden mountain.

Orestes.—The *Orestes* (408 B.C.) is a strangely violent play. Orestes, a few days after his matricide, lies mad and sick, nursed by his sister. They are prisoners in the palace, and the Assembly of Argos is debating their fate. Meantime safety dawns on their despair. Menelaus, with Helen and an army of veterans, has arrived in the harbour. He will of course save his nephew! Unfortunately he is the next heir to the kingdom and he behaves ambiguously. The sick man blazes into rage and Menelaus becomes an open enemy. All is lost, when the faithful Pylades breaks into the palace to share his friend's fate. The decision of the assembly is announced: the prisoners must die. But at least they can strike first: kill Menelaus—or, better, kill Helen and then die. Better still, capture Hermione, and threaten to kill her unless the villain Menelaus will save them! The madness of Orestes infects the whole play. Helen escapes, being divine; but Hermione is captured. Menelaus rushes up only to find the gate barred and the madman on the roof shrieking derision and holding a sword at his daughter's throat. Menelaus rejects all terms. Orestes' party sets fire to the palace, Menelaus batters at the burning gate, when suddenly with a crash of thunder Apollo speaks and strikes all beholders into a trance. They awake from their trances with the fury gone out of them and the immediate past forgotten. Finding Hermione in his arms Orestes draws her to him, and thus it happens that, as all Greeks knew, she became his wife! Apollo tells them of their future lives and charges them to forgive one another. This violent epiphany of a god, changing at a word the whole course of action, is unique in our remains of tragedy (*cf.*, however, the *Iphigenia in Tauris*). The success or failure of the effect would probably depend on the audience and the stage-management.

Estrangement from Athens.—The *Orestes* was the last play which Euripides produced in Athens. We hear much of his increasing isolation. In 412 indeed he had been invited to write the national epitaph on the soldiers slain in Sicily; but that short-lived Government of "intellectuals" was soon swamped again by the war party. This was the time when, as Thucydides says, "men tried to surpass all records by the ingenuity of their plots and the enormity of their revenges." The old poet was doubtless considered half a traitor for being against the war party. He was anyhow a dangerous sophist; and we hear that he was prosecuted for impiety. He was not convicted, but other charges remained. He had written plays to deny the gods, to advocate perjury, to defend adulteresses and worse. What must his personal life be? No wonder he lived so secretly, he and his black-avised secretary Cephisophon. Perhaps he was a miser with secret wealth? An action was brought by one Hygiainon to make Euripides perform some liturgy instead of himself as being richer. The result is not known, but the line "My tongue has sworn" was brought up in court to show how little the defendant could be believed. There may have been some darker cloud (not the infidelity of his wife; *see* above). The *Life* tells us that "he lost patience with the ill-will of his fellow-citizens"; Philodemus says he left Athens "in grief, because almost all people were maliciously rejoicing over him." Whatever the cause, at the age of 76 he struck off into voluntary exile. He went first to Magnesia, probably the Magnesia near Ephesus, where he had already some connections, having been *proxenus*—a sort of consul—to Magnesians resident in Athens; soon however he went on to the court of Archelaus of Macedon, where he produced a tragedy, *Archelaus*, called after his host's legendary ancestor. The king was anxious to Hellenize his semi-barbarous court by collecting "wise men" from all parts of Greece, and must have heard the story how some of the Athenian prisoners in the quarries of Syracuse had been granted their freedom for teaching their captors choruses of Euripides.

There are several stories of the poet's adventures with these wild Macedonians, among whom a youth could not dine with grown men till he had killed a boar, nor put off a leathern girdle till he had killed a man; but if he had really been eaten by the king's hounds or caught in some sensational intrigue, Aristophanes would certainly have mentioned it in the *Frogs*. We only hear that he was dead before the Dionysia of 406, leaving behind him three plays *Iphigenia in Aulis, Alcmaeon in Corinth** and *Bacchae*. The first and third are still extant.

Last Plays.—The *Iphigenia in Aulis* presents many problems. It is incomplete in our mss., to which an unmetrical last scene was added at the time of the Renaissance. But it must also have been seriously incomplete at the time of the poet's death and been finished by another hand. The plot deals with the trapping of Iphigenia to Aulis to be sacrificed; the mental struggles of Agamemnon, the intrigues of Menelaus, the discovery of the plot by Clytemnestra, the bewilderment and indignation of Achilles and the acceptance of her doom by Iphigenia. She was probably rescued at the altar by Artemis, but the last scene is lost. The play shows a transition from the style of tragedy proper to that of the New Comedy. Its metre deviates from the tragic, permitting for example the elision of -αι; the messenger, instead of being formally announced, rushes in and begins his speech in the middle of a line; there are two different opening scenes inartistically combined (*cf.* the *Rhesus*), and great variety of incident, including one scene closely akin to Menandrian comedy—where Achilles thinks that Clytemnestra is making overtures to him. There is much psychology: the brothers Agamemnon and Menelaus quarrel and fiercely analyze one another's faults, but by the end each wishes to give way to the other. There are fine studies of Clytemnestra still young and innocent, of Achilles and above all of Iphigenia herself, at first utterly crushed, but, on reflection, exalted by the thought of dying for Hellas.

The *Iphigenia* is all invention, entertainment, psychology; it is full of informalities and interruptions: its Chorus is insignificant. Curiously different is the *Bacchae*. The *Bacchae* takes an old ritual story with fixed characters: God, Old King, Young King, Prophet, Mother. It is formal throughout and its Chorus is its very soul. In this extreme of formality and faithfulness to ancient tradition Euripides seems to have found his greatest originality and freedom.

The plot is little more than the regular sequence of scenes belonging to the cult of the Year Daemon: the Daemon and his Enemy, who is exactly like himself: the Contest, the *sparagmos* or Rending, the Messenger, the Lamentation mixed with Joy-cries, the Discovery of the scattered members, and the Epiphany

*An asterisk denotes a lost play.

of the God. The god Dionysus comes with his inspired Bacchanals to his own land of Thebes and is rejected by his kindred. He sends his divine madness upon them. The king, Pentheus, persecutes and imprisons the god and the holy women; then yielding in spite of himself to the divine power, agrees to go, disguised as a Maenad to watch the secret worship on Mt. Cithaeron. He is discovered and torn to fragments. His mother returns in triumph, dancing, with her son's head, which she takes for a lion's. It is too much. The Chorus of Maenads, hitherto wildly devoted to Dionysus, are transfixed with horror. Dionysus appears in glory pronouncing judgment on all who have rejected him. The mortals go forth to their dooms, still faithful, still loving one another, while the ghastly and triumphant god ascends to heaven.

The marvellous power of the *Bacchae* is beyond doubt. The spell of Dionysus affects the reader and makes the world seem mad. But the meaning of the play, for it certainly seems to have a meaning, is much disputed, and may perhaps be helped out by an analogy. Imagine a free-minded modern poet composing for some local anniversary a rhymed play in the style of the Mysteries on the legend of some mediaeval saint, persecuted by a wicked emperor, whom he threatens with hell-fire. Imagine the emperor brutal and despotic, the saint very saintly and the songs of the persecuted Christians very beautiful; and at the end the emperor writhing in hell-fire and the saint in glory saying "Hallelujah! What did I tell you?" Neither the exquisite beauty of the Bacchanal poetry nor the savage cruelty of the god can be denied. Both are true. After all, Euripides, with all his lucidity, never professes to be lucid about the ultimate mystery of the world. He sometimes denies, sometimes asserts, the rule of divine justice, or the existence of some "Great Understanding" and some life beyond the grave "dearer to man than this" (*Hipp.* 191 *ff.*). He is never apparently exercised by the problem whether God, or "the divine," is one or many, but, with all his passionate belief in "wisdom," he seems to have a strong sense of man's comparative unimportance in the presence of unknown powers: δουλεύομεν θεοῖς, ὅτι ποτ' εἰσὶν οἱ θεοί (*Or.* 418).

BIBLIOGRAPHY.—The Alexandrians possessed of Euripides 67 tragedies and 7 satyr-plays *plus* 3 tragedies and one satyr-play which were considered spurious. They believed him to have written altogether 92 plays, *i.e.*, 23 tetralogies; but it is not clear whether they took into account one or two plays, like the *Andromache* and the *Archelaus*, which were not recorded in the *didascaliae* (Wilamowitz, *Analecta Euripidea*, p. 145). Nauck's collection of the *Fragmenta* (2nd ed. 1889) gives 1,132 fragments, the last 26 being doubtful, from 55 lost plays. Papyri and other sources (esp. Johannes Logothetes, see *Rhein. Mus.* 63) have added passages from the *Antiope*, the two *Melanippae*, *Oeneus*, *Stheneboea*, *Phaethon* and above all the *Hypsipyle*. *See* Hunt, *Fragmenta Tragica Papyracea* (1910) and von Arnim, *Supplementum Euripideum* (1913).

The mss. of Euripides fall into two classes: one with scholia and one without. The former represents a collection of ten plays (*Hecuba, Orestes, Phoenissae, Medea, Hippolytus, Alcestis, Andromache, Troades, Rhesus* and originally *Bacchae*) selected for the use of the schools about the 4th century A.D., with a commentary compiled from earlier sources; the latter, comprising 18 or more plays, seems to represent some odd volumes of a complete edition of Euripides, with arguments, dramatis personae, and variant readings but no commentary. Its archetype was doubtless the edition by Aristophanes of Byzantium (*c.* 200 B.C.) of which we can form an adequate picture from the papyrus of the *Hypsipyle* (*Pap. Oxyrh.* 852). A further selection was made in Byzantine times of three plays, *Hecuba, Orestes, Phoenissae,* which occur in a vast number of mss.

The scholia-plays are all found in Vat. 909 (V.), *saec.* xiii., and some in the better mss. Marc. 471 (M) and Paris 2712, 2713 (A, B). The uncommented plays depend on Laurentianus xxxii. 2 , *saec.* xiv. (L or C), which contains all the plays except the *Troades*, and one on a ms. (P) of which half is in the Vatican (Pal. 287) and half (formerly called G) in the Medicean library (Laur. 172): this contains all the plays. There are many inferior Byzantine mss., while some 32 papyrus fragments and other ancient remains are useful in testing the soundness of the texts (Oldfathers *Greek Literary Texts*, Madison, Wis., 1923). Of similar value is the curious Byzantine tragedy, *Christus Patiens*, a cento attempting κατ' Εὐριπίδην τὸ κοσμοσωτήριον ἐξειπεῖν πάθος. It bears the name of Gregory of Nazianzus, but is attributed by Krumbacher to the 11th century. The scholia may be divided into those belonging to the 4th century edition (*Sch. Vetera*) and containing much knowledge from the best periods of Alexandrine and Roman scholarship, and those added afterwards (*Sch. Recentia*). There are great masses of late Byzantine scholia, especially on metres (editions by Dindorf, 4 vols., 1863; rather promiscuous; better selected and arranged by E. Schwartz, 2 vols., 1887, 1891).

Editiones principes: J. Lascaris (Florence, 1496), *Medea, Hippolytus, Alcestis, Andromache.* M. Musurus (Aldus, Venice, 1503), all the extant plays except *Electra*, which was first published by P. Victorius in 1545.

Of the older commentaries we may note especially: Valckenaer's *Phoenissae* (1755) and *Diatribe in Eur. perditorum dramatum relliquias* (1767); Markland, *Supplices* and *Iphigeniae* (1763–71); Porson, valuable for establishing metre and diction, *Hec., Or., Phoen., Med.* (1797–1801); Elmsley (similar) *Med., Bac., Hclid., Suppl.* (1813–21); Weil, *Sept Tragédies d'Euripide* (1879); Paley, the whole, oldfashioned but thoughtful (1872–80). In recent times may be mentioned the numerous commentaries of Wecklein; Bruhn, *Bacchae, Iph. in Tauris;* Sandys, *Bacchae,* with archaeological notes (4th ed. 1900) and above all Wilamowitz-Moellendorff, *Herakles* (1889, reprinted 1895, with epoch-making introduction), *Hippolytus* (1891), *Ion* (1926). Also J. U. Powell, *Phoenissae* (1911).

Among the numerous essays on Euripides may be mentioned A. W. Verrall, *Euripides the Rationalist* (1895), *Four Plays of Euripides* (1905), *The Bacchants of Euripides* (1910); G. Norwood, *The Riddle of the Bacchae* (1908); Gilbert Murray, *Euripides and His Age* (1914), and introduction to his translations. P. Décharme, *Eur. et l'esprit de son Théâtre* (1893); P. Masqueray, *Eur. et ses Idées* (1908); Nestle, *Euripides der Dichter der Gr. Erklärungzeit* (1901); Steiger, *Eur. Dichtung und Persönlichkeit* (1912). The article by Dieterich in Pauly-Wissowa's *Encyclopädie* is excellent. Invaluable for the poet's works as a whole is Welcker's *Griechischen Tragoedien mit Rücksicht auf den Epischen Cyclus geordnet* vol. ii. (1839); interesting, though uncritical; Hartung's *Eur. Restitutus* (1843).

Critical editions: Matthiae (1829); Kirchhoff, important (1855); Wecklein (1898–1901) from Prinz's collations; Gilbert Murray, with help from Wilamowitz and Verrall (1902–09).

Translations: In English verse by Way (the whole, 3 vols., 1894–98): Gilbert Murray (*Hippolytus, Bacchae, Trojan Women, Electra, Medea, Iphigenia in Tauris, Rhesus, Alcestis*). Verrall, *Ion.* In German *Hippolytus* and other plays by Wilamowitz.

Some interest attaches to Browning's "transcript" of the *Alcestis* in *Balaustion's Adventure*, and to Goethe's reconstruction of the lost *Phaethon* in his *Sämmtliche Werke*, vol. 33 (1840). (G. G. A. M.)

EUROCLYDON, a stormy wind blowing from the north-east or north-north-east in the eastern Mediterranean (Gr. εὖρος, east wind; κλύδων, wave). Where the Authorized Version of the Bible (Acts xxvii. 14) mentions *euroclydon*, the Revised Version, taking the reading εὐρακύλων, has *euraquilo*, or north-easter. The word is sometimes incorrectly used for the Bora (*q.v.*).

EUROPA (or EUROPE), in Greek mythology, according to Homer (*Iliad*, xiv. 321), the daughter of Phoenix or, in a later story, of Agenor, king of Phoenicia. The beauty of Europa fired the love of Zeus, who approached her in the form of a white bull and carried her away from Phoenicia to Crete, where she became the mother of Minos, Rhadamanthys and Sarpedon. She was worshipped under the name of Hellotis in Crete, where the festival Hellotia, at which her bones, wreathed in myrtle, were carried round, was held in her honour (Athenaeus xv. p. 678). She apparently is a personification of the continent of Europe.

See Apollodorus iii.; Ovid, *Metam.* ii. 833; Helbig in Roscher's *Lexikon;* Hild in Daremberg-Saglio.

EUROPE, the smallest of those principal divisions of the land-surface of the globe which are usually distinguished by the conventional name of continents.

INTRODUCTORY

Individuality of the Continent.—The earliest mention of Europe is in the Homeric *Hymn to Apollo*, but there Europe is not the name of a continent, but is opposed to the Peloponnesus and the islands of the Aegean. The distinction between Europe and Asia is found, however, in Aeschylus in the 5th century B.C., but there seems to be little doubt that this opposition was learnt by the Greeks from some Asiatic people. On Assyrian monuments the contrast between *asu* "(the land of) the rising sun," and *ereb* or *irib* "(the land of) darkness" or "the setting sun," is frequent, and these names were probably passed on by the Phoenicians to the Greeks, and gave rise to the names of Asia and Europe. Where the names originated the geographical distinction was clearly marked by the intervention of the sea, and this intervention marked equally clearly the distinction between Europe and Libya (Africa). The difficulty of fixing the boundary between Europe and Asia where there is land connection has always caused uncertainty in the application of the two names, but never obscured the necessity for recognizing the distinction. Even in

the 3rd century B.C. Europe was regarded by Eratosthenes as including all that was then known of northern Asia. But physical features and climate finally determined that what we know as Europe came to be occupied by more or less populous regions in intimate relation with one another, but separated on the east by sparsely peopled areas from the countries of Asia, and the boundary between the two continents has long been recognized as running somewhere through this area. Within the limits thus marked out on the east and on other sides by the sea, the climatic conditions are such that inhabitants are capable of and require a civilization of essentially the same type, based upon cultivation of grain. Those inhabitants have had a common history in a greater measure than those of any other continent, and hence, however divided among themselves, are more thoroughly conscious of their dissimilarities from, than of their consanguinity with, the peoples of the east and the south.

Officially the crest of the Caucasus and that of the Urals were formerly regarded in Russia as the boundaries between Europe and Asia on the south-east and east respectively, although in the Urals it is impossible to mark out any continuous crest, though they form a boundary to some extent in climate and vegetation (*v. inf.*).

Extent.—The following calculations in English square miles (round numbers) of the area of Europe, within different limits, were given in Behm and Wagner's *Bevölkerung der Erde*, No. viii. (Gotha, Justus Perthes, 1891), p. 53:—Europe within the narrowest physical limits (to the crest of the Urals and the Manych depression, and including the Sea of Azov, but excluding the Caspian steppe, Iceland, Novaya Zemlya, Spitsbergen and Bear island) 3,570,000 square miles. The same, with the addition of the Caspian steppe up to the Ural river and the Caspian sea, 3,687,750 square miles. The same, with the addition of the area between the Manych depression and the Caucasus, 3,790,500 square miles. The same, with the addition of territories east of the Ural mountains, the portion of the Caspian steppe east of the Ural river as far as the Emba, and the southern slopes of the Caucasus, 3,988,500 square miles. The same, with Iceland, Novaya Zemlya, Spitsbergen and Bear island, 4,093,000 square miles. In all these calculations the islands in the Sea of Marmora, the Canary islands, Madeira, and even the Azores, are excluded, but all the Greek islands of the Aegean sea and the islands of Thasos, Lemnos, Samothrace, Imbros, Hagiostrati or Bozbaba, and even Tenedos, are included.

The most northern point of the mainland area is Cape Nordkyn in Norway, 71° 6′ N.; its most southern, Cape Tarifa in Spain, in 36° 0′ N.; its most western, Cape da Roca in Portugal, 9° 27′ W.; and its most eastern, a spot near the north end of the Ural mountains, in 66° 20′ E. A line drawn from Cape St. Vicent in Portugal to the Ural mountains near Ekaterinburg has a length of 3,293 m., and finds its centre in the west of Russian Poland. From the mouth of the Kara to the mouth of the Ural river the direct distance is 1,600 m., but the boundary line has a length of 2,400 miles.

Distribution of Land and Water.—Europe is unique among the continents in that no other is so deeply penetrated by the sea; the result is that it is composed of two compound peninsulas on the west flank of the Russian plain. The present relations of sea and land have obtained, with minor but important variations, during the historic period. Aquileia and Ravenna have been separated from the sea by a process of silting and the Rhone delta has grown (*see* R. D. Oldham, *Geog. Journ.*, London, lxv., 1925, p. 403); the North sea coasts have been attacked by the sea in several places but locally land has been added here and there; the opinion has been strongly held that land is rising out of the sea (or the sea level sinking) in Scandinavia; local tradition emphasizes attacks of the sea in the Gulf of Avranches, and there have been many changes in the volcanic zones of the Mediterranean. Earthquakes are reported for all Europe save the very stable Russian plain; there is thus no indication of finality in the form of Europe and it has certainly altered considerably since the beginning of the human period. The opinion is held by many that the land stood higher during the maximal ice-phases of the Pleistocene glaciation, and, however this may be, there is abundant evidence of the fact that the last conspicuous movement has been at the expense of the land, and archaeological hints suggest that such movements may have been important in western Europe towards the end of the 3rd millennium B.C. as well as earlier. It is thus a feature of Europe that detached fragments of one-time continental land now form islands in great profusion along its coasts and in its penetrating seas, and these islands have played a great part in the early development of maritime commerce and of the general development of civilization. The coasts of south Spain, Italy and North Africa lie parallel to the great curves of fold mountains and are not rich in islands save near the volcanic zone of south Italy. Though the east coast of the Adriatic is in the main parallel to the line of mountains, yet that line is really a group of lines which bend successively westwards from the general north-westward direction with the result that the broken and partly sunken ends form numerous islands set obliquely or sub-parallel to the coast. The northern Aegean has islands which may be mainly unsubmerged remnants of a sunken old block, but many islands of this area are in chains that show them to be emergent hilltops of a partially drowned mountain line. Sicily, Corsica and Sardinia and the Balearic isles belong to the systems of fold mountains and old blocks of the western Mediterranean basin, Sicily being largely fold mountain and volcanic material, the Balearics also a part of one of the fold mountain-arcs, and Sardinia and most of Corsica surviving fragments of a Hercynian block.

Whereas, in the Mediterranean, coast and mountain-fold are often, but not always parallel, this occurs but rarely in any direct way in Atlantic Europe, in which Hercynian and other blocks variously broken project into the sea and give a coast that usually cuts across the grain of the land and is characterized by large numbers of drowned valleys in Spanish Galicia, Brittany, western Britain and Ireland and Norway, the northern ones being heavily modified by ice-action. Whereas the St. George's and English Channels seem to be essentially drowned valleys, it is possible to describe the North sea as having coasts along which the European plain shelves down gently under water, and much the same can be said of the Baltic, large areas of which are very shallow indeed. The islands of Denmark and the Estonian coast as well as the Aland islands are merely unsubmerged fragments as on a larger scale are the British Isles, the Orkneys and Shetlands. As the coasts of Norway and Scotland are in part at least fracture-lines of an ancient land block, though the original directives (N.E.-S.W.) are the main ones still, these coasts are fringed with islands parallel or sub-parallel to the coasts, usually leaving channels along the coasts inside the islands (Vest Fjord, the Minch) that played a great part in the early centuries of navigation. The Black sea has a shelving north shore but its south shore is parallel to high structural lines and characteristically drops into deep water. This relation of deep water near coasts flanked by high structural lines is illustrated in the west Mediterranean and, to a certain extent, off the north coast of Spain as well as off the Norwegian coast, but not in the Adriatic, the shallowness of which contrasts markedly with the great depths of the Mediterranean basins. The White sea, Gulf of Finland and Gulf of Bothnia all have shelving shores and shallow water and represent portions of the European plain now covered by sea, the sea having within the human period also covered south central Sweden as well as a zone between the Gulf of Finland and the White Sea at times. These relations are important for the understanding of the distribution of European lakes (*v. inf.*).

PHYSICAL FEATURES

Mountains.—The most outstanding physical feature of Europe is the series of great mountain ranges of the Alpine system of Suess (*see* section on Geology), characterized by curved lines of heights in the Balkan peninsula, the Carpathians, the Alps and Apennines, the Atlas of North Africa and the Sierra Nevada, with the Pyrenees as a related range. To the south-west these mountain ranges enclose such basins as the shallow one of the Adriatic and the deep one of the western Mediterranean, to the south-east the sunken area of the Aegean, all with volcanic and earthquake zones of disastrous importance. Within the mountain

curves are rich lowlands such as those of Rumanian Wallachia, Hungary and the Po Basin. To the north and north-west of the Alpine system stand the remnants of the Hercynian and earlier chains (*see* section on Geology), mostly showing forms completely planed down and then uplifted afresh as blocks to be dissected afresh by wind, water and ice. The Spanish plateau, the central plateau of France, the Vosges and Black Forest, the Ardennes and Eifel, the hills of central Germany, Bohemia and much of its hill frame all illustrate the condition just described and some like the central plateau of France show striking irregularity of surface resulting from volcanic activities affecting these regions and probably related to the uprise of the Alps. This zone of old, round shouldered mountains stands out from the European plain which lies mainly to its north; the chief part of this plain may be said to stretch from south and east England, with the North sea covering a part of it, past the war-tried gate of Ypres in the gap west of the Ardennes, to Germany and Poland where it widens out into the vast Russian lowland. The Paris Basin (*see* FRANCE) is a portion outlying southwards.

North-westwards beyond the European plain as just defined we have mainly along south-west–north-east lines in Ireland, Scotland and Scandinavia, the old mountain masses of the Caledonian system of Suess (*see* section on Geology), with features showing that they were worn-down to a dead level and re-uplifted perhaps more than once; this topography is at any rate highly complex and owes some of its most striking features, such as the sharp coasts of Norway and west Scotland and Ireland, to the process of formation of the Norway sea and northernmost Atlantic mentioned in the Geological section. There is much evidence of vulcanicity in connection with the changes involved, and volcanoes are still active in Iceland at the end of the long ridge, now largely submerged, which extends north-westward by way of the Faröe islands. The Scandinavian highland is by far the largest highland structural unit in Europe unless the whole Balkan peninsula be counted as a unit. These broad topographical facts are complicated by influences of the Ice age which modified the valleys of Norway, west Scotland and Wales into their present steep-sided forms and, while exercising similar influences farther to the south-east, affected the Swedish side of the Scandinavian and the European plain to the east and south largely by deposition of immense moraines. These form lines of hills along the Prussian plain (*see* GERMANY and BERLIN) and are major topographical features in Denmark, central Sweden and south Sweden and Finland. Moraines also occur around the Alpine chains, but in a region of such striking topography they play a lesser part.

The Alpine system, broadly, forms in the west a dividing line between the region of marine basins with coastal hills and islands on the south and the broken hills and wide plains of the north. The former region, in which maritime intercourse and exchange began early, developed cities as a feature of its civilization long before the lands to the north. But the disposition of the Alpine system allows the oceanic westerly winds to penetrate far eastwards in summer however completely the dense cold air on the Russian plain may keep them out in winter. Thus oak, maples, elms, ashes, etc., are able to grow as far east as the Urals though hardly beyond. This climatic relation has permitted the gradual acclimatization of cereal cultivation and village-life and eventually the rise of trade and cities in northern Europe. The southern border of the Alpine system, apart from this line in the broken area of the Aegean, may thus be said to divide the civilization of Europe into two parts one in which cities are of immense antiquity, the other in which agricultural villages are a fundamental human characteristic, and no city existed until more than 2,000 years after Knossos in the south had become a metropolis.

Rivers.—The penetration of the seas into the land, the broken topography, and the openness of the land to oceanic influences give Europe a multiplicity of rivers of the most varied types. The Danube and Po are rivers of basins within mountain-fold curves, and their alluvial basins and multitude of tributaries are characteristic features. The rivers of the Mediterranean basin are often short, with torrent-sections followed by courses across flood-plains that have in many cases become malarious; many in the east cease to flow in dry summers. The Guadalquivir, Garonne, lower Rhone and in a measure the Ebro occupy troughs between fold ranges and Hercynian blocks (*see* section on Geology) and the mainstream is typically beneath the edge of the Hercynian block. The Guadiana, Tagus and Douro utilize weak lines in the Spanish plateau, called the Meseta, and the two latter have deep cut sections through the plateau edge on the way down to the Portuguese coast. The Rhine system depends on weak lines in the Alpine systems in its upper parts, on the syncline between the Alps and their Jurassic foreland, on fractures in Hercynian blocks and so on; the relations and characters of its regions and their feeders are thus most complex. This has contributed not a little, on the one hand, to make the Rhine a line of communication, on the other to make the problem of useful political boundaries in this region almost a hopeless one. Though the upper parts of Weser and Elbe are related to weak lines in the Hercynian blocks, their lower courses, and the Oder and Vistula are essentially rivers of the European plain with their courses and those of their tributaries affected by the west-to-east morainic lines mentioned above. Between these morainic lines are courses marked out for these rivers and their feeders and as these lines run for long distances, they have lent themselves to the construction of canal systems, almost without locks, which for example, played an important part in the rise of modern Germany. The Loire and Seine in France and the Thames in England drain basins that are essentially part of the European plain, modified by slight influences of the Alpine uplifts that have given hill frames around and thus have helped them to become distinct political units, which nevertheless have easy communications beyond their borders.

The rivers of the Russian plain are characteristically large with sluggish currents along great stretches though, as in the case of the Dnieper, there may be a more confined and rapid section where a low rocky barrier is cut through. Whereas apart from the Danube, which owes its special length (1,644 m.) to the fact that it drains a succession of basins, the rivers of western Europe are all less than 600 m. in length, save the Rhine (709 m.), Elbe (612 m.) and Vistula (estimates vary between 596 and 646 m.), there are on the Russian plain three rivers Volga, 1,977 or 2,107 m.; Ural 1,446 or 1,477 m.; Dnieper (estimates vary between 1,064 and 1,328 m.) well over 1,000 m. in length and the Kama, Don and Petchora near or above this limit with the Oka, Dniester and Viatka of the same length as the Rhine and Vistula. Flooding from melting snows in spring, and the long hard frosts of winter impart further peculiarities to these Russian rivers in their relations with man. The drainage system of Russia is however distinguished from that of Finland by the fact that though moraines affect their courses, yet, broadly, it may be said that the drainage system has re-established itself in Russia subsequent to the Ice age, while in Finland this is not the case and the country is an inextricable tangle of lakes behind moraines. In Scandinavia on the Norwegian side the slopes are so steep and coastal sinking has had such marked influence that the rivers are generally torrents falling into fjords which are submerged heavily-glaciated valleys; on the Swedish side the drainage from the highland runs mainly in direct (consequent) lines and glaciation has both scarped the valley sides and left moraines with the result that there are many parallel rivers and the upper courses of several are in the form of long lakes. There are many analogous lakes in Scotland.

Lakes.—Some points concerning lakes have just been made. An important fact is that every European lake with an area of more than 300 sq.m. (as usually calculated there are at least 17), belongs either to the Finland-Lapland region where moraines still dominate the topography or to structural low zones across from the White sea to the Baltic and across south central Sweden. These low zones have been under the sea in comparatively recent geological periods and their great lakes include Ladoga (7,004 sq.m.), Onega (3,765 sq.m.), Peipus (1,357 sq.m.), all in Russia and on its borders, and Vener (2,149 sq.m.), Vetter (733 sq.m.) and Malar (449 sq.m.) in Sweden. The largest of the Finnish system of lakes are Saima (680 sq.m.) and Pajane (608 sq.m.). The Swedish lowland-lakes, being between the Cattegat and the Baltic, have encouraged the development of water communications

across Sweden, and the journey from Göteborg to Stockholm across Sweden by boat is scenically one of the most remarkable on inland waters.

The lakes of the Alps and their foreland are of various types; some like those of north Italy are largely due to morainic dams across valleys formerly heavily glaciated; others have this origin in part but may occupy structural troughs as well. The largest lake of Europe apart from the northern region above discussed is however Lake Balaton (266 sq.m.) elongated parallel to and beneath the slopes of the Bakony Wald. Finland is unique in Europe in the matter of its lake system but regions of indeterminate drainage with abundant lakes and lakelets on a waterproof boulder clay cover occur in East Prussia, in Zealand (Denmark), in the Dombes region north-east of Lyons (France), and on a small scale in north Shropshire (England). The volcanic lakes of parts of the Apennines should be mentioned as also the tiny but characteristic corrie-lakes just beneath the ridges of the once heavily glaciated old mountain masses of Britain, with analogues in the Alps.

Marshes.—These are a feature of the geography of Europe especially on the Russian plain. From Leningrad eastwards to Vologda and the upper parts of the northern Dvina there stretch great areas of marsh more or less along the northern limit of the deciduous forest, and the marshes extend over large areas from Leningrad towards Moscow. The Peipus region on the Estonian-Latvian borders of Russia also abounds in marsh related to the distribution of boulder clay while farther south are the Pripet marshes. Here the Vistula-Dnieper low-zone north-east of the Carpathians crosses the European plain, and the Pripet marshes are the north-west part of the Dnieper basin towards the indefinite boundary between the drainage systems of the Black sea and the Baltic. These great areas of marsh have had great influence in isolating central Russia, especially from the west, and they determine to a large extent the historic ways of communication from the west into Russia, that of Vilna-Smolensk north of, and that of Lemberg-Kiev south of the Pripet marshes. The varied and broken topography of Europe farther west has prevented the occurrence of any marsh areas at all comparable with these but small patches occur in low alluvial basins and behind dunes on low shores and so on. The interior of Ireland is impoverished by large areas of bog land. There are great marshy areas in the European Arctic regions, in north Finland, the Kola peninsula and north Russia, nearly continuous eastwards beyond the northern Urals with the immense marshy lowland of the lower Ob.

CLIMATIC CONTRASTS

Europe is situated in the north temperate, and to a slight extent towards the north, in the arctic zone between lat. 35° N. (Crete) and lat. 71° N. (Norway), with islands of the Arctic ocean beyond this limit. It faces the North Atlantic ocean on the west and may receive from it at any time cyclonic disturbances which typically move eastwards especially along the belt between lats. 50° and 65° N. The prevalent wind is from the south-west and west-southwest, and the next most prevalent winds in western Europe are those blowing approximately from the south in the early phases of cyclones before those from the south-west set in; and those blowing from the north-west in the late phases of cyclones. The prevalence of the west-southwest winds brings a drift of water on the ocean surface moving with a northward component towards the coast, the Atlantic water is thus always relatively warm for its latitude and especially so during winter. The air over relatively warm water tends to be moist and at low pressure and the cyclonic systems of the north temperate zone are essentially systems of winds blowing in a counter clockwise curve into a low pressure centre. The warmth of the North Atlantic is so marked in winter that the cyclonic systems are very strong and the winds blow with a great fury, but another result is that the warming effect is carried far northward along the coast and even harbours along the north coast, like Alexandrovsk, can thus be kept open in winter. This mildness in winter, and in summer (for the neighbourhood of the ocean keeps summer temperatures down, and the moisture in the air promotes cloudiness), is of the utmost importance to man. He is able to maintain a good level of activity of body and mind and of intercommunication even in mid-winter provided that he is able to keep his standard of living high enough to ward off some of the ill-consequences of the small amount of sunshine.

The Russian plain in the matter of winter climate is, however, essentially an extension of the immense high-pressure system of north-central Asia and the cold dense air lying on it repulses sea-winds and cyclones, and causes long periods of steady intensity of cold which contrast strikingly with the variability of the west, that so often has mild temperatures with south-westerlies followed by a bracing day with north-westerlies. The steady severity of climate on the Russian plain, with fierce winds especially in the north, is not only a famous subject of folk tale and literature but also a crucial difficulty in the way of any scheme of government by consent, as it is difficult to maintain a good level of activity and vigilance under these conditions save among those fortunate enough to be able to create a more genial environment artificially. The social contrasts thus accentuated by climate have created bitter problems.

The Alpine system of mountains, instead of fronting the ocean as does the American Cordillera, is pointed westwards to the sea and the Russian zone of high pressure air in winter often spreads westward in a tongue along the highlands and may be continuous right across it to the highland of Spain, and may even thence reach the belt of oceanic high pressure which in winter lies over the mid-Atlantic about lat. 30°. The presence of this south-west to north-east zone of high pressure marks out a path for the Atlantic cyclones to the north of its habitual border. The severity of conditions gives six to eight months frost in a normal year on either side of the White sea, not diminishing below five months until one gets near a line from Leningrad to Moscow, and keeping above four months nearly as far south as Kiev, with the lower total of one to three months on the plain north of the Black sea. Approach to the sea westwards along the European plain is accompanied by reduction of the frost period from four months near the Baltic Dvina to three months near the lower Vistula, two months near Oder and one month along a line that approximately divides Danish Jutland (colder) from German Schleswig-Holstein (milder) and then runs southward from the neighbourhood of Kiel across the Weser to the Black Forest, *i.e.*, just east of the Rhine. To the west of this the cold is not only less but also much less continuous.

In summer the European parts, and especially the centre and south, of the Russian plain warm up so that regions which were at 20° F (average) in January, may be at 70° or more (average) in July. The expansion of air on the plain in summer promotes indraught from the sea, and the weak summer cyclones and westerly winds thus penetrate far in, and make the European plain and central Russia a region of summer-maximum in the matter of rain. As a result a broad wedge, with base from Uleaborg in Finland to the Bukovina and apex between Nizhniy Novgorod and Kazan, has more than 20 in. of rain per annum while the land north, east and south of this wedge has less, often much less. The broken topography in west Europe implies not only increase of total rainfall as compared with Russia but also variation of rainfall from place to place within relatively short distances. The total generally exceeds 60 in. per annum on several coastal patches from north Portugal via Ireland to South Norway. The summer rainfall of the Russian plain has its maximum in June in the south before the heating of the land has gone too far, in July in the centre, and in August north of the Gulf of Finland. Analogous relations hold good in east central Europe where the Danube basin generally has a June maximum, the north German plain and the east side of the Rhine basin a July maximum and the Baltic region except Denmark an August maximum.

These facts bring out the great contrast over against Atlantic Europe with its typical October maximum of rainfall and its December to January maximum in such regions as west Ireland and Iceland. The Netherlands are sufficiently influenced by the European plain to have their rainfall maximum in summer and like the Baltic lands they usually have it in August. Statements

concerning western Europe are however specially subject to reserve due to variability of seasons. Of recent years research upon the extent and date of melting of Arctic ice, especially in the north-west of the Atlantic area, has led to attempts to forecast seasons in a broad way and it seems clear that the contrast between the colder air over an ice-sheet and the warmer air over open water in winter is an important factor of air movements helping to settle the tracks of cyclonic storms and thus exercising great influence upon our seasons. The North Atlantic wedge of relative winter warmth, pointing north-eastwards and forming the main zone of cyclones, may thus be said to be bounded on the north by the influence of Arctic ice and on the south-east by the tongue of high-pressure reaching out from the Russian plain along the highland zone, often to the Spanish plateau and the subtropical high-pressure belt of the Atlantic. This wedge of relative warmth is in large measure the European region of agricultural-village civilization already mentioned, and it seems reasonable to say that the village in the apical part of that wedge has spread eastwards, *i.e.*, that the idea of the village has on the whole spread eastwards into the summer-rain wedge, the area of deciduous forest, in Russia, more probably via Kief than via Vilna (*see* above, *Marshes*). Nevertheless the wedge area has not had this type of penetration from base to apex; the agriculture of Europe owes a great debt to factors that have reached it via Asia Minor, south east Europe and the zone of European tongue of highland that is weak because of the basins of the Danube river that succeed one another in it; it was not only in the days of Islam that this zone brought disturbing influences into Europe's life. Before leaving the wedge area it is well to draw attention to the fact that a strengthening of the continental winter high-pressure conditions (such as would occur if the land lay higher) might well abolish this wedge which then, with its highlands and broken topography, would experience very severe conditions. The relation of these considerations to the glacial period is a matter that needs to be worked out still more critically.

The southern boundary of the wedge area is the tongue of winter high pressure that has been said to stretch, frequently, right out along the highlands from Russia to Spain and the Atlantic. That high pressure tongue generally separates off from the Atlantic influences the basin areas of the Mediterranean, though they may occasionally break through, either in South France with its deep tell-tale wedge of heavy rainfall having its base on the gulf of Gascony and its mistral wind blowing across the central plateau and down across Languedoc and the Rhone delta to the sea, or in the Adriatic farther east. In the Mediterranean region the relations of sea and land affect climate all the more deeply because of the strength of the mountain framework around the deep basins of the sea. High pressure on the highlands and low pressure over the sea, which long preserves much of the summer warmth appropriate to such latitudes, is a governing factor from October to March; and the cyclonic storms for which the Mediterranean is famous as well as winds down the mountains, *e.g.*, the bora, mistral and others, are natural consequences. In the western basin the contrasts develop most quickly in the north, giving a season of maximum rainfall in autumn as contrasted with a winter maximum along the coast of Algeria and Tunis. The configuration of south Italy facing the west Mediterranean basin gives it considerable rainfall in both autumn and early winter while the configuration of Sardinia gives it almost continental conditions in winter. Late-winter conditions with their diminution of differences of temperature between land and sea bring diminution of rainfall, and, then the seasonal increase of warmth in the lowlands before the Alpine snows have melted brings increased rain to the Alps in April and leads to the spread over the Alps of the low pressure areas that still tend to linger on the Mediterranean sea. The warming of the Sahara and North Africa changes these relations as summer advances and the sea is now cooler than the land and so is a high-pressure area. The set of the winds becomes southwards towards the deserts of North Africa, and probably the pull exercised by trade winds farther south is also felt; from June to September temperatures run high and rainfall is very low, the bay enclosed by south Italy and north Sicily being a little less dry even at this season thanks to its mountain frame facing the sea. The isotherm of 70° typically has the Mediterranean on its warmer side from early June to late September, and in July the averages in the western basin are as high as 75° to 78°. The general conditions just sketched need adjustment in detail for understanding of any particular region. Thus, the subtropical high pressure area over the Atlantic is markedly extended in summer and may spread into the Iberian peninsula but the mid-summer sun strongly heats the great plateau of that peninsula balanced about lat. 40° N. and correspondingly reduces atmospheric pressure which thus tends to be lower than would otherwise be the case.

The Adriatic region illustrates some of the conditions of the western Mediterranean in accentuated fashion, with its massive Dalmatian highlands closely fronting the sea. The rainfall along this highland edge is said to be the heaviest in Europe, it has an autumn maximum but its more southerly portions go on getting heavy rain well into the winter and April increase of rain is marked here as in the Alps. July and August are relatively dry. Summer temperatures are like those of the western basin but winter temperatures run lower. In the eastern Mediterranean, the Aegean, enclosed as it is by land, and subject to influences from the south Russian steppe, feels the cold still more than the Adriatic, and parts of it are a rain-shadow area of the Illyrian mountains. The early establishment of high-pressure conditions on the Russian plain in autumn (October) affects the Aegean region, which hence lacks heavy rainfall till contrasts between land and sea are thoroughly established in November, December and January. The summer is naturally very dry but the considerable early summer (June) rainfall of the Balkan land mass must not be overlooked. Summer conditions here include the southward set of the winds towards the heat of Africa and the Red sea, as already mentioned for the western Mediterranean, but here there seems to be a pull towards the great monsoonal air stream setting at this season on to India. The north or Etesian wind of the Aegean is famous in literature and history, rising with the day and calming towards night. Its regularity and the general predicability of the weather and the bright summer starlight were important factors, alongside of the multiplicity of sheltering islands, in the rise of navigation and maritime commerce in this their earliest home in the Mediterranean region.

Southern Asia Minor, the majority of the Aegean islands, Greece, Sicily, Corsica and Sardinia, south-east Spain and the North African coast have an average temperature above 68° F for four months and this period of heat is longer on the south-east side of the sea, where summer rainlessness is still more marked. The difficulties of summer heat affecting the health and well being of the general population and its participation in modern efforts towards government by discussion and consent should not be overlooked, nor their bearing on the social structure of classical Greece, for example, ignored. The more moderate climate of Italy and its greater rainfall are important facts. The Po Basin needs a short note. Its enclosure with a mountain frame makes the middle of the valley cold in winter, sometimes with temperature inversion (*i.e.*, the coldest air immediately above the surface of the land) and on the other hand the heat of summer in such a basin gives low pressure and a certain amount of rainfall. The special conditions in the Iberian peninsula with its spring rainfall in the northern half will be dealt with in the article on SPAIN.

THE STUDY OF SOILS

The study of soils is advancing quickly at the present time (1928), largely under the leadership of Russian men of science, of whom Glinka is one of the best known (*see* K. D. Glinka, *The Great Soil Groups of the World and their Development*, 1928). E. Ramann is contributing to this study (*Evolution and Classification of Soils*, 1928) and is also applying the views developed to the study of geographical distribution. It appears now that the direct influence of the composition of the underlying rock or deposit is by no means a determinant, and that climatic influences play the larger part, though their influence will work out differently

according as the rock or deposit is permeable or impermeable. Moreover the influence of the underlying material is far greater in a temperate climate than in a climate of extremes. As the newer classifications have been applied thus far in most detail in Russia the subject will be treated more particularly in the article RUSSIA, and this section of the article on Europe will be confined to an introductory statement.

Classification into transported soils such as loess, dunes, etc. (Aeolian formation), morainic, fluvioglacial, etc. (glacial formation), alluvial (fluvial formation), and sedentary soils has its utility but is applicable mainly locally rather than broadly over great regions and it is noted that the black earth appears over many different formations in eastern Europe, over loess, boulder clay, calcareous rock, etc. Temperature in its relation especially to rainfall and evaporation is one of the most important factors governing soil character. Surveying the soils of Europe broadly and using the new names as far as possible we have, according to Ramann the following classification:

(1) In the cold zone there are humid soils, because evaporation is slight, chemical weathering is slow and the soil may be water-logged in the open season and may thus be inclined to move or flow. Soils then are often tessellated by formation of great frost-crack patterns, and fine sandy material leaches out into the cracks. Many areas of the Tundra or Arctic zones are covered by hillocks said to arise from differential strains in freezing of the upper layers when the depth also is frozen but zones in between are not. Hillocks are also due to the form of moss-cushions which grow in the Arctic. On the heights rock splinters abound in the soils, which usually have the iron leached out of them by water and so are grey. In many places the depths of the soil may be permanently frozen though the surface may grow trees or even occasionally crops.

(2) In the temperate zone the soils are affected by the presence or absence of lime in the rock for, if lime is present, there will not be accumulation of acids from humus. The rock naturally affects the texture of the soil. In the north leaching by water which does not evaporate too quickly gives grey soils, generally poor in iron hydroxide but in sandy soils the iron hydroxide may not be got out of its combinations in the soil material and what little is got out is quickly carried away. Therefore grey soils are typical even fairly far south near sandy areas. Grey soils heavily leached are characteristic of north Scandinavia. Such soils in Russia are called *Podsol* and the humus here washes down into the subsoil and gives it higher iron-content, tending to form "a pan." Podsol is especially the soil of the northern coniferous forests of Europe but it occurs on mountains farther west. In the parts of Russia farther south, largely under deciduous forest, the bleaching is found again but the evaporation in summer is greater and "pan" is not generally formed; these soils are the *Forest Grey Earths*. The *Humid Brown Earths* develop where rainfall, temperature and evaporation are moderate and leaching is not taken to extremes. In dry summers lime in solution rises in the soil, humus content is low because organic matter decays quickly with moisture and moderate warmth, iron is present in fair quantity from decomposition of the soil material, but that quantity is much less if the underlying rock is poor in iron. The brown earths are coherent and do not powder easily; they need to be fed with organic matter if crops are to be grown year after year. They are the typical soils of the lowlands of central and western Europe and the surface does not differ much from the deeper layers, while the subsoil often contains fragments of the underlying rock. If the underlying rock be calcareous it dissolves away, and in extreme cases little soil is formed; but sometimes, as in central Europe where the summer is warm and dry, humus accumulates in some quantity and one gets a dark earth (reef soil) as for example on the Swabian Jura. The calcareous soils being dry through soaking away of the water become warm and evaporation is great. Moreover the humus acids combine with the lime and this prevents much accumulation of the humus acids in colloid form. The percolating water makes the surface poor in iron but the deeper layers may have more of it.

With more extreme climate as towards the south of central Russia the typical soil is black earth, rich in humus because it is decomposed less quickly than under wetter conditions. The factors of its formation are stated by Ramann to be high temperature and much evaporation in summer with, therefore, an ascending current of water that brings up salts from the subsoil; lasting soil frost in winter is also important as hindering decomposition of humus. Tchernosen occurs in patches in east Prussia and near Magdeburg, according to Ramann. Black earth grades northward in Russia into forest grey soil, and some of this is degraded black earth, being either due to increased leaching when forest was removed, or due to increased leaching with the advent of a moister climate after the hard conditions of the Pleistocene age passed. Black earth grades into chestnut brown soils on the warmer and still more arid regions of south Russia where plant growth and humus formation is less, and lime, etc., are brought at least as far up as the deeper layers.

In south Europe with its warm dry summers and strong evaporation the amount of hydroxides of iron, brought up by the upward current of water and formed by fairly rapid chemical action under the warm conditions, makes the soils reddish, while humus is quickly decomposed when there is moisture because the rainy season is not cold, and so the humus content is low. If, because of very strong evaporation, the soil contains soda and is alkaline it appears that colloidal humus compounds are maintained and leaching of iron compounds goes on, thus giving grey soils of a special character in steppe lands. These grey steppe-soils are characteristic of central Spain as well as of Turkestan, etc. They naturally grade into soils with a large content of salt, such as are found in south-east Europe and in some lands of the southern Mediterranean, and something of their type occurs in south and south-east Spain. The black earths are invaluable agriculturally because they need less organic food than the brown ones. The forest grey soils are distinctly poorer. The red earths need organic food if they are to grow crops with roots near the surface, but they rather lend themselves to the growth of deep-rooting plants which, again, are suited to the climate with its long dry season during which plant roots near the surface could not get enough water. The local sedentary red soils over the red sandstones of western Europe also give conditions highly suited to fruit trees and the like with deep roots. The local transported soil called loess, covered in large parts of Russia by black earth (Tchernosen), is highly porous with a good salt content from the upward current of water in it under dry conditions, and it often retains a fairly considerable humus content. Its looseness and porosity are not favourable to heavy growth of trees and it has been seized upon by man from early times for agricultural settlements.

VEGETATION ZONES

The vegetation of Europe is set in extensive zones which depend mainly on the zones of climate, partly in a direct fashion and partly through the influence of climate upon the soil (*see* above). Behind the influences of present conditions there are vestiges of the influences of former conditions of climate, discussed especially by C. E. P. Brooks in *Evolution of Climate*, (1915), and Gams and Nordhagen in *Postglaziale Klimaänderungen* (München, 1923).

The region of Mediterranean climate is characterized by the presence of the olive, the cultivation of which spread from coasts or islands of the eastern part of the sea. The distribution basin is wider and reaches farther from the coast around the western basin than around the eastern. Among limiting factors on the north is the cold of winter in the highlands, even near the coast; in the south-east the heat becomes too great for the olive as it becomes sufficient for the date palm. A noteworthy point is that northern Castile in Spain has very little if any olive, nor has the Garonne basin; but the Ebro basin and that of the lower Rhône below Pierrelatte have a great deal of it. Again the Po basin has very little olive save in certain districts beneath the Alps. It is very much of a coastal plant in the Balkan peninsula save to some extent in Greece. It occurs along the coasts of the south-east of the Black sea. It is important especially in the lowlands in Palestine and Syria.

The zone of western, oceanic or sub-oceanic climate, the zone of the humid brown earths, is just as strikingly characterized, at the present time, by the beech-tree (*Fagus sylvatica*). This lives in Castile and the Garonne basin, but, farther to the south-east, occurs only on mountains where the summer temperature, and consequently the evaporation, are not too great. The zone of beech has specially lent itself to agricultural improvement in recent centuries, with the development of root-crop feeding stuffs for beast and man (especially, now, the sugar-beet) and the spread of the potato which has done so much to increase the population of the European plain from Holland to Poland. The zone of oak-without-beech is in the main a fringe of the beech-zone northwards. It includes the lake zone of south central Sweden and the south-west corner of Finland, both regions which stand out as much more developed than those next farther north, for in this zone of Sweden is Stockholm and in this corner of Finland are Turlu (Åbo) and Helsingfors. The ash reaches a little farther north than the oak. Eastwards the oak spreads far beyond the beech especially on the forest grey earths north of the black earth, in the wedge of summer rain that has its base on the Vistula-Dniester line and its apex at the line of the Urals. The beech stops about the line from Königsberg to Kherson but it appears in the Caucasus. It is the Russian zone of oak-without-beech that is the essential "Great Russia" with its traditionalist agriculture; it is separated from western Europe not only by the fact that it lacks the beech and the humid brown earth, but also by the sheer physical obstacle of the Pripet marshes, and the marshes stretching southward from the region of Lake Peipus.

North of the zones of beech and oak is the region of *Pinus sylvestris*, the region of cold soils in which root action is necessarily slow, and of cold air in which evaporation is also slow. The pine forests are adapted to these conditions, the leaves are resin-protected and tough, and do not let water evaporate faster than the slow-working roots can absorb it from the soil. Often enough an area of pine forest in the north is not worth reclaiming for agriculture but sometimes barley and rye can be grown and it is to be remembered that the removal of forest raises the summer temperature of the soil very distinctly. The pine and birch dwarf gradually towards the north where the deeper layers of the soil rarely unfreeze, and in this way the forest grades into tundra and the mossy-hillocks of the Arctic, the former with quick growing herbaceous plants flowering in the short summer season. Many minor points might be discussed such as the creep up the west coast of Europe of the holly (*Ilex aquifolium*) which has spread right into mid Germany, of the evergreen oak which reaches as far north as Brittany save for specially sheltered spots beyond. The invasion of the Alpine mountain system by Asiatic species of *Cytisus* since the end of the Ice age is an interesting matter and the Alpine system is also characterized in a high degree by the larch (*Larix europaea*).

The Mediterranean region has many plants with tough or hairy drought-resisting leaves which develop, not in one burst, as farther north, but slowly at all times, being thus free of dependence on rain at a particular season. Olive, oleander, myrtle, laurel are characteristic and the woodlands include chiefly evergreen oaks, Aleppo and other pines and silver poplars. On the mountain ranges the plants of the "beech zone" of Europe penetrate southward. Bush covers large areas and includes large growing heather, arbutus, myrtles, laurels, pistachio and many strong scented labiate plants; in dry spots, as in Spain, this bush formation, called *Macchia* in Italy, grades into pure heath. The French word *Maquis* connotes a heath land with shrubs in its general acceptance. The Mediterranean regions which cannot support these tree and brush growths may be covered by a mat of grass and bulbous plants, plants which can maintain life underground when the dry season makes their leaves wither; in dry parts of Spain the alfalfa grass is an important feature. The Mediterranean has been famed for its fruit from the dawn of history. The vine, furnishing rich wines in the west and chiefly currants and raisins farther east, is an important plant save in the south-east in Asia where Islam and the unsuitability of the climate for maturation of wines combine to limit production. The citrous fruits introduced long ago from the monsoon lands occur in the more sheltered and better watered tracts and their presence is often an indication of a favoured locality. In the irrigated gardens of East Spain (Valencia) oranges are grown on a large scale. Almonds, figs and pomegranates are other notable fruits. The date palm grows in a few specially warm spots.

The beech and oak-without-beech regions of Europe became forested, apparently, first with pines and then largely with oak and elm, ash and thorn when the steppe conditions of the Pleistocene passed away, and the sinking of coasts in western Europe helped to bring in oceanic influences on climate. The beech may have lived near the Atlantic and Clement Reid speaks of beech leaves found in early post-Pleistocene deposits in England; it spread, apparently, during the last millennium or two, B.C., and is much mixed with these other characteristic trees in many parts. The region is thus one which was heavily forested before man cut the trees. But some areas of thin soil on porous rocks and the areas of loess in the Danube basin, under Carpathians, Czechoslovakian mountains, Thuringian hills and Harz, and in the Neckar, Alsace and Rhein-Hessen lowlands were apparently not at all densely wooded. In Belgium, northern France and East Anglia soils related to loess and described by the French as *limons de plateau* were also apparently fairly free. These areas thus became important early centres of settlement and have remained important agricultural areas ever since. The coastal dunes and marshes and the windswept coastal plateaux have also been free from forest since present conditions were established and among them heath plants, gorse (*Ulex*) and bracken (*Pteris*), the latter on the more rocky areas, are highly characteristic.

The steppe region of south Russia has trees for the most part only quite near rivers, and they are chiefly willows, alders and poplars. The period of growth after the passing of winter and before summer heat dries everything up is reduced to about three months (April 15 to July 15). Herbaceous quick growing plants and especially those with underground food stores are characteristic, and often one finds very large numbers of a particular plant together, offering a contrast to the rich mixture of species in many of the plant associations farther west. The chief plant is the grass *Stipa* with specially tough stalks and narrow rolled leaves, but labiates and composites are also widespread. Towards the Caspian, and in analogous spots elsewhere, salt-loving plants are a feature. There are a good many thorn shrubs mainly of the order of the leguminosae. The northern region of pines also has birches and willows among its trees, with grasses, ranunculaceae, heather plants, cruciferae and saxifrages conspicuous among its herbaceous plants. Mosses, liverworts and lichens are a marked feature.

Fauna.—Animals in Europe and the Mediterranean region are, or were until men reduced their numbers, of many kinds related to those of lands farther south or farther east, and the name Palaearctic has often been given to the region including Europe and most of Asia north of the Himalaya, as a region with a distinctive fauna of forest and steppe. The fauna of Pleistocene Europe is a matter of archaeological interest but it is useful to interpret certain features of the life of a few regions, still fairly wild or only recently adapted by man, as remnants of an ancient fauna. It is, for example, claimed that the truly wild steppe-horse survived in the Vosges until the middle ages and the Saiga antelope, a sheep-like animal lingers east of the Volga while the Urus has left some of his blood at least to wild cattle that were formerly widespread in forest glades and that still linger here and there. The Mouflon perhaps in part the ancestor of some breeds of sheep, survives in Corsica, Sardinia, Crete, Cyprus and the Taurus mountains. The brown bear, wolf, fox, otter and badger are the chief of the larger carnivores that survive in Europe but the wild cat still lingers. The deer of Europe are for the most part distinct from those of Asia and do not extend far into Russia. The chamois, a member of the antelope group, is peculiar to Europe and lingers in the high Alps and Caucasus, and the musk-rat and related desman are confined to the French Pyrenean slopes and the Don and Volga banks respectively. Moles are highly characteristic of the region and some genera are confined to it.

Boyd Dawkins and others following him have interpreted the present European fauna as the result of immigration both from the south across former landbridges, and especially a landbridge between Sicily and Tunis, and from the steppes of central Asia, and it is probable that both sets of migrants have contributed to the domestic animals of Europe. It has been suggested that the Soay sheep and the so-called Celtic pony are mainly southern in ancestry, while Asiatic races of sheep, cattle and horses have displaced almost completely the southern ones, presumably earlier immigrants along the west. Doubtless the intermixture with local wild forms, especially of cattle and swine, has had much to do with the evolution of existing types of these animals as domesticated in Europe and its borders. The spread of the rabbit from the Mediterranean as far north as Britain and Germany in the middle ages is a noteworthy feature of European animal life entirely due to man. The spread of the brown rat at the expense of the old European black rat is another feature of man's influence in recent centuries, this time an undesigned influence.

AGRICULTURE: EARLY AND MODERN

Settled life in Europe has for long been based primarily on the cultivation of cereals; and of these wheat and barley, at least in the forms in which they are cultivated, are believed to be introductions from south-west Asia and were spread in Europe in the third millennium B.C. largely by way of the Danube basin but possibly also by maritime communications along the Mediterranean and Atlantic coasts. Though wheat and barley are the older food plants, rye has become a crop of great importance especially north and east of the Rhine, the Austrian Alps and the Carpathians and in Russia north of a line running from lat. 44° N. in the west to lat. 55° N. in the Ural mountains. It is often said that a fundamental contrast in peasant life between France and Germany is that between wheat and rye, though much wheat is grown in Germany. The proportion of wheat to rye in France is 8¼ to 1, in Germany 1 to 2½, in Hungary more than 2½ to 1, in Poland 1 to 4. In both Austria and Czechoslovakia there is more rye than wheat. Rye is more tolerant of cold than is wheat, and is a food producing more bodily heat. Belgium on the wheat side of the Rhine produces more rye than wheat at present. Barley is a specially adaptable crop giving a good yield of straw in the south in some Mediterranean regions and yielding grain in some places too cold for useful wheat cultivation. Oats are cultivated in most European countries and are produced in greater quantity than wheat in the British Isles, Belgium, the Netherlands, Denmark, Norway, Sweden, Finland, Estonia, Latvia, Lithuania, Germany, Austria, Czechoslovakia and Poland. In most of these countries, however, except the British Isles, Denmark, Norway, Sweden and Finland, the amount of oats appears to be less than that of wheat and rye combined. It is thus a crop adapted to the cool moist north-west in which it gives a harvest earlier than does wheat, while in Poland the oats harvest is after that of wheat.

Archaeological studies have suggested that the earliest agricultural scheme was one which still prevails in some parts of Africa, in a few backward regions of India and in north Korea, etc., where a group of villagers cultivates a patch of soil until it is exhausted and then moves on. This was apparently quite early superseded by the more settled village with some scheme of rotation for use of the fields of the village. There is increasing probability that some areas especially on the loess have been continuously utilized in this manner for thousands of years. The fertility of the soil has been renewed by fallowing and by manure from stock as well as by the ploughing-in of leguminous crops which enrich the soil in nitrates formed from the atmosphere by root nodules of plants of this order.

Within about the last three centuries schemes of cultivation have been much modified by the spread of root-crops (parsnips, turnips, mangold wurzels, forage beetroots), which grow on into the autumn in western Europe and provide winter food for farm animals. The spread of these crops is generally held to have had a powerful influence in modifying traditional agriculture, one feature of which was the pasturing of cattle on the stubble of the fields after cutting of the corn harvests in order to manure the land. The root crops left in the ground for some time after the corn harvests prevented the use of the land in this way. Root crops gave additional food for man and beast and by increasing the number of animals helped to make more flesh food available for man, and also gave more leather.

The spread of the potato has made great changes in European life, it has become a great food crop in Norway, north Germany, Czechoslovakia, Poland, the lands of the south-east Baltic, in most of which countries the weight of the crop exceeds that of all the cereals combined. The potato has become important also in Russia where the weight of the crop is now nearly equal to the sum of the weights of the wheat and the rye crops. The potato is however tolerant enough to form a fairly important crop in France, Italy and Hungary as well. Its importance in Ireland is well known. It has clearly played a considerable part in promoting increase of population in Ireland, and on parts of the European plain, notably in Prussia, where the soil is cold and impervious. The sugar-beet has further increased European food supplies and is important in Italy, north France, Belgium, the Netherlands, Germany, Czechoslovakia, Hungary, Poland, Russia and Rumania. The introduction of maize from America, to be cultivated for the most part after the fashion of European cereals rather than as it was originally grown in America, has been important especially for south and east France, Italy, Hungary, Yugoslavia, Rumania, and parts of Russia.

The break up of traditionalist agriculture led to experiments in the direction of improvement of vegetables, and the growth of modern bulk-transport has further changed the situation by liberating countries from complete dependence on their own products, and by making available imported fertilizers such as chili saltpetre (nitrate of soda) and guano; while the rise of chemical industries, added to that of bulk commerce in palm products from the equatorial zone, has increased the variety of fertilizers and of animal foods which produce fertilizers. The present crop-production of a country may thus be far from a result of the soil and climatic features of the country concerned. In Britain the precariousness of wheat harvests in many parts has played a part along with other factors in the decline of the crops grown, while France with its more assured sunshine in summer has remained more substantially agricultural. Germany, industrialized later than Britain, has done more to maintain its agriculture, and in this effort the application of science to the making and using of manures, imported or manufactured, has been an important factor. All these modern changes in cultivation have tended to emphasize the independence of each farm and there has been a marked tendency among rural populations towards scattering of homesteads, towards the "single farm" rather than the "nucleated village" type of habitation or, in the French terminology, towards the *habitat disperse* as contrasted with the *habitat concentré*. Along with this however there have grown up schemes of co-operation among agriculturists which are well known in Denmark but are developed in various degrees in several other countries. Areas of specially high cultivation have developed in the last half century, notably in Holland, around Paris, in North Brittany and the Channel Isles, in Provence, Lombardy, etc. Among other food crops may be mentioned buckwheat grown in France, especially in the west, and northward to Denmark, as well as in South Russia, lentils in France and the adjacent parts of Germany and millet in Russia. Sugar cane is cultivated to a small extent in Spain and Sicily and rice is largely grown in the basin of the Po.

The vine is a plant the stock of which can withstand a certain amount of cold while its roots need a fair supply of water and well drained soil, and sunshine is important for growth of the fruit. Its effective northern limit is lat. 47½° on the Atlantic coast, 50°–52° in Germany and much farther south in Russia. The fruit, and the wines made from it, differ greatly in different regions, being rich in sugar and giving heavy wines in south Spain and Portugal, for example. Towards the effective limit, *i.e.*, in general north of the central plateau in France and north of the Jura in Switzerland, vineyards are for the most part highly specialized as it is now no longer worth while to make inferior wines on a large scale under the difficult conditions near the practical limit.

Thus Saumur, Champagne, Moselle, Hock, Tokay, are, in the main, "choice" wines, as are many of the Burgundian vintages. Formerly the vine was grown farther north and its importance for the Sacrament of Holy Communion promoted this; it can actually grow and even on occasion ripen as far north as sheltered spots of southern aspect in south Norway, thanks in part to the long duration of summer sunlight.

The zone north-westward beyond that of the vine in France, and the red soils in England have the cider apple, and in England, Belgium, Germany and Austria hops are cultivated for beer. Farther east the tendency is rather to distil spirit from grain or potatoes. The combination of stock-raising with crop growing varies in different parts of Europe but is on the whole far more characteristic of what may broadly be called north-west Europe than it is of Mediterranean lands or of Russia, *i.e.*, it is developed especially in those countries where rain falls at most seasons and pastures are rich and root crops thrive. The plateau lands of the Iberian peninsula are, however, famous for their sheep, which are moved over long distances from pasture to pasture as the seasons change (*transhumance*); and Greece has many sheep, and Italy a considerable number of cattle. Intensive methods give interesting results in certain cases.

	Horses (per square mile)	*Cattle* (per square mile)	*Swine* (per square mile)
Denmark	31	176	225
Netherlands	29	164	120
Belgium	21	150	97

Only Hungary and Germany rival these figures as regards horses and they are far behind these countries in cattle and swine. Germany has 120 swine and is rapidly increasing their number, and 21 horses, but only 96 cattle per square mile. England and Wales are interesting in this respect with 19 horses and 107 cattle but only 38 swine; they have, however, 289 sheep as against 22 in Germany and 50 in France and only a very few in Denmark. Switzerland has a high average for cattle but stands relatively low in pigs and quite low in horses and sheep. The Irish Free State also stands high in the matter of cattle, but is far behind the countries listed above in pigs and horses; it has however a considerable number of donkeys which are also a feature in Italy and Spain and Portugal and Greece. The breeds of these animals vary from country to country, sheep for wool and sheep for mutton, cattle for draught, for dairying or for beef, horses for riding or for draught and so on. The cattle for dairying and those for beef are chiefly those of the rich pastures favoured by Atlantic rains and among dairy breeds Frisians, Jerseys and Guernseys have wide renown. The buffalo is used in Rumania and southern Italy. The pig is important in the old kingdom of Serbia though the statistics for the whole of Yugoslavia do not give quite 30 per square mile. The goat is important in Greece, Italy and Spain and Portugal and also abounds in the hilly parts of Germany.

Reference has been made above to fruits and it is necessary only to summarize by mentioning the olive, grapes, figs, apricots, peaches, pomegranates, and citrous fruits of Mediterranean lands, the plums and cherries of France and central Europe, with a special mention of Yugoslavia here, as well as the specialized vineyards of central and north-eastern France, the Rhine and Hungary, the apples and pears of France and parts of Britain. The fibre-crops cultivated in Europe were formerly more widespread than now that exotic fibres are imported and artificial ones made. Flax, however, remains important in Flanders and is still grown in northern Ireland, in north Italy and in Russia towards the north. Hemp is fairly widely grown in Russia and in parts of central Europe and France. (H. J. F.)

GEOLOGY

The geological history of Europe is, to a large extent, a history of the formation and destruction of successive mountain chains. Four times a great mountain range has been raised across the area which now is Europe. Three times the mountain range has given way; portions have sunk beneath the sea, and have been covered by more recent sediments, while other portions remained standing and now rise as isolated blocks above the later beds which surround them. The last of the mountain ranges still stands, and is known under the names of the Alps, the Carpathians, the Balkans, the Caucasus, etc., but the work of destruction has already begun, and gaps have been formed by the collapse of parts of the chain. The Carpathians were once continuous with the Alps, and the Caucasus was probably connected with the Balkans across the site of the Black Sea. There was, however, a large area which was not involved in the folding that produced these ranges, except, perhaps, the earliest. In the eastern part of Scandinavia and throughout the greater part of Russia even the Cambrian beds are nearly horizontal and there has been no folding since archaean times. This resistant area constitutes the Baltic Shield and Russian Platform of Suess. It extends eastwards to the Timan range and Ural Mountains, southwards to the folded belt of the Sandimir Wald and the Donetz, and north-westward to the mountain axis of Scandinavia.

The oldest mountain chain lay in the extreme north-west of Europe, and its relics are seen in the outer Hebrides, the Lofoten islands and the north of Norway. The rocks of this ancient chain have since been converted into gneiss, and they were folded and denuded before the deposition of the oldest known fossiliferous sediments. The mountain system must therefore have been formed in pre-Cambrian times, and it has been called by Marcel Bertrand the Huronian chain. It is probable that a great land-mass lay towards the north-west; but in the sea which certainly existed south-east of the chain, the Cambrian, Ordovician and Silurian beds were deposited. In Russia, as we have seen, and South Sweden these beds still lie flat and undisturbed; but in Norway, Scotland, the Lake District, North Wales and the north of Ireland they were crushed between the north-western continent and the Baltic Shield. Not only were they intensely folded but they were also pushed forward over the old rocks upon each side. Thus was formed the Caledonian mountain system of Ed. Suess, in which the folds run from south-west to north-east. It was raised at the close of the Silurian period.

Then followed, in northern Europe, a continental period. By the elevation of the Caledonian chain the northern land-mass had grown southward and now extended as far as the Bristol Channel. Upon it the Old Red Sandstone was laid down in inland seas or lakes, while farther south contemporaneous deposits were formed in the open sea.

Carboniferous Period.—During the earlier part of the Carboniferous period the sea spread over the southern shores of the northern continent; but later the area again became land and the coal measures of northern Europe were laid down. Towards the close of the Carboniferous period the third great mountain chain was formed. It lay to the south of the Caledonian chain, and its northern margin stretched from the south of Ireland through South Wales, the north of France and the south of Belgium, and was continued round the Harz and the ancient rocks of Bohemia, and possibly into the south of Russia. It is along this northern margin, where the folded beds have been thrust over the rocks which lay to the north, that the coalfields of Dover and of Belgium occur. The general direction of the folds is approximately from west to east; but the chain consisted of two arcs, the western of which is called by Suess the Armorican chain and the eastern the Variscan. The two arcs together, which were undoubtedly formed at the same period, have been named by Bertrand the Hercynian chain. Everywhere the chief folding seems to have occurred before the deposition of the highest beds of the Upper Carboniferous, which lie unconformably upon the folded older beds. The Hercynian chain appears to have been of considerable breadth, at least in western Europe, for the Palaeozoic rocks of Spain and Portugal are thrown into folds which were formed at approximately the same period. In eastern Europe the evidence is less complete, because the Hercynian folds are buried beneath more recent deposits and have in some cases been masked by the superposition of a later series of folds.

The formation of this Carboniferous range was followed in northern Europe by a second continental period somewhat similar to that of the Old Red Sandstone, but the continent extended still

farther to the south. The Permian and Triassic deposits of England and Germany were laid down in inland seas or upon the surface of the land itself. But southern Europe was covered by the open sea, and here accordingly, the contemporaneous deposits were marine.

Jurassic and Cretaceous Periods.—These periods were free from any violent folding or mountain building, and the sea again spread over a large part of the northern continent. There were indeed several oscillations, but in general the greater part of southern and central Europe lay beneath the waters of the ocean. Some of the fragments of the Hercynian chain still rose as islands above the waves, and at certain periods there seems to have been a more or less complete barrier between the waters which covered northern Europe and those which lay over the Mediterranean region. Thus, while the estuarine deposits of the Upper Jurassic and Lower Cretaceous were laid down in England and Germany, the purely marine Tithonian formation, with its peculiar fauna, was deposited in the south; and while the Chalk was formed in northern Europe, the Hippurite limestone was laid down in the south.

Tertiary Period.—The Tertiary period saw fundamental changes in the geography of Europe. The formation of the great mountain ranges of the south, the Alpine system of Suess, perhaps began at an earlier date, but it was in the Eocene and Miocene periods that the chief part of the elevation took place. Arms of the sea extended up the valley of the Rhône and around the northern margin of the Alps, and also spread over the plains of Hungary and of southern Russia. Towards the middle of the Miocene period some of these arms were completely cut off from the ocean and large deposits of salt were formed, as at Wieliczka. At a later period south-eastern Europe was covered by a series of extensive lagoons, and the waters of these lagoons gradually became brackish, and then fresh, before the area was finally converted into dry land. Great changes also took place in the Mediterranean region. The Black Sea, the Aegean, the Adriatic and the Tyrrhenian Sea were all formed at various times during the Tertiary period, and the depression of these areas seems to be closely connected with the elevation of the neighbouring mountain chains.

Exactly what was happening in northern Europe during these great changes in the south it is not easy to say. The basaltic flows of the north of Ireland, the western islands of Scotland, the Faeroe islands and Iceland are mere fragments of former extensive plateaus. No sign of marine Tertiary deposits of earlier age than Pliocene has been found in this northern part of Europe, and on the other hand plant remains are abundant in the sands and clays interbedded with the basalts. It is probable, therefore, that in Eocene times a great land-mass lay to the north-west of Europe, over which the basalt lavas flowed, and that the formation of this part of the Atlantic and perhaps of the North Sea did not take place until the Miocene period.

At a later date the climate, for some reason which has not yet been fully explained, grew colder over the whole of Europe, and the northern part was covered by a great ice-sheet which extended nearly to the Thames in England and as far as 50° N. in Russia, and which has left its marks over the whole of the northern part of the continent. With the final melting and disappearance of the ice-sheet, the topography of Europe assumed nearly its present form. Minor changes, such as the separation of Great Britain from the continent, may have occurred at a later date; but since the Glacial period there have, apparently, been no fundamental modifications in the configuration of Europe.

The elevation of each of the great mountain systems already described was accompanied by extensive eruptions of volcanic rocks, and the sequence appears to have been similar in every case. The volcanoes of the Mediterranean are the last survivors of the great eruptions which accompanied the elevation of the Alpine mountain system.

REFERENCES: Our general conception of the structure of Europe as a whole is due chiefly to Suess, *Das Antlitz der Erde* (Eng. ed., *The Face of the Earth*) and Marcel Bertrand, "Sur la distribution géographique des roches éruptives en Europe," *Bull. Soc. Géol. France*, ser. 3, vol. xvi. (1887–1888), pp. 573–617. A readable summary, intelligible without much previous knowledge of geology, will be found in *The Growth of Europe* by G. A. J. Cole. The *Kleine geologische Karte von Europa*, issued by the Prussian Geological Survey, with its transparent covering sheet *Tektonisches Bild von Europa* will be found helpful. (P. LA.)

ARCHAEOLOGY

EASTERN EUROPE

General Description.—Eastern Europe includes the wide plain of European Russia, bounded by the Arctic ocean, the Urals, the Caucasus and the Black sea together with Rumania east of the Carpathians and Bulgaria north of the Balkans; the western boundary might find a better physical basis in the White sea, the lakes Onega, Ladoga and Ilmen, and then the Carpathians and the backbone of the Balkans peninsula. To the east there is no real boundary but the Urals and the Caspian. The history and archaeology of this territory are unintelligible, unless we call to mind that it is divided into belts running east and west and each characterized by special vegetation, the product of its climate and soil. The northern belt of tundra hardly comes into archaeology; below it runs the broad expanse of fir and spruce forests down to a line going east-north-east from Berdichev, by Kiev, Orël, Tula, across the junction of the Volga and Kama south of Kazan to the Urals, where it dips down almost to Orenburg. The next belt is of mixed deciduous trees and open ground, from Kishinev (Chişinaŭ) in Bessarabia to Saratov on the Volga, along it to Samara and across to be interrupted by the Ural woods. South of this is open steppe as far as the sea; as we go south and east the steppe gets more and more salt, so that most of the government of Astrakhan is desert.

The conifers grow on the area which was formerly glaciated; the subsoil to the south of this is loess, covered in the deciduous belt by the rich deposit known as *chernozëm*, black-earth. All these belts are continued into Siberia except so far as the Ural forests interrupt them; so the loess and the steppes appear in the west beyond the Carpathians. The Crimea is half of it steppe, but its mountains have a Mediterranean forest flora, like a piece of Greece. So the Caucasus with its southern flora is no part of Eastern Europe, but its fertile foot-hills with many rivers flowing into the Kuban and Terek are to be taken with the great plains to the north. And essentially it is all plain; the mountains are upon the boundaries, the only hills are either old moraines, or the low limestone ridge which without rising to any height deflects to the eastward the rivers Dnieper, Donets and Don. These rivers, with the Danube, the Pruth and the Dniester to the west and the Volga to the east, are the chief landmarks in the plain, but have never served as permanent frontier defences.

With such a structure the country offers in its northern forests and its southern mountains refuges in which backward tribes have maintained themselves almost undisturbed for untold ages, but the fertility of the middle strip of black earth has attracted settlers, and the steppes below have been not so much a place for settlers as a corridor in which, as far as history goes back, tribe has succeeded to tribe, each holding it for less and less time, perhaps as the woodlands in the steppe grew less, until by about the 17th century the mutual raids of Muscovites, Cossacks and Tartars had almost depopulated it. Most of these historical movements came from the East, but there have been enough from the north-west to show that we must not assume the westward movement to be a universal law. From the south-east cultural influences have ascended the Volga or crossed the Ural steppe to the northern forests. From the south influences from Hither Asia penetrated through the Caucasus, and commercial settlers on the south coast, Ancient Greeks, Mediaeval Genoese and Western Europeans in modern times, have affected the southern part of our area.

Palaeolithic man appears in Eastern Europe in Mousterian times; in Russia he occurs just at the edge of the ice-sheet and his remains are buried under the loess. There have been reports of many sites, but few have been published adequately, and mere descriptions are not convincing as there is much difficulty in correlating forms found in this Eastern area with the sequences established in the west. To the Moustier time are referred types from Izyum near the great bend of the Donets, from Kiik-Koba and Volchi Grot near Simferopol in the Crimea, from Ilskaya just north of the Caucasus and from Afontova Gora near Krasnoyarsk in Siberia. A good many sites are put down to the

Madeleine period, but it is perhaps more correct to say that there was no true Madeleine period in Russia, only a continuation of Aurignac. Such may be mentioned at Kiev, Cyril St., where was a mammoth tusk with engravings representing some sort of creature, something like the woman from Předmost in Moravia. From Mizin on the Desna came an ivory statuette of a woman, figures of birds and an ivory bracelet. The birds and the bracelet had upon them meanders and developed swastikas, the first known occurrence of these motives. At Kostënki in Vorónezh was found a statuette rather like the Solutré work; another late Aurignac site which must be mentioned is Hontsí or Gontsý in Poltava. A skull like those of the Aurignac period was found at Podkumok near Pyatigorsk, north of the Caucasus, and bones at Kiik-Koba; a skull like that from Galley hill occurred at Undory in Simbirsk government. The latest palaeoliths come from Karachárovo near Murom, being found in the substance of the loess.

This Eastern Aurignac stretches into Siberia to Tomsk, Irkutsk and Krasnoyarsk, and further to Shen-hsi in China. In Bulgaria palaeolithic finds occur at Malkata Peshtera in the Trnovo district and on the Moravitsa farther west.

In Mesolithic times there was the so-called Littorina lake, a kind of greater Baltic and kitchen middens on the Russian shores of it, *e.g.*, at Kolomtsy near Novgorod. The Tardenois microliths have been found in Poland, Lithuania, Southern Russia, on the kinghiz steppes north of the Caspian, and away into Siberia. Axes, not unlike the Campigny or the Nostvet types, occur in Olónets, about the Valdai waterparting and further south-east to Ryazán and the Oka. Thin butted axes and then the thick butted improvement stretch right across the north of Russia, and seem to point to Scandinavian affinities. To the same age belong bone harpoons and other bone points with inset flints, but these are not readily to be distinguished from neolithic; finally pottery comes in, and shows we have reached the neolithic stage.

Mesolithic finds are reported from Bulgaria. But these small flints are still used by fish-eating Tartars in Siberia, so dates must be assigned with caution, especially as we do not know how far behindhand these out-of-the-way regions may have been. Through a great deal of the time when North Russia was still neolithic, the southern countries were using copper, perhaps even bronze.

The neolithic types of North Russia are mostly reflections of Scandinavian or German work; the most interesting and peculiar have the butt end of an axe worked in the shape of an animal's head, quite well done sometimes, and the love of this survived into the bronze age. Farther south on the Valdai plateau and on the Oka at Bologóe, Balákhna and Volósovo, stations with abundant flints, bone work and pottery have been investigated. The pottery has impressions made with a stick, or thumb nails, the maggot pattern, and that of grass woven work. Before the wheel was invented it was probably a great help to make a pot within a wooden mould lined with a mat, pull it out with the help of the mat and peel this off, leaving the perfect pot. This kind of ware goes right across by Irkutsk to Japan, and the flints are also similar. Neolithic stations have been well examined about Bakhmut and Izyum near the bend of the Donets.

The transition to metal in Eastern Europe offers various interesting problems. The civilization of the black earth regions of South-west Russia, Podolia, Kiev, Poltava and Bessarabia, continuous with Galicia, Moldavia and Transylvania, and traceable through Bulgaria as far as Thessaly, seems to belong to Central Europe. It was contemporaneous with a very different life in the steppes and seems to have been destroyed by a western encroachment of steppe folk.

The great characteristic of the copper age in Eastern Europe is the occurrence not so much of objects in copper, which are mostly few and small, but of stone axes of usually admirable workmanship which in their details, *e.g.*, in a kind of raised collar about the shaft hole, must evidently have been modelled upon metal originals. Axes such as these go right across from Jutland to North Russia, then to South Russia and the Kuban region, to Bessarabia, Bulgaria, and appear among the rich metal wares of Troy II. They are evidently connected with the central European type of Marschwitz.

In the far north this stone-age culture seems an extension of the Scandinavian, and something the same may be true in North Central Russia, where in cemeteries of the Fatyanovo type we find globular vases such as may be traced westward into North Germany. Two chance finds at Galich and Seyma appear to show that Mesopotamian influences were reaching even so far north and crossing those from Finland. On the middle Donets and everywhere south of the forests this period is marked by the occurrence of skeletons, associated with lumps of ochre or other red colour. This ritual again goes right across into North Germany. Three phases of such tombs have been distinguished, pit graves, chambered pit graves and graves under wooden erections, and they seem to come in this order. On the open steppe the finds are very poor, but the size of the barrows argues that the dead men were great chiefs. In the Kiev regions red skeletons go with pottery, showing basket-like patterns, as at Yatskovitsa near Kiev. Elsewhere we have corded ware. A chance find at Borodinó in Bessarabia yielded four wonderful axes in jade and serpentine, limestone mace-heads and silver looped spearheads and pin; these objects had spirals upon them in gold plate. The work points to great progress in metal technique, and the things must have been mere insignia.

But it is along the north slope of the Caucasus that the red skeletons are accompanied by splendid grave goods which give some hope of dating them. Two barrows at Tsarevskaya contained dolmens, divided into two chambers by a holed stone. One dolmen had a roof made of two stones with opposite slopes, which looks like a translation of a wooden structure into stone, and so may be independent of dolmens in Western Europe or elsewhere. One of them contained a globular pot just like those from Fatyanovo.

A barrow at Ulski on the Kuban river yielded alabaster long-necked statuettes just like the well-known types from the Cyclades, also a model of a hut, which looks as if it were meant to be put on a waggon, so the people were apparently waggon dwellers such as the Greeks knew in the steppes. The richest barrow, opened in the town of Maikop, contained a man, a woman and a servant, all sprinkled with red. The chief had about him the remains of a canopy, gold and silver sticks threaded through oxen, vessels in gold, stone and clay, mostly of globular form, with almost cylindrical necks, in copper one flat axe and one holed axe, an axe-adze, a dagger, and a head-dress with golden ribbons and rosettes. One of the vessels had beasts upon it, also a real landscape, another only beasts, and upon the canopy were sewn gold plaques shaped as lions and oxen. All these beasts are in a naïf peaceful manner as different as possible from, say, the vigour of Assyrian art, but curiously like the friezes of beasts from Ur, or the predynastic Egyptian work which seems under Asiatic influence. Moreover, the holed axe is identical in form with the gold axe from Ur. These resemblances cannot but mean some influence exercised by early Mesopotamia, but they do not help us to assign dates; we have no reason to suppose that we have at Ur, *c.* 3500 B.C., the earliest examples of such work, whereas beasts as a subject come back again and again into oriental art and we cannot readily distinguish each recurrence as differing from all others in style. As we get away from our timekeepers in Egypt and Mesopotamia, at each remove dating becomes more uncertain. A good many things point to the painted pottery of South-west Russia coming down to about 1700 B.C. The red skeletons succeeded to it in that region, but no one can tell how long they had dominated the steppes to the east, and again there is nothing much to put between them and the Scythic culture which history ascribes to 700–200 B.C. Now these red skeletons look like the Indo-Europeans on their way to conquer Asia, whether coming from North Germany, as Tallgren and Kossinna would have it, or formed in South Russia, as Childe. They cannot well come from the north-west and be in the steppes in the third millennium, because the people in Jutland with similar axes and pottery only seem to belong to about 2200 B.C., about the date when battle-ax folk were ruling Troy II.

The first historical name in Southern Russia is that of the Cimmerians, who are reported to have invaded Asia Minor in 784 B.C.,

and certainly appeared south of the Caucasus in Sargon's reign (722–706 B.C.); in Assyrian they are Gimirrai and in Genesis Gomer. Under Esarhaddon (681–669) we find the Scyths mentioned as available for use against the Cimmerians, so we may put the expulsion of the Cimmerians from Southern Russia about 700 B.C. But of the Cimmerians archaeology can only say that objects which on other grounds belong to the time just preceding 700 B.C. may be assigned to the Cimmerians. It is not clear that they were anything but an earlier wave of Scyths, so that the most archaic "Scythic" things may be theirs, or again they may be part of the "red skeletons." One thing is certain: that the resemblances in name with Cimbri and Cymry are entirely illusory.

Mention must be made of the civilization best represented at Koban just north of the central Darial pass of the Caucasus, an early iron civilization (1100 B.C. and subsequently) making great use of bronze and showing most remarkable coincidences with Hallstatt types, grafted as it would appear upon a stock whose roots are south of the Caucasus; the European influence, if such there were, has left hardly any trace in the intervening steppe, and the Koban things do not journey west, save for perhaps a stray axe from Kerch or a bronze belt from near Kiev. Some influence from the west is marked by the few Hallstatt finds in Western Russia, antennae swords, fibulae and high-handled cups. Meanwhile in the Eastern Balkans the painted pottery people, whoever they were, were succeeded by tribes whom we may class as Thracians. Some of these began to pass over into Asia Minor by 1500 or so B.C. and others followed *c.* 1000 and *c.* 700, but they seem to have left little archaeological trace in Bulgaria.

In North-east Russia, upon the Kama, we find belated survivals of types known in Scandinavia (Malar axes) or in Southern Russia, and much use of stone continuing. In the steppes the coming of the Scythians means new light from Greek as well as Assyrian sources. (*See* SCYTHIA.) They seem to have come from very far East, with a culture formed under influences from Iran and Mesopotamia which they handed on to Siberia and even China. By about 300 B.C. they were giving way to a new wave of Eastern nomads, the Sarmatae, undoubtedly Iranians; instead of the Scythian bow and dagger, they used long spears and swords and wore coats of mail; we can see their outfit upon frescoes and grave slabs of the Bosporan kingdom on the Straits of Kerch, and graves with similar equipment occur along the Kuban, and in the region south of Orenburg, and spread steadily westwards. They brought with them a new development of the beast style marked by a strong taste for bright-coloured stones, especially garnet and turquoise. This influence extended even to the northern backwaters. The bronze age in north Russia had passed into the Anan'ino culture on the Kama, with iron, bronze and stone all used together until about the Christian era. In it the peculiar taste for beast-headed axes lived on. Upon the Upper Yenisei round about Minusinsk, and later Krasnoyarsk, a bronze culture had developed almost in isolation since before 1000 B.C. For the next 500 years it was almost cut off, though a few western influences penetrated; in the last 500 years B.C. it was strongly influenced by the Scythic beast style, not so much from Southern Russia as from some more easterly focus, and yet the antennae sword of Hallstatt seems first to have affected the Scythic dagger and then the Siberian. Apparently a Siberian invention is the curved knife with a ring on the end of the handle, which is regarded as the ancestor of the Chinese knife money.

The Sarmatian style went right across the north of Asia; specimens of it, both daggers and decorations, have been found in Korea in graves of about our era, and at the same date Mongolian graves north of Urga contained even textiles, with beast motives exactly like the gold work of Western Siberia (now preserved mostly in the Hermitage in Leningrad, but collected for Peter the Great), Southern Russia and even Hungary, into which the Sarmatians penetrated in the first centuries A.D.

But the current was not only westwards. La Tène finds in south Bulgaria begin about 300 B.C. and La Tène II. swords occur in Rumania, and so in Western Russia about Kiev both periods are represented; this means the historical raids of the Kelts and later the Germanic Sciri and Bastarnae. These must have crossed the territory of the Getae and Daci, Thracian tribes whose well built settlements have been investigated by Pârvan. With the extension of the Roman power to the Balkans the archaeological interest takes a new character as part of the archaeology of the Roman provinces rather than of Eastern Europe. In the same way the remains of the Greek cities along the Black sea dating from the 7th century B.C. are a province of Greek archaeology; we need only say that their interest for students of sculpture and architecture is small, but for ceramics not negligible, for painting quite important, and for textiles, woodwork and jewellery almost unrivalled.

Roman coin finds are common in Russia from just before A.D. 100 until just after A.D. 200, and penetrate up to Scandinavia. The end of them coincides with the arrival of the Goths upon the Black sea. To these are assigned graves (not in barrows) containing wheel-made pots, silver fibulae, bronze buckles, bone combs, glass beads and vessels, and of course iron weapons. The fibulae develop from the La Tène II. type with recurved foot and assume the familiar cross-bow, five-knobbed, square-headed and other forms of Teutonic use. But their origin seems to be in South Russia. This is the Sarmatian taste developed by the half-Sarmatian craftsmen of the Bosporus, adopted by the Goths, spread by them all over Europe and handed on to the other Germanic tribes, together with a form of beast style that radically changed the earlier Germanic beast style, itself perhaps not free from Scythic influence. One section of the Goths penetrated the Caucasus, and their cemetery is at Rutkha on the northern slope; others stuck in the Crimea and survived until the 17th century. The richest Gothic cemetery is at Gurzuf; similar things are found in the Balkans as far south as Chataldzha by Constantinople. A Gothic kingdom seems to have maintained itself upon the Dnieper until the middle of the 6th century, succumbing to the Avars, and there was another settlement upon the Oka.

Meanwhile the native Finnish cultures of the centre and north of Russia went on repeating old types, very much behind the times, and occasionally accepting and simplifying imported designs, applying them to strange cast bronze figures in which the Scythic beast style survived in a degenerate form. These had some use in Shamanist cults, which also required great silver dishes imported from the south and paid for in furs. Hence it comes about that, besides Greco-Roman and Byzantine plate, the recesses of Perm have furnished the greater part of the surviving specimens of Sassanian silver work. In Central Russia the people lived in fortified villages of the type called D'yakovo.

The Huns in the 4th and 5th centuries were forerunners of swarms of Asiatics, mostly of Turkish race, who passed along the corridor. Coming from the north-east they often divided the inhabitants and forced part into the Caucasus and part westwards; this happened to the Goths and to the Alans whose descendants survive in the Ossetes of the Central Caucasus, and later to the Magyars. To the Huns succeeded the Avars, fleeing from the Turks in the 6th century and the Bulgars in the 7th; then came the Magyars in the 8th century, Finno-Ugrians under Turkish influence, of whom the Bulgars left some part of their nation to develop into a civilized state at the confluence of the Kama and Volga, where their buildings have lately been excavated; Khazars, Pechenegs, Cumans and finally the Tartars in the 13th century, each came in from the East and most were forced out to the west, Bulgars into the Balkans, the others into Hungary. Archaeologically we note these peoples by the development of oriental metal work, especially in horse trappings buried in their barrows, and by great hoards of loot that they or their victims hid and never recovered, such as the Pereshchepina hoard amassed by an Avar chief, the Nagy Szent Miklos treasure with its Bulgar inscriptions, or the many hoards buried by the Russians at the coming of the Tartars.

Again, we must not forget the less catastrophic and more important western currents, above all the Slavs, who must have been spreading from the Carpathian countries under the Gothic rule, but have left singularly little trace by which we can distinguish them from Finns; certain semi-circular ear-rings, and

particular pots are put down as Slavonic because of their western analogues. Most of the objects found in graves of settled people show a mixture of Scandinavian and Arab influence, and the Arab coins are most important, going up the Volga to Scandinavia. With the conversion of the Russians to Christianity their things become more interesting, and the ear-rings develop into the well-known *kolts* often with enamel imitated from the Byzantine. In recent years much has been done to investigate the remains of pre-Mongol Russia. The Tatar invasion may be taken as the final point, but the Finns to the north continued till very recent times to bury with elaborate grave-goods after the ancient tradition.

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CENTRAL EUROPE

Frontiers.—Central Europe is divided effectively from the Mediterranean and Atlantic regions by the Alps and Illyrian-Balkan ranges. On the east the Carpathians and the Transylvanian mountains border the Hungarian plain, without, however, constituting an ethnic frontier. To the north the Riesen and Erzgebirge are pierced by so many passes that the real cultural divide has always lain beyond the mountains near the terminal moraines of the last ice-sheet. Within the area thus defined the Danube, the Elbe, the Rhine and their tributaries form natural ways of communication, easily accessible from one another and so unifying the whole region. On the other hand, the great Middle Danube-Tisza plain is really contrasted with the more broken country further north that is separated from it by the complicated ranges of Slovakia and the eastern spurs of the Alps.

In late glacial and postglacial times the löss, clothing the slopes, but neither the higher hills nor the low-lying plains, was the main unifying factor; it provided a series of relatively open strips linking the middle Danube to the northern plain and the Rhine valley. The forests, which constituted the most serious barrier to early human settlers, fringe the Central European löss belt, but do not interrupt it by any really impassable transverse stretches.

Lower Palaeolithic Remains.—In lower palaeolithic times this area was an outpost of the cultural province termed pre-Mousterian, where men of the Neanderthal species have left their flake implements. An early ancestor of that species is apparently represented by the celebrated jaw found at Mauer (near Heidelberg) belonging to the Mindel-Riss' interglacial, while true Neanderthalers are found at Krapina in Croatia during the next warm phase. Only near Arad are there any traces of an industry comparable to the western Chellean, and these are doubtful. But towards the end of the lower palaeolithic age rather small hand-axes of Acheulean affinities attest influences from the west and perhaps also from the south, especially in Lower Austria, Galicia and South-west Germany. These types persist, in company with typical Mousterian, throughout the middle palaeolithic term.

Upper Palaeolithic: Předmost.—Then, after the crisis of the Würm glaciation, mammoth hunters of neanthropic type pitched their camps on the löss at Předmost, Vistonice and Willendorf and must have followed the tracks that the great pachyderms must follow as they passed to and from the Eurasiatic plain through the Moravian gates. The flint work here is reminiscent of upper Aurignacian but shows Solutrean "influence" at Předmost. On the other hand, these hunters employed great clubs and perhaps even hafted axes of mammoth bone and ivory, unknown to the west. They carved female figures, similar to those from contemporary deposits in France and Italy, and models of their prey in ivory and even moulded clay figurines which they allowed to harden by their hearths. Their decorative art, on the other hand, was extremely abstract in contrast to the naturalism of the west. At Předmost the remains of the departed, ceremonially buried in a collective tomb fenced about by mammoth bones, seem to belong to two physical types, one of which is thought by some to exhibit Neanderthaloid affinities.

Proto-Solutrean.—Side by side with the Předmost culture there flourished another south of the Slovakian mountains, from which the Solutrean of western Europe is sprung. Its earlier tools are often Mousterian in form, but have been worked on both faces by the pressure flaking that characterizes the French Solutrean. The authors of this culture, derived apparently from a local Mousterian, in a later stage of their development influenced Předmost and eventually spread westward, perhaps to escape the cold of the Bühl advance, bringing with them the classical Solutrean culture which on French soil developed to a stage that is scarcely represented in Central Europe.

Survival of Hunters.—Both the men of Předmost and the proto-Solutreans disappeared, leaving but few descendants to hunt the reindeer. In Bavaria, Bohemia and Galicia these were more or less affected by the Magdalenian culture of France, though their civilization shows certain peculiarities. And then, as the forests began to spread with the return of milder climatic conditions, some of these in turn migrated northward with the reindeer, taking to Denmark the so-called Lingby culture, while scattered bands, isolated by the primeval forests in caves or on sand-dunes in Bavaria, Thuringia, Poland and North Hungary, carried on the old traditions in an epipalaeolithic microlithic industry.

Neolithic Cultures: Danubian.—Meanwhile the neolithic culture was blossoming forth as something quite new on the open löss plains of Lower Austria, Moravia and Silesia. Its authors, who may be termed Danubians, were peasants, not hunters. As their principal crop they raised the small "Einkorn" wheat (*Triticum monococcum*), tilling small plots with stone-bladed hoes. Owing to their primitive methods of "garden culture" the Danubians made no permanent settlements, but squatted for a few years in half-subterranean huts, to move on again as soon as the soil showed signs of exhaustion. In this way they spread into Bohemia, Thuringia and Bavaria, and eventually, when drier climatic conditions had brought about a thinning out of the forest, on to the löss lands of the Rhine valley, Belgium and North France.

The Danubians' typical tool was a polished stone adze or hoe, flat on one face and arched on the other, and a chisel of the same form; both are termed "shoe-last celts." Bone and flint were very sparingly used. The sole weapon was a disc-shaped stone mace-head, with precursors at Předmost and in pre-dynastic Egypt. Fine pots were manufactured in a grey ware, the commonest forms being a hemispherical bowl and a globular bottle, both seemingly imitations of gourds.

The Danubians decorated their pots and bone objects in a free geometric style with spirals and maeanders, the latter being a motive familiar to the hunters of the Předmost culture. The Danubians also made female figurines of clay as had their palaeolithic forerunners. Early graves are scarcely known, and certain finds in Bavaria suggest that the Danubians had burned their dead. But later on inhumation in the contracted position was regularly practised. In such graves ornaments made from a Mediterranean shell, *Spondylus gaederopi*, are often found.

Vinča.—South of the marshy regions of Central Hungary an allied but far richer culture was growing up that is best studied at Vinča, just below Belgrade. Here the settlements were of a more permanent character, and the presence of copper beads suggests some sort of intercourse with the Eastern Mediterranean. The implements agree with those described further north, but the pottery, though obviously akin to the northern Danubian, is far more varied. *Spondylus* ornaments occur as in Moravia. It is possible that the Danubian culture is just a degenerate offspring of that of Vinča. Or perhaps both are separate branches of an older culture that had used gourds instead of pots. In any case the roots of both civilizations lie in the east Mediterranean region, though a survival of Předmost traditions can hardly be denied.

The simple Danubian of the north gave birth to various local cultures which may be due to epipalaeolithic hunters mixing with the peasants who were invading their territories. Meanwhile the civilization of Vinča spread into Istria, Bosnia, and perhaps along the Morava-Vardar corridor into Macedonia and North Greece.

Lengyel Culture.—Before 2,500 B.C. a third group termed the Lengyel culture had emerged on the Upper Tisza and quickly spread as far as Silesia, Thuringia, and Bavaria in the wake of the Danubians, while it profoundly influenced its southern neighbours. The new folk dwelt in regular villages and combined farming with trade and war. While their tools were mostly of Danubian type, they enriched their armoury with obsidian knives, arrows, spheroid mace-heads and hammer-axes, and imported copper in addition to sea shells for trinkets. The vases, no longer mere copies of non-ceramic vessels, include composite forms, notably a dish on a high hollow foot, and vases with necks. Some mugs are provided with two handles suggesting the influence of Trojan metal-work.

Art now demanded expression in colour, and so the vases were decorated with red, yellow and white earth-paints, daubed thickly on the black surface to form spirals and other patterns. Clay figures of women and animals and miniature vases were also manufactured. The dead were normally interred in the contracted position in regular cemeteries like the later Danubians, or, much more rarely, cremated.

The Lengyel culture is essentially Danubian, albeit profoundly influenced by Anatolia and perhaps also by steppe-folk from the east. Still relations in all these directions were bilateral. Lengyel influence is certainly detectable in Thessaly and perhaps in Troy, and on one theory extended eastward to the Dnieper.

Painted Pottery.—In eastern Hungary high-footed dishes of Lengyel form were sometimes adorned with rectilinear patterns painted in a *fast* brown on a buff slip. Then on the Upper Alt in Transylvania these and other types of vases are found beautifully painted with polychrome spirals and maeanders at 26 sites, of which Erösd is the most celebrated. Rather similar material has been found in the oldest settlement on the hill of Cucuteni near Jassy, in Moldavia, and then in the Kiev Government, in settlements of the "Tripolye A" group where, however, incised ware is far commoner than painted. All these eastern vase-painters lived as farmers in regular villages, which at Erösd and Cucuteni were fortified. At Erösd the houses were quite substantial gabled structures of wattle and daub with a porched entry on the short side. The Tripolye sites are characterized by "areas" of burnt clay—presumably the ruins of huts destroyed by fire—but said by Russian archaeologists to represent cremation necropoleis. The villagers were acquainted with copper, which they used for ornaments and even axe-heads, but were losing the art of working stone except for battle-axes, long knives and arrow-heads. Clay models of men, animals and huts and miniature vases everywhere accompany the painted pottery. Some hold that these allied cultures are just an eastern extension of that of Lengyel, enriched by cultural borrowings from Thessaly or Hither Asia. Others, on the contrary, contend that the cultures in question are of oriental origin (camel bones were actually found at Tripolye) and spread westward across the Ukraine to the Danube valley, where their reaction on the Danubian substratum produced the Lengyel culture. It is at least certain that these cultures are not of southern origin. On the contrary, people allied by pottery and architecture to the inhabitants of Erösd reached eastern Thessaly (Dimini) and even Corinthia as intruders.

In Transylvania Erösd had no direct successor, but at Cucuteni and in the Ukraine the older culture, characterized by polychrome painting and spiral motives, grew into another, distinguished by light coloured pots adorned by disintegration products—circles etc.—in black paint on a buff ground. With the latter, which otherwise carries on the older traditions, middle Helladic pottery imported from Greece has been found at Cucuteni, so that the later settlements were still inhabited after 1800 B.C. A very specialized branch of the same stock found in Thrace (Wallachia and Bulgaria) seems in places at least to have lasted into the iron age, though no tools or weapons of the types current in the bronze age further west occur in the area.

Pastoralist Intrusions.—In the Danube valley we find that with the closing years of the third millennium the forest barriers to the north and east were breaking down completely; for the climate was growing drier and warmer than to-day, and the woods were thinning out. And so Central Europe was exposed to the incursions of warlike tribes of pastoralists and hunters and the so-called "Nordics." They introduced the oldest sheep-dog (*Canis familiaris matris optimae*), and perhaps the horse, as well as new grains, including emmer. They used flint celts or rectangular stone celts with squared small sides, stone battle-axes, flint arrow-heads, and a variety of tools of bone and horn. Rare amber beads reveal the first relations with the Baltic area, while copper objects, including awls and axe-heads, and Mediterranean shells denote continued intercourse with the south.

A first result of such incursions was the emergence of hybrid groups, largely Danubian, as the technique of the pottery shows, while its forms, influenced by vessels of leather or basketry, no less clearly betray the superposition of the pastoralist element from without. Furthermore, there was one compact body of semi-nomadic folk with a centre in Thuringia who ranged from the Volga to the Rhine and from the Upper Tisza to Finland. They were armed with great battle-axes of stone, reared a barrow over their graves (in which the dead were buried in the contracted position) and ornamented their vases—beakers and amphorae—with cord-impressions. In Hungary the incursions have left less mark, unless the curious copper axes with one blade parallel and the other at right angles to the shaft be the counterparts of the stone battle-axes used further north, where no copper was available. In eastern Hungary there are also barrows covering contracted skeletons stained with red ochre as in South Russia.

Lake-dwellings.—The invading tribes may have come from Scandinavia or from South Russia, or they may, in part at least, have been descendants of the epipalaeolithic hunters living on the sand-dunes of Poland and Thuringia. In the Alpine regions and along the Rhine such survivors of the old stone age had certainly evolved a civilization of their own, though its constituents were largely borrowed from the Danubians, and perhaps partly from cultural centres on the western Mediterranean and Atlantic coasts. On the Swiss lakes small hamlets were built, strung out along the margin of the lake, the rectangular wooden houses being raised on piles above the sedgy shores (the lake-waters had already sunk below the present level). Further north kindred people were occupying the hills overlooking the Rhine and defending them with wide, flat-bottomed moats, banks and palisades. Here the type site is the Michelsberg north of Carlsruhe. Lake-dwellers and Michelsberg folk alike were farmers possessed of flocks and herds and cultivating grains, flax, and perhaps even fruit-trees. They excelled in basketry and horn-work; the stone axe-heads were often hafted with the aid of horn sleeves to diminish the shock of the blow by the elasticity of the horn. The pottery, in technique very like Lengyel ware, is based upon leather forms and devoid of ornament.

In the Eastern Alps, in Carniola, near the mouth of the Drave in Slavonia and in Bosnia settlements akin to those just described occur, but they show here an infusion of "Nordic" elements—*e.g.*, stone battle-axes—while the pottery is decorated with patterns suggestive of Cypriote influence, though they are executed in a technique that must have been borrowed from the wood-carver.

South-Eastern Trade.—All this time the current from the south-east detectable already in the Lengyel culture had been flowing up the Danube. Eventually it culminated in the foundation of new settlements on the auriferous streams flowing out of Transylvania and on the approaches to the Slovakian copper lodes; the best known is at Tószeg near Szolnok. In the new settlements, though Lengyel forms occasionally appear, the pottery in technique and form is dominated by Anatolian traditions. Stone axe-heads are rare in the settlements, whereas in them and in contemporary graves copper or bronze torques with looped ends as in North Syria and the Caucasus, wire pins with a knot head as in Cyprus and at Hissarlik, and gold ear-rings of Mesopotamian-Trojan type, are to be found. Daggers with long hooked tangs, imported from Cyprus, have turned up stray or in hoards in the same region. Similar Anatolian bronzes and pot-forms are found as far north as Bohemia. Everything points to the conclusion that Anatolians or Aegeans were by now collecting gold on the Maros and Aranka, exploiting the copper-lodes of Slovakia and washing for tin in the streams that flowed over the Bohemian löss from the stanniferous Erzgebirge. The beginning of tin-working in Bohemia is perhaps dated by the appearance of rich bronze at Troy and in North Syria at the opening of the second millennium.

Beaker Folk.—About the same time a new element, the so-called Beaker-folk, appeared on the scene from the west, crossing the Alps by the Brenner and visiting Bavaria, the Rhineland, Bohemia, Thuringia, Silesia, Moravia and the district round Budapest. In their graves—settlements are unknown—short-headed skeletons were buried in the contracted position accompanied by fine, well-shaped beakers, flint arrow-heads, stone wrist-guards, copper awls, small tanged daggers, conical buttons with V-perforations, and trinkets of gold all very much as in Spain, South France, Brittany, Sardinia and North Italy. Between the Elbe and the Rhine the Beaker-folk combined forces with the warlike nomads who buried their dead under barrows with cord-ornamented pottery. The fusion is symbolized by a beaker of inferior technique and slender form that is found under barrows as well as in flat graves. People of the mixed stock descended the Rhine and crossed to Britain soon after 2000 B.C. Though beakers are found at some 80 sites in Moravia and at 70 in Bohemia, their makers never settled down there in any numbers. They had made incursions as armed traders, but disappear as a physical type from Central Europe. Still they had established communication between the Mediterranean and Bohemia via the Adriatic and the Brenner, while Bohemia was in turn linked with the amber deposits of Jutland and the copper lodes of Slovakia. The commercial connections that are preconditions of the rise of a bronze industry were thus established, and simultaneously with the fall of Troy II. about 1800 B.C. the Anatolian metallurgists who had discovered Bohemian tin and Slovakian copper were forced to begin producing for a local market.

Early Bronze Age: Aunjetitz Culture.—Almost immediately after the Bell-beaker episode begin the extensive cemeteries of the Aunjetitz culture (so called after Únětice, south of Prague), spread out along the amber trade-routes, leading from Upper Italy to Denmark and East Prussia across Bavaria and Thuringia or Silesia, and along those connecting the Bohemian tin district with Slovakian copper, but concentrated especially in Bohemia. Long-headed people are buried in them accompanied by round-heeled, riveted daggers, flat and flanged celts, and various pins, bracelets and torques all of true bronze. Amber is common in the graves, and gold is far from rare. The pottery is largely developed out of the "Anatolian" series that spread up across Hungary modified by "Nordic" and Bell-beaker traditions. The development of the older culture at Tószeg and other Hungarian sites led to very similar shapes, and in the second strata we find daggers and pins that agree on the whole with those from Aunjetitz graves. But the focus of that culture was Bohemia, and the parallel cultures of Hungary were relatively poor. Yet Tószeg was at this time defended by a palisade of stout posts, and some of the houses may also have stood on piles.

Tumulus Bronze Culture.—The Aunjetitz folk were peasants, traders and industrialists living in the fertile valleys. While their life was proceeding uneventfully from 1800 to 1500 B.C. (for Minoan metal vessels of the latter age were imported and imitated locally), the pastoral tribes who had occupied the hill country of south-west Germany and western Bohemia were slowly learning the art of metallurgy. Like their neolithic ancestors they heaped barrows over their graves and are accordingly known as the Tumulus folk. The graves are sometimes richly furnished with weapons and ornaments: ogival knife-daggers with bone or wood handles fastened to the blade by large rivets, swords of the same type or with solid bronze hilts, sometimes 70cm. long, socketed spear-heads and very slender axe-heads with flanged sides or medial wings or, in Bohemia, with a V-shaped stop-ridge, and round shields of wood or leather strengthened by bronze bosses, which alone survive. Men and women alike wore pins with an eyelet in the swollen neck or terminating in a wheel, penannular bracelets and finger-rings terminating in opposing spirals of bronze ribbon, anklets, again with spiral ends, and pendants hung on the necklace or the girdle. Amber was imported from the Baltic and glass beads from the eastern Mediterranean.

The foregoing types characterize the middle bronze age of south-west Germany and Bohemia, which lasted from 1600 to 1300 B.C. Before its end a rapier of late Mycenaean type had found its way to Bavaria, and heavy slashing swords, often with an octagonal bronze hilt, were coming into use among the Tumulus folk. Their culture lasted on throughout the late bronze age till, with a return of a damp, cold climate about 800 B.C. it becomes transformed, through contact with intruders from Illyria into a Hallstatt culture. In the late bronze age barrows cremation became the commonest funerary rite under the influence of the urnfield folk, the swords were heavy and leaf-shaped and the pins grew to extravagant lengths. Barrows of this period are found also south of the Alps in north-west Hungary, Styria and Bosnia. In the last-named area inhumation was the regular rite and early forms of safety pin were in use. They were little more than pins bent round for security with the point caught against the head.

Hungarian Bronze Age.—In Hungarian settlements which, like Tószeg, were occupied continuously throughout the bronze age, the beginning of the middle phase is marked by a layer poor in ceramic remains that may denote a partial evacuation of the site. The foundation of the *terremare* in the Po valley about the same time may be the counterpart of this partial break. Nevertheless the Hungarian plain was by no means deserted, since numerous and splendid bronzes (dated by their occurrence in middle bronze age hoards in the north) were being cast in this period. Most distinctive are battle-axes, some with a knobbed butt-end and others with but one blade, that recall Asiatic types. They are often gloriously decorated with scroll patterns. Such Hungarian bronzes were exported to Bavaria, Mecklenburg and the Ukraine.

Eventually the whole plain is found to be covered with urnfields, *i.e.*, cemeteries of urns containing cremated bones. The urns and accessory vases were often beautifully decorated, in the west with excised patterns, in the south with punctured lines and stamped circles and in the north with conical warts. In the southern graves models of female personages were sometimes deposited, as at Kličevac in North Serbia. The people buried in these cemeteries must have belonged to a mixed race of farmers, traders and metallurgists.

Lausitz Urnfields.—Similar communities appear about the same time in Moravia, Bohemia and Silesia, but especially in Lausitz, whence these are termed the Lausitz people. They were the economic heirs, and probably the descendants, of the Aunjetitz people of east-Central Europe though they cremated their dead, burying the remains in large urnfields. Their houses were built on the log-cabin principle and formed regular villages. The Lausitz folk were the first people in Europe to adopt the socketed celt, and sometimes they used safety pins (*fibulae*) for fastening their clothes. The Lausitz pottery was ornamented at first with big conical worts like the contemporary ware of northern Hungary, and later with corrugations. The typical ossuary, shaped like two cones placed base to base, was usually perforated with a hole to allow the ghost to escape.

The Lausitz people spread very widely, over-running Lower

Austria, Slovakia and North Hungary and apparently even reaching Macedonia about 1050 B.C. Another branch spread westward towards the North Alpine zone—Bavaria and the Tyrol—where extensive urnfields with occasional Lausitz ossuaries mixed with other types appear in the late bronze age. But the North Alpine urnfield culture is complicated owing to the absorption in it of western Aunjetitz people and Alpines and to its relations, both peaceful and hostile, with the Tumulus folk of the same area. Hence the North Alpine culture has a martial aspect, the graves being furnished with heavy swords and other weapons. Yet the people buried in them were pre-eminently industrialists; it was they who inaugurated the systematic exploitation of the Alpine deposits of copper and salt by shafts and tunnels that are traceable to-day. The same people conquered Switzerland, where they synoicized the hamlets beside each lake into one or two larger pile villages. The latter became flourishing industrial centres whose products—swords, knives, penannular razors and ornaments—were exported in all directions. In exchange there came amber, bronze basins and *fibulae* from Denmark, copper, tin and antimony from the east, and Villanovan artifacts from Upper Italy. Another branch of the same stock had spread down the Rhine valley to Holland, whence they eventually reached England.

The Coming of Iron.—Just south of the Alps in Styria and Illyria there were other urnfields, existing side by side with tumulus groups, whose authors may have included Hungarian and Lausitz elements. In this area, traversed by the trade routes that led from Upper Italy to the copper and antimony mines of Hungary and the Alps and eventually to the amber of East Prussia, the use of iron, transmitted up the Adriatic, was early adopted, as was that of the safety-pin. Before 1000 B.C. we meet here the prototypes of the slashing leaf-shaped swords and the various safety-pins, especially the spectacle brooch, that later characterized the "Hallstatt" culture. So we infer that the civilization, named after the prehistoric village of salt-miners at Hallstatt in Upper Austria, was moulded along the eastern slopes of the Julian Alps, whence the knowledge of iron was spread along the main trade-routes among the urnfield-folk of Austria, Moravia and Silesia.

In Slovakia and North Hungary, on the other hand, which since 1100 B.C. had been under the control of Lausitz people engaged in exploiting the rich deposits of copper, a brilliant but belated bronze age civilization was elaborated while the use of iron was beginning further west. In the enormous hoards of this period we meet not only socketed celts, beautifully decorated leaf-shaped swords and very complicated brooches, but also great bronze buckets and bronze or gold cups, ornamented with embossed patterns such as birds' heads flanking a disc, identical with those current in Villanovan Italy. Farther to the south-east remnants of the native population, having survived the shock of the Lausitz invasion, continued in a bronze age, as, farther north, till the 8th century B.C., rejecting not only iron but such innovations as the safety-pin and the socketed celt that their neighbours had appropriated.

By 900 B.C. the Tumulus-builders living south of the Noric Alps had adopted from their neighbours, the urnfield-folk of Styria, the use of iron and the types of safety-pin and sword that the latter had elaborated. Some of the Tumulus folk, notably those congregated on the high plateau of Glasinac in South Bosnia, were also in contact with the Greek world. From these western highlands inhumationists spread eastward into the upper Morava valley and thence to Macedonia and Bulgaria, taking with them the spectacle brooch and other types of Styrian antecedents. Other bands spread along a parallel route across western Hungary and then up the Maros, while, very probably, a similar movement in a more northerly direction brought the classical Hallstatt culture to Moravia and Silesia on the one hand and to south-west Germany on the other. In these regions the presence of Illyrian intruders among the urnfield-folk is revealed by inhumation burials furnished with horse-trappings and Hallstatt swords and safety-pins. But the intruders were far from numerous and mingled with the urnfield folk and the older Tumulus-builders.

Then between the 7th and 5th centuries Silesia and still more Transylvania and northern Hungary were raided by Scyths from the east, while abundant Scythian products were introduced in exchange for copper and antimony. The regular use of iron in Hungary and Transylvania was due to these incursions. Down to the 4th century the lowlands east of the Danube were dominated by the eastern power, while further west the later Glasinac and Hallstatt cultures developed under Italian influence. After 400 B.C., however, La Tène forms and the use of the wheel began to percolate eastward, in some cases at least brought by Celtic invaders. Their infiltrations form a prelude to more extensive incursions, as a result of which the culture of Illyria and Pannonia was assimilated to that of the Celtic west before the Romans occupied those provinces. (*See* Hallstatt, *La Tène*, *Villanovans*.) (V. G. C.)

For archaeology of North Europe, *see* the articles ARCHAEOLOGY: *Bronze Age, Iron Age, Stone Age;* SCANDINAVIAN CIVILIZATION. For archaeology of the mediterranean region, *see* AFRICA: *Archaeology,* North Africa.

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RACES AND PEOPLES

Pigmentation of skin, hair and eyes, diminishes in Europe from the Mediterranean northwards to mid-Norway and Sweden, to increase again in the Arctic. Stature increases from the Mediterranean northwards to mid-Norway and Sweden, to diminish again in the Arctic, but the changes are less regular for the Dinaric peoples, and the Castilian Spaniards are mostly tall. The Iberian peninsula, Sardinia, Corsica, Sicily, south Italy, have long-headed populations and so have various areas in France, the British Isles and Norway and Sweden, apart from the Arctic area, in which the head runs very broad. The great mass of peoples of central Europe, from central France eastward to central Russia, and from Greece and north Italy to Prussia is broad-headed though less pronouncedly so in the north.

Main Divisions.—Ripley and Deniker have made schemes to express the above facts. A *Teutonic* or *Nordic* race, with tall stature, bony frame, light colouring and a fairly narrow head is described chiefly for Norway, Sweden and parts of Finland, Denmark, north-west Germany and Britain. A *Mediterranean* race is described chiefly for the western basin of that sea, with short stature, relatively slight build, dark colouring and a narrow head; and an *Alpine* race inhabiting central Europe as above mentioned is described as broad-headed with broad face, thick-set frame, brown hair and grey to brown eyes, the colouring being darker in the south. The majority of the British people would be somewhere between the Nordic and the Mediterranean, and would include representatives of both.

Deniker added an Adriatic or Dinaric variant of the Alpine race, with tall stature, and a high head, found chiefly in the west of the Balkan peninsula and in Venetia, with congeners from Asia Minor and Armenia. The more ordinary short Alpine round head he called "Cevenole" or "Occidental." The rather broad-headed fair types of the regions north-east of central Europe he called the Oriental race; much the same group being termed by others the East-Baltic race. He also gave the name Atlanto-Mediterranean to an element with taller stature and less narrow heads among the people of the Iberian peninsula.

Origins of the European Types.—The origins of these types are a difficult problem. Myres has suggested the spread of broad-headed peoples from Asia Minor and, since it has been shown that peasantry spread into Europe largely through the Danube basin, it has become increasingly probable that the Alpine race is closely linked with this spread, and that its Occidental or Cevenole branch is an earlier arrival that has spread farther. In Galicia and the Ukraine, etc., are found both taller and shorter varieties, and it is thus probable that both have spread into Russia. The extension of broad-headedness northward and north-eastward is a

marked feature, and is probably connected with a biological dominance of broad-headedness over long-headedness; the extension is marked by increasing fairness of colour. Tall, broad-headed men with strong supraorbital sinuses and prominent brows are a marked feature of the European plain from Polish Galicia to England, and they are usually fair in colouring. Their skull type is much the same as that found in burials of the early ages of metal, with accompaniments of Beaker pottery, and so this type has been called the "Beaker" type.

As to origins of the long-headed types in Europe, most of the Upper Palaeolithic skulls are dolichocephalic, and in that early period there were streams of people, with long heads, from north Africa, as well as, probably at a later stage, from the south Russian steppe. Here and there, as in Tras os Montes (Portugal), Sardinia, La Dordogne (France), Plinlymon (Wales), inland Norway and mid-north-Sweden, there are groups of people with the very long, very high and narrow heads, strong brows, big cheek bones and rather broad noses of certain Upper Palaeolithic skulls. It is, therefore, likely that survivals from the Upper Palaeolithic age are one element in the composition of the European peoples. Ripley was inclined to think, and many agree, that in the cool, cloudy north-west, the type became taller through postponement of maturity, and fairer; the warmth of the south, on the other hand, encouraging the maintenance of pigment and of relatively early maturity. The localized distribution of survivals of ancient types suggests that they are not merely the extreme cases in a large group of variants, their likeness to early skulls (especially Combe Capelle and Předmost skulls) supports the view that they are survivals. It has also been claimed, with less strength, that there are survivals of other Upper Palaeolithic types such as that of Grimaldi (lower layers) and that of Cromagnon.

Arctic Europe has received westward drifts from Asia of dark-skinned dark-haired broad-heads, and there have been spreads of Asiatic broad-heads into the south Russian steppe and into east-central Russia.

Giuffrida-Ruggeri, Biasutti, Collignon, Pittard, Beddoe, Arbo, Bryn and Fleure have noted at various coastal spots from south Italy round to Norway, dark broad-heads, often tall, who seem to be the origin of Deniker's idea of the Atlanto-Mediterranean type, a type which he derived from statistics of populations that included both these broad-heads and the Mediterranean type. Many of the broad-heads of north Brittany belong to this powerful type rather than to the Alpine type as commonly stated.

It seems not improbable that broad-headedness in Europe acts to some extent as a Mendelian dominant (*see* HEREDITY), and probably, in some crosses at least, brown eyes are dominant over blue ones. Thus types may appear to change in the course of time without there being vast migrations to account for this.

Thus almost every country has a people of mixed breeds. Italy has chiefly Mediterraneans in the south and chiefly Occidental Alpines and Alpine-Dinarics in the north. Germany is mainly Alpine, with marked fairness of colour and some Nordic long-headedness near the Baltic, and here and there in other parts. France is mainly Alpine, but of darker colouring than Germany, with some Mediterraneans in the south and west, and some Nordics in the north and east and many mixtures. Britain is long-headed, with a good many Nordic types in the east, and Mediterranean types in the west and south-west, and vestiges of the curious type noted above for Castile in Devon, Wales and the west Scottish Highlands. But the great mass is neither fully Mediterranean nor fully Nordic, thus lending support to the idea that each of these is the result of evolution in its characteristic area, Britain being between the two.

Terms Used for Races.—It may be useful to add notes on various terms the names of which are often used in racial discussions.

The *Basques* are a linguistic and social rather than a racial group, though they are mostly long-headed and very probably include survivals of Upper Palaeolithic types. They occupy the western Pyrenees on the French and Spanish sides, and the language has a considerable extension south-westward on the Spanish flank. The Basque language (*q.v.*) does not belong to the Indo-European language family at all, and is probably very ancient. The people have many social features, such as house-types, ceremonies, games, etc., distinguishing them from their neighbours. They still call themselves *Eskualdunak, i.e.,* "those who possess the *Eskualda*" or Basque tongue.

The name *Aryan* (*see* INDO-EUROPEANS) has been used in many senses at different times. It was once supposed to relate to a people of central Asia who were supposed to have drifted west into Europe, bringing our civilization with them. It is strictly used for an element in a language-group, the two most primitive survivals of the group being Sanskrit and Lithuanian. It has recently been argued on archaeological grounds that the Aryan languages probably developed on the steppes of south Russia, and were spread thence in the 3rd and 2nd millennia B.C. by long-headed warriors armed at first with perforated stone battle axes, and later with bronze.

The name *Celtic* has been used, especially in France, to name the Alpine broad-heads so characteristic of the region that the Romans called Gallia Celtica. It is strictly used for a language group (*see* CELTIC LANGUAGES) and is best discarded as a racial name. The peoples of Celtic speech in modern Europe include a considerable proportion of individuals of dark, short, long-headed type (Mediterranean race).

In the Balkan peninsula race, language, religion and economic life are all important as dividing features among the peoples. The western mountains contain many of the people called Dinaric, the ordinary short round-headed Alpine stock is characteristic for the Serbian Morava basin and for the Rumanian peasantry, as well as among the Bulgars. The last owe their name, some features of their language, and occasional physical characteristics to Asiatic (Tatar) elements entering from the south Russian steppe. The Rumanian peasantry, largely Alpini, includes also some dark long-headed elements, especially, it is said, in the north-east. The name of Vlăchs, people of Wallachia, is applied also to nomad groups, who in generations past have wandered between Thessaly and the Danube and in Transylvania. The Rumanian language, as is usual for any European region that felt the Roman power, owes a great deal to Latin. In the west the Albanians form a warlike highland group organized in clans, with blood feuds between them; they are largely Dinaric in type, but apparently include some fair broad-heads who may be descendants of immigrant conquerors of early times. The coastal Greek population appears to be predominantly broad-headed on the mainland, with long-headed elements chiefly in the islands.

The Lithuanians and Letts are the best known peoples of the forested basins of the Niemen and Duna, mainly rural, with German elements in the ports and Jewish elements in the towns generally. It has been said that the Lithuanian language (*q.v.*) is an early member of the Aryan family; the Lett language (*q.v.*) includes Slavonic elements and is said to preserve features from the non-Indo-European tongues of the region. Both language groups include many fair, broad-headed types with some Nords.

The Finns and Goths speak languages with north Asiatic affinities, but should apparently not be confounded with the Lapps and Samoyedes on this account. They include a Nordic element of Swedish origin, the fair broad-headed element usually described as "East Baltic," and doubtless in the remoter parts a considerable Arctic (Lapp) element. The Tavastlandian Finn has been supposed to be longer and the Karelian or Eastern Finn broader-headed.

The Magyars speak a language of the Finno-Ugrian family (*see* HUNGARIAN LANGUAGE) brought in by conquerors who came westward via south Russia after the decline of the Roman power. Asiatic elements are not physically conspicuous among them save among gipsies, who are fairly numerous on the Hungarian plains, and it is supposed that those elements have diminished and disappeared in the course of subsequent centuries. (H. J. F.)

HISTORY

The history of Europe can only be written in so far as it is possible to consider the European peoples as a whole. The task

of history, therefore, is to show how the unity of Europe was effected. This resulted from several causes: first, from the common customs of everyday life, religion, and law; secondly, from the general similarity of social and political organization; thirdly, from the subjection of different peoples to a single political or religious authority; fourthly, from the establishment of permanent relationships between the different European States. The solidarity of Europe has only been achieved very slowly as from time to time new peoples have come under the influence of European civilization. In this sense Europe has continued to expand throughout the centuries. Beginning in the extreme south-east, in the days of the Roman empire her civilization spread over the Mediterranean sea-board and to the coasts of the Atlantic. During the middle ages it advanced over central Europe and the Scandinavian countries. Russia entered the comity of Europe only at the beginning of the 18th century, and it was not until the 19th century that the conception of European unity was expressed in the language of diplomacy by the use of the word "European."

THE FOUNDATIONS OF EUROPEAN UNITY

The People.—Since prehistoric days the inhabitants of Europe have belonged to the same white race, whose branches are also to be found in western Asia and northern Africa. Anthropologists, in classifying the population of Europe according to anatomical characteristics, have distinguished three principal types living in three distinct zones: in southern Europe on the coasts of the Mediterranean, the Mediterranean type with very dark skin, black eyes and hair, and long heads (dolichocephalous); in central Europe the Alpine type with light brown skin, brown hair and eyes, and round heads (brachycephalous); and in northern Europe the tall Nordic type with white skin, golden hair, blue eyes and long heads. The peoples of Europe are essentially the products of the long cross breeding of these types; they show a mixture of the characteristics of each type, and individuals of a single pure type are rarely found except in small isolated groups. This mingling of characteristics remains the most typical characteristic of the European population. *See* RACES OF MANKIND.

From prehistoric days this people has possessed a common primitive civilization which, in its origin, goes back to the Neolithic age. Its principal occupation was the cultivation of crops and the raising of cattle; its cattle were used in the processes of cultivation, and their manure was used upon the fields. These primitive peoples grew wheat, rye and barley which have remained the staple foodstuffs in Europe until the end of the 19th century; their domestic animals—cows, sheep, pigs and goats—were the same as those of modern times.

The languages spoken throughout Europe, with the exception of Basque, are all derived from a mother-tongue (called by philologists Indo-European). This language can accurately be called European, for the Aryan languages outside this region, such as Iranian in Persia and the Indian Sanskrit, were those of peoples who passed from Europe into Asia.

Throughout Europe political organization developed along similar lines. The tribes were divided into small independent communities, each of which acknowledged the authority of warrior chiefs, whose office was nearly always hereditary but who were possessed of scanty material resources. No single chief was powerful enough to make his authority run throughout a wide territory, nor to compel his subjects to render to him the servile obedience shown to an oriental despot. Until the days of the Roman empire no great autocratic monarchy arose in Europe, but while maintaining the independence of their local sovereignties, the European peoples preserved also a sense of unity among themselves and an interest in public affairs at a time when the Governments of the autocratic empires had destroyed the sentiments among the peoples of the East.

The possession of a common racial and linguistic origin and of similar customs and political institutions, created in the European races certain common characteristics which facilitated the attainment of European unity. Not that the peoples could be alive to these profound affinities; as yet they showed no sense of brotherhood or solidarity. Each man saw an enemy in his nearest neighbour; war was a normal condition, not only between groups that differed one from another in customs and language (as for example, the Greeks, Thracians, Latins, Samnites, Gauls and Germans) but also, and even more frequently, between little neighbouring tribes who were conscious of a common origin like the Spartans and Athenians, the Romans and the Albans, the Aedui and the Arverni.

The European peoples were brought together voluntarily by commerce and the spread of science and art, forcibly by military conquest and by the barbarian invasions. The unity of Europe had been prepared between the 5th century B.C. and the 8th century A.D. by three great events: the diffusion of Greek culture throughout the Mediterranean sea-board; the establishment of the Roman domination, first in the Roman empire and, later, in the Roman Church; and the invasion of the Germanic barbarians, which destroyed the social and political organization of the empire.

Greek Civilization.—Greek civilization, preceded from the 18th to the 15th century B.C. by the Aegean civilization, was established between the 6th and 4th century B.C. in the Greek cities as a result of the reaction of the Greek intellect on the material culture or the old civilizations of Egypt and Asia. It reached its widest extent from the 3rd to the 1st century B.C. in the Hellenized kingdoms founded by the successors of Alexander the Great. It was this later civilization known as Hellenism, and not the pure Greek civilization, that gradually spread over the Roman empire and hence throughout Europe. It was, above all, of an intellectual character and it was in the spheres of art and science that it left its most permanent traces upon European civilization. For example, in all European languages, as spoken in the 20th century, words derived from the Greek are still used for many forms of art—music, poetry, lyric, epic, tragedy, comedy, drama, theatre; while the same is true of scientific terms—mathematics, arithmetic, geometry, mechanics, astronomy, physics, optics, chemistry, biology, botany, geology, philosophy, rhetoric, grammar; and also of mental science—method, logic, dialectic, critic, empiric, autopsy. The whole of modern science is permeated with the Hellenic spirit—the spirit of reason, observation and criticism, and free from the trammels of religious mysticism and tradition, which have killed the intellectual life of other peoples.

The Roman Empire.—Having conquered the Mediterranean peoples and those on the shores of the Atlantic, the Romans subjected them to a permanent domination known by the significant term *Imperium* (military authority). The Roman empire in the 2nd century A.D. extended throughout northern Africa and western Asia, and in Europe over all the Mediterranean countries, and over Spain, France and southern Britain. Throughout its immense extent inter-tribal warfare was stopped and the *pax romana* established, while, as a defence against the still barbarian peoples, it maintained permanent garrisons along the entire length of its frontiers, marked in Europe by the Rhine and the Danube. It is true that the greater part of Europe remained outside the empire, but this external region was only thinly populated by barbarian tribes—Scotland, Ireland, Germany, Scandinavia, Austria and Russia. The whole civilized and settled part of Europe was united under a unique authority, which lasted for three centuries, and accustomed the whole population to a single political and social organization. The empire, although becoming little by little an autocratic centralized monarchy, yet left a large local autonomy to the cities that were governed after the Roman model by a local aristocracy of landed proprietors. But the continuous action of the central power, exercised by his delegates in the name of the emperor, ended by bringing the whole of Europe within the same economic, political and legal civilization which, under the name of Roman, was an international conflation of the customs and ideas of all the peoples of antiquity.

Roman Civilization.—Roman civilization survived the empire and became a common European possession. It survived in the Latin language, which in its vulgar form gave birth to all the Romance languages (Italian, Provençal, French, Portuguese, Castilian, Catalan, Rumanian) and in its literary form survived until the 17th century as the common intellectual tongue of

Europe. It survived in political terminology where words of Latin origin are still used (suffrage, scrutiny, vote). It survived in the language of building construction—mortar, arch, door, bridge, road (strata), castle (castellum). It further endowed Europe with a system of weights and measures and a currency based on the combined employment of gold and silver, and it gave her a calendar, oriental in origin but reformed by Caesar, and hence known as the Julian calendar, containing the names of the 12 months and the seven days of the week, which in the Romance lands still preserves the memory of the Roman gods, Mars, Mercury, Jupiter, Venus and Saturn, for some of which were substituted in the Teutonic countries the names of the Germanic gods, Woden, Thor and Freya.

But the principal gift of Roman civilization to Europe has been the system of Roman law (*q.v.*), a system very different from that of the old tribal law of the Roman people, for it arose from the precedents created by the Roman judges charged with trying the suits of *foreigners* in Rome. Hence it became a kind of international law, derived from the mingling of the legal customs of the civilized peoples of the whole empire, elaborated and organized into a legal system in the 3rd century A.D. by the Roman jurists who were disciples of the Greek philosophers. This Roman law, permeated by the Greek spirit, rational, logical, lucid, precise, humane, which has sometimes been designated *la raison écrite*, has been preserved in the Roman countries in the guise of customary law, while it has been adopted by the Germanic peoples in the form of written law. Above all, it has become in questions of ownership and contract the source of the principle of common law throughout Europe.

Despite its extent, the Roman empire was a single State forming a single political entity under the authority of a single emperor. At the end of the 3rd century A.D., Diocletian, finding that the task of defending the frontiers was too arduous for one man, invited the assistance of a colleague, and the two emperors divided up between them the task of government without, however, destroying the essential unity of the empire. When he became sole emperor, Constantine transferred the seat of government to Byzantium which became Constantinople (*q.v.*). After the death of Theodosius in 395 the empire was divided between his two sons, and although its unity was maintained in official language, the division became permanent. Henceforth there were two emperors: the one in Italy who ruled over the Latin-speaking countries; the other in Constantinople who ruled over the Greek-speaking countries. The Balkan peninsula, which became attached to the Byzantine empire, was from that time cut off from Europe; it remained separated until the 19th century.

Christianity and the Roman Church.—It was under the Roman empire that the Christian religion, which was born in Asia, penetrated into Europe. Christianity had been organized in the Greek-speaking countries of the Near East; "Christ" and "Christians" are Greek words, and its sacred books were written in Greek. Moreover, its teaching, elaborated by the doctors and synods of Asia Minor, was called by a Greek name—dogma. Christian institutions and officers in the Christian Church bore Greek titles—baptism, catechism, hymn, eucharist, church, synod, diocese, alms, parish, bishop, priest, deacon—words which still endure in popular forms in the European languages. So long as it was opposed by the official authorities, Christianity did not make many converts in Europe outside the towns, at least among the Greek-speaking peoples. A very large majority of the population, especially the peasants, remained unaffected by it. It was not until the emperor had declared himself a Christian that the mass of his subjects followed his example, at first voluntarily, and later by his command. Before the end of the 4th century Christianity had become obligatory and the old pagan cults were forbidden. The priesthood had become an official body and formed part of the officialdom of the empire. The Church was organized within the framework of the empire and a bishop was appointed to each city. The Church adopted the Roman procedure and the official language of the empire, namely Latin; it became a Latin Church.

Christianity, as a religion strange to Europe and of urban origin, was for long confined to the towns, and only very gradually penetrated into the depths of the country districts. An ignorant population was not interested in assimilating doctrines inspired by the spirit of Eastern Hellenism and far too subtle for their comprehension. While they adopted the Christian rites they preserved old pagan customs in the form of the cult of local sanctuaries and of pilgrimages to holy places where miraculous cures were effected. The clergy themselves were little interested in theological studies. But, at least after the disappearance of the empire, it was they who maintained in Europe the memory and the love of Roman unity.

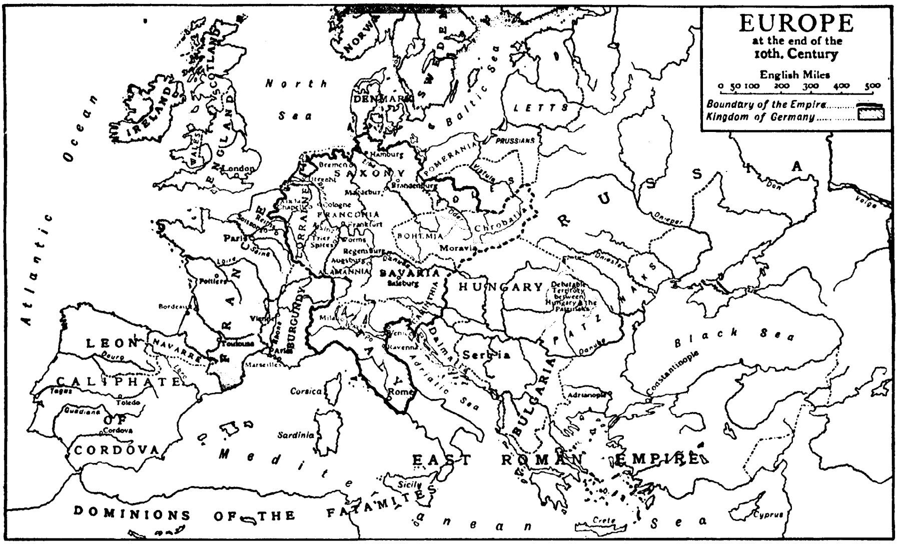
The Barbarian Invasions.—The inhabitants of central Europe, loosely attached to the soil, which they cultivated with difficulty, now and then emigrated with their families towards the south and sought to obtain lands from the Roman authorities, either by persuasion or by force. Until the 4th century, Roman leaders had always been successful in repelling these invasions. But it became increasingly difficult to maintain the strength and to pay the armies that defended the frontiers of the empire, both because silver had become too scarce to be used as pay and because the citizens of the empire had become unsuited for the profession of arms. In order to recruit its armies the empire took into its service bands of barbarian warriors; little by little the imperial armies became filled with such soldiers to such an extent that the word *barbarus* became synonymous with *miles* (a soldier). In the 5th century the armies were commanded by barbarian chiefs like Arbogast, Stilicho, Aetius, Ricimer. Certain barbarian peoples who had entered nominally into the service of the emperor, finally ended by establishing themselves within the empire; their chiefs, who bore the title of *kings*, conducted themselves as sovereigns; but there always remained an emperor in Italy. This confusion lasted for at least 100 years.

The year 376 has often been taken as marking the beginning of the barbarian invasions which opened in the history of Europe; a period known as the middle ages. In that year the Visigoths, fleeing before the Huns (*q.v.*) took refuge on the south side of the Danube, within the frontiers of the empire. At the battle of Adrianople of 378, in which the emperor Valens was killed, they destroyed a great Roman army. In 410 Alaric, their king, captured and sacked Rome. Then they passed on into Gaul, where their king, establishing himself in Toulouse, extended his power over Spain.

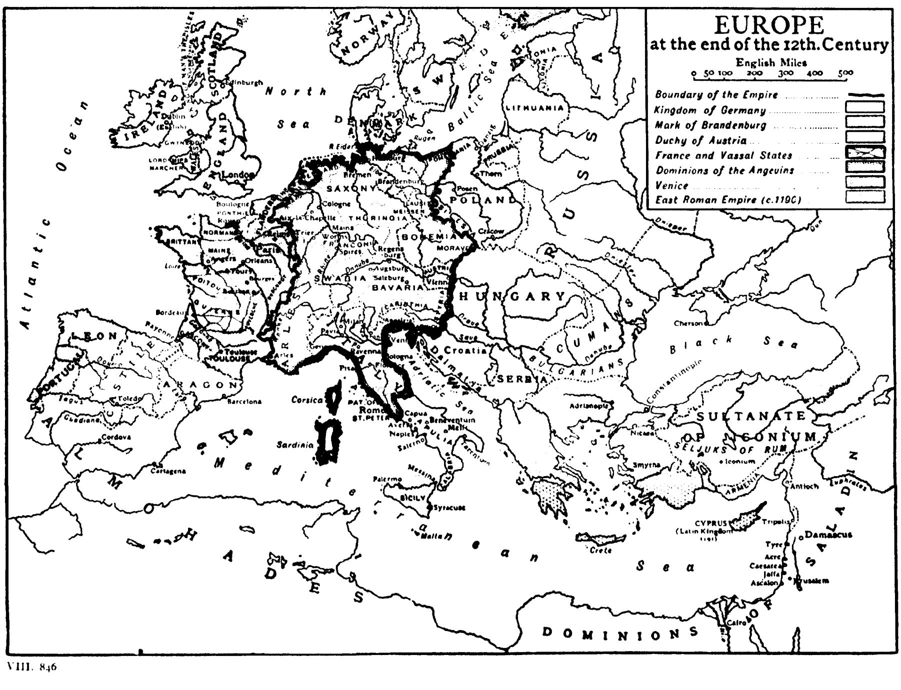
Other Teutonic races invaded the empire by way of the Rhine. The Vandals (*q.v.*) crossing Spain, at first established themselves in Andalusia, and later passed over into Africa, where their king established his capital at Carthage. The Burgundians, established in Savoy, in 435 extended their power over the country on the east bank of the Rhone. The Franks (*q.v.*), who owed allegiance to numerous petty kings, overran the north-eastern part of Gaul. German tribes coming from the shores of the North sea, Jutes, Saxons and Angles, settled in the south and east of Britain.

Odovocar.—In 476, Odovocar, the leader of the Barbarian warriors of the Imperial Guard, decided against the creation of an emperor, and returned the imperial insignia to the Eastern emperor. The European territory of the empire was divided up between the Germanic kings, among whom succession by right of primogeniture was customary. These lordships, scarcely meriting the name of States, differed in extent, according to the fortunes of war and the changes within the ruling families. The most extensive were those of the Ostrogoths in Italy, the Visigoths in Spain (*see* GOTHS), the Vandals in Africa and the Franks in Gaul. The most enduring was the kingdom of the Franks, founded by Clovis (*q.v.*), 486–511, which was handed down for more than two centuries in the Merovingian family, which ruled all Gaul except Languedoc, and even exerted its authority beyond the Rhine over certain tribes, in Germany. In the 6th century the emperor Justinian (*q.v.*) destroyed the Vandal and Ostrogoth kingdoms and re-established the imperial suzerainty in Africa and Italy. But a Germanic people, the Lombards (*q.v.*), overthrew it again in 568 and established their power in northern Italy and in Tuscany up to the walls of Rome.

The Arabs.—In the 7th century a barbarian people of different origin—the Arabs—united under the religious and military com-



EUROPE
at the end of the
10th. Century
English Miles
0 50 100 200 300 400 500
Boundary of the Empire
Kingdom of Germany
North Sea
Atlantic Ocean
Baltic Sea
IRELAND
SCOTLAND
ENGLAND
WALES
London
DENMARK
NORWAY
SWEDEN
LETTS
PRUSSIANS
POMERANIA
SAXONY
Hamburg
Bremen
Magdeburg
Brandenburg
Utrecht
Cologne
FRANCONIA
Frankfurt
Paris
Trier
Worms
Spires
Regensburg
Augsburg
BOHEMIA
Moravia
Chrobatia
RUSSIA
Dnieper
Dniester
Don
Volga
BAVARIA
Salzburg
HUNGARY
Debatable Territory between Hungary & the Patzinaks
Loire
Poitiers
Bordeaux
Vienne
BURGUNDY
Rhone
Milan
Venice
Ravenna
Rome
Toulouse
Arles
Marseilles
LEON
NAVARRE
Douro
Tagus
Toledo
Guadiana
CALIPHATE OF CORDOVA
Cordova
Corsica
Sardinia
Sicily
Serbia
Dalmatia
Adriatic Sea
BULGARIA
Danube
Adrianople
Constantinople
Black Sea
EAST ROMAN EMPIRE
Crete
Cyprus
Mediterranean Sea
DOMINIONS OF THE FATAMITES



EUROPE
at the end of the 12th. Century
English Miles
0 50 100 200 300 400 500
Boundary of the Empire
Kingdom of Germany
Mark of Brandenburg
Duchy of Austria
France and Vassal States
Dominions of the Angevins
Venice
East Roman Empire (c. 1190)
North Sea
Atlantic Ocean
Baltic Sea
SCOTLAND
Edinburgh
IRELAND
Dublin
ENGLAND
London
NORWAY
SWEDEN
DENMARK
LITHUANIA
PRUSSIA
Rugen
Hamburg
Bremen
Brandenburg
SAXONY
Thorn
Posen
POLAND
Cracow
Cologne
Aix-la-Chapelle
THURINGIA
Meissen
BOHEMIA
MORAVIA
Mainz
Worms
Spires
FRANCONIA
Regensburg
Augsburg
Salzburg
Vienna
SWABIA
BAVARIA
CARINTHIA
Danube
HUNGARY
CUMANS
RUSSIA
Dnieper
Dniester
Don
Paris
NORMANDY
BRITTANY
MAINE
Angers
Orleans
Tours
Loire
POITOU
Bordeaux
Bayonne
Toulouse
TOULOUSE
LEON
PORTUGAL
CASTILE
ARAGON
Barcelona
Toledo
Tagus
Guadiana
Cordova
Cartagena
ALMOHADES
Arles
Milan
Pavia
Venice
Ravenna
Bologna
Pisa
Rome
PAT. OF ST. PETER
Capua
Beneventum
Naples
Salerno
Corsica
Sardinia
Palermo
Messina
SICILY
Syracuse
Malta
Croatia
Dalmatia
Adriatic Sea
SERBIA
BULGARIANS
Adrianople
Constantinople
Black Sea
Cherson
Nicaea
Smyrna
SULTANATE OF ICONIUM
SELJUKS OF RUM
Iconium
ARMENIA
Antioch
Euphrates
CYPRUS (Latin Kingdom 1191)
Tripolis
Damascus
Tyre
Acre
Caesarea
Jaffa
Ascalon
Jerusalem
Crete
Mediterranean Sea
DOMINIONS OF SALADIN
Cairo

mand of the prophet Mohammed (*q.v.*), rapidly conquered northern Africa and western Asia, then Spain and a part of southern Gaul reaching to the Rhone. Out of this conquest arose the Arab empire, which developed an eastern civilization called Arabian, unified by the Mohammedan religion, and the Arabic language and literature. Henceforth the unity of the Mediterranean world was finally broken; Africa and Mohammedan Asia remained cut off from Christian Europe. (*See* also ARABIA; CALIPHATE; ISLAM; ISLAMIC LAW; ISLAMIC INSTITUTIONS; MOHAMMED.)

Results of the Barbarian Invasions.—In the midst of the old population, no longer accustomed to the practice of arms, a new population of barbarian warriors settled down and preserved, until the 9th century, its own family system, its customs of property and legal process. The reaction of these new comers differed according to the conditions of the country in which they had settled. In the Mediterranean countries, which had not been depopulated, the Visigoths and the Ostrogoths were absorbed into the Roman inhabitants without leaving any trace. The countries bordering Germany, devastated and depopulated from the 3rd to the 5th century, were re-populated by the Germans, who brought with them customs of much greater simplicity and a great deal of natural energy. The re-population of Gaul to the north of the Loire by the Franks, of Britain by the Saxons and the Angles of north Italy by the Lombards, made these countries, which took their names (France, England, Lombardy) the centres of a new European civilization during the middle ages.

The Lombard invasion, by suppressing the rule of the empire over central Italy, isolated Rome, where the pope, Gregory the Great, 590–604, became the master of the city, obtained a practically independent political power, and by sending missionaries to England began to spread his spiritual domination over distant lands. The rupture between the Western Church and the iconoclast Eastern emperors was the final step towards the elevation of the pope to the position of a sovereign prince.

The Carolingian Empire.—The Frankish family of the Merovingians, before they ceased to bear the title of kings, were replaced in the government of the Frankish kingdom by a new family of warriors, from the district of Metz, who exercised for a century the functions of head of the royal household in the kingdom of Austrasia, where the population had remained wholly Frank. One of these warriors, Charles Martel, re-established the power of the Frankish king over Gaul south of the Loire, and expelled the Mohammedans who had come in from Spain and had occupied the country between the Pyrenees and the Rhône.

His son, Pepin, called to the help of the pope against the Lombards, delivered the land round the city, and made a donation of it to the pope, which was the foundation of the temporal power of the papacy. He took the title of king of the Franks and was consecrated by the pope in a coronation ceremony—a precedent which gave rise to the custom which has been followed by all the sovereigns of Europe throughout the centuries.

Pepin's son, Charles, called the Great (*q.v.*), who gave his name to the Carolingian dynasty, conquered the Lombard kingdom and subdued the Saxons. He extended his rule over the greater part of western Europe, from the Ebro in Spain to the Elbe in Germany. He kept the way of life, the dress and the language of the Franks, and resided for choice at Aix-la-Chapelle, in the German-speaking country. But, having gone to Rome to establish order after a rising against the pope, he allowed himself to be proclaimed emperor and to be crowned by the pope (800). There were from that time two emperors—an emperor of the East and an emperor of the West.

Charlemagne reorganized the Government by exacting obedience from the local magnates who exercised the functions of dukes and counts, and by giving official power to the prelates (bishops and abbots). He established a compulsory tithe on all produce of the soil for the benefit of the clergy; and created a joint Government of the secular and clerical authorities, which from that time governed both the subjects of the king and the members of the Church. This system of Government spread itself over the whole of Europe, and has been called "the union of the throne and the altar."

In the 8th century education had fallen so low that the clergy themselves, the sole guardians of the Roman culture, could write nothing but a kind of barbarous Latin in an almost illegible script; Ireland alone maintained in its convents the tradition of classical study. Charlemagne gathered round him the most learned men from Britain, Italy and Gaul; his court became a centre of learning, where literary works were produced of little intrinsic value and of a low intellectual content. But this "renaissance" revived the study of the Latin language and of the most celebrated Latin authors, and the recopying of the manuscripts of their works. Schools established in abbeys and bishoprics for monks and clerks revived the teaching of the Roman schools of the later Roman empire. This was the origin of the teaching, common to the whole of Europe, founded on the *trivium* (*q.v.*)—grammar, rhetoric, logic—and reducing to a few elementary rudiments the sciences of the *quadrivium*—arithmetic, geometry, astronomy, music. Finally, the Carolingian renaissance regenerated style, which had become degraded. The clerks henceforward produced their works, their letters and official deeds in correct Latin. Script became beautifully legible, in the form of the Carolingian *minuscule,* which has been perpetuated in our European printed characters.

The Dismemberment of the Carolingian Empire.—The Frankish kings, having become emperors, did not abandon the Frankish custom of dividing up their lands among their sons. The empire of Charlemagne was divided by the Treaty of Verdun, 843, between his three grandsons. Charles received the country between the Pyrenees and the Meuse, the Saône and the Rhône; Louis the country to the east of the Rhine; shares corresponding roughly to France and Germany. Lothair, the eldest, received along with the title of emperor, the Lombard kingdom (Italy) and the belt between France and Germany. His share underwent a further partition; the territory between the North sea and Switzerland fell to his son, Lothair II., who gave it his name, Lotharingia (*see* LORRAINE). The Treaty of Mersen, 870, divided this territory between the kings of France and Germany, and it has remained for more than ten centuries a bone of contention between France and Germany.

Even before the Carolingian family was extinct, the title of emperor had lapsed, and the title of king was in dispute in France. Italy and Germany between the families of lords powerful enough to secure recognition from the other chief lords of the country. It cannot be said that the monarchy became elective, for recognition did not take the form of a regular election. In the region between France and Italy, it would happen that a prince, sometimes two princes, would take the title of king without making it possible to say that there were exactly two kingdoms, for the titles were purely personal and were not attached to a fixed territory. In the same way, in Spain the Christian warrior chiefs coming from the mountains of the Asturias and the Pyrenees, took the title of king when they occupied the districts that had been evacuated since the 9th century by the Moors; sometimes they transmitted the royal title to several sons, with the result that Spain became divided into numerous kingdoms, each of which was no bigger than a province.

Invasion of the Norsemen.—The final barbarian invasion was that of the bands of Scandinavian warriors (*see* VIKING; NORMANS), who throughout all the 9th century swept the coasts in their galleys and sailed up the rivers. They pillaged the towns and monasteries and fleeced the inhabitants whom their incompetent Governments were unable to defend. They ravaged the whole of western Europe, northern Germany, Britain, France, Spain and even Italy. They made permanent settlements in England in the Danelaw and in France in the district that took their name (*see* NORMANDY), where they bred a new population remarkable for its adventurous spirit and the distinguishing features of its Nordic origin.

Alfred the Great (*q.v.*) accomplished, at the end of the 9th century in England, a task analogous to, though less great than that of Charlemagne. He extended his authority over all the English peoples who had not been conquered by the Danes. He sought the aid of the clergy in the work of government and set up clerical schools for the teaching of Latin.

FEUDAL PARTITION AND CHRISTIAN UNITY

Feudalism.—The feudal system (*see* FEUDALISM), which arose during the 9th century in the Carolingian empire, was based upon the division of the country into very large estates, held by the warrior chiefs, and upon the necessity of their maintaining bands of mounted and armoured soldiers. The soldier was bound to his lord by a ceremony of homage which created a personal bond between the lord and his vassal. For his support and the upkeep of these arms the lord gave him horses and servants and a domain with its peasants. The vassal, in exchange, rendered the lord military service and fealty. All lords who bore the title of duke or of count regarded themselves as vassals of the king; the great landowners considered that they held their estates immediately from the king or from some other supreme lord; the fiefs, as these estates are commonly called, from the end of the 10th century, became hereditary and the obligation of homage finally amounted to no more than a bare ceremony. The whole country then became divided into fiefs and the owners exercised complete power over their tenants. Europe was divided up into many thousands of independent lordships, whose owners behaved as though they were sovereigns. The countryside became covered with fortifications and castles, the seats of different nobles. As in the days before the *pax romana*, war was again the normal state of Europe.

Originating in France, feudalism finally extended over the whole of Europe with the exception of Russia and the Balkan peninsula, and gave rise everywhere to a similar organization of lay society. In every country there arose an upper class composed of warriors who owned fiefs, divided according to their wealth into: (1) titled princes (in Spain, grandees; in Germany *Fürsten*); (2) great lords (in England, barons; in Germany, *Herren*); (3) knights (*chevalier* or *Ritter*). These formed an hereditary aristocracy, to which was added, during the 13th century, the inferior and much more numerous class designated by the vague appellation of *gentlemen* (*écuyers, squires, Edelknecht*).

The peasants who cultivated the estates of the nobles on a system of fines and *corvées*, constituted a lower class of little social consequence. The new class of the *bourgeois* that arose later in the town formed an intermediate class, but the nobles never consented to regard them as equals. These class divisions were common to all countries. Thus, despite the division of political power, the unity of Europe was strengthened through the uniformity between the deepest strata of society.

The Kingdoms.—From the beginning of the 11th century, princely families who bore the title of king, sought to strengthen their power and increase their territories. Most powerful of these was the king of England, because William the Conqueror, after he had reduced the whole kingdom to obedience, had divided the land between his leading followers, thus making them his direct vassals, had forbidden private war and placed all his subjects under the control of his officers. England was the most centralized State in the middle ages. The Norman knights who, in the 11th century, founded the kingdom of Sicily and Naples (*see* SICILY) set up there an analogous system of government.

In France the royal title that had been fought for during a century between the Carolingians and the leading families of the district around Paris, after 987 fell into the possession of this family, later known as the Capetians, and finally became hereditary in it owing to the transmission of the crown without a break from father to son from 987 to 1318. But the king's authority did not run beyond his own royal domain, which was greatly reduced during a century and a half, whereas the dukes and counts who were nominally his vassals, ruled over great territories amounting to States in themselves. Thus the duke of Normandy, even before he had conquered England, was more powerful than the king, and the counts of Anjou (*q.v.*) who, at the height of their power, possessed the kingdom of England and all the west of France, were for a time incomparably more powerful than the French king. It was not until after Philip Augustus had won from John all the country to the north of the Loire that the royal domain exceeded that of other princes.

In Spain the petty Christian kings of the north, availing themselves of the break up of the Arabian caliphate, extended their authority, at the end of the 11th century, over the centre of the peninsula. The conquest of the south was undertaken along parallel lines by the three kings of Portugal, Castille and Aragon, who succeeded, in the 12th century, in conquering the small Moorish kingdoms of the south with the exception of that of Granada which did not submit until 1492. Each king created a State which formed the nucleus of one of the three nations—Portuguese, Castilians, and Catalans—each speaking its own dialect. (*See* SPAIN.)

Northern and eastern Europe were divided, until the 11th century, among tribes that were still pagan, governed by warrior chiefs, who on their conversion to Christianity, took the title of king. In this way there arose the Scandinavian kingdoms, then the Slav kingdoms of Poland and Bohemia, and the Magyar kingdom of Hungary.

The Holy Roman Empire.—In Germany the royal title, which had remained elective, was borne successively by three ducal families ruling over the chief Teutonic tribes—Saxons, Franks, and Swabians (*see* GERMANY). The Saxon king, Otto I. in 963 took the title of emperor, which from that time forth was borne by the German kings. Tradition demanded that the emperor could only be crowned in Rome by the pope. Each king therefore made an expedition to Rome at the head of an army of German princes; and at Monza, near Pavia, he also took the iron crown of the Lombard kings. Each became nominally the sovereign of Germany and of Italy, and since the 11th century, of the kingdom of Arles, which was carved out of the land between the Rhône and the Jura mountain. The most powerful of the emperors, Henry III., extended his sway over the kingdoms that bordered Germany on the east. The power of the emperors was weakened through their combat with the popes, which arose first between Henry IV. (1050–1106) and Gregory VII. on the investiture question (*see* INVESTITURE), and was continued between the Hohenstaufen emperors and the popes supported by the chief Lombard towns. (*See* GUELPHS AND GHIBELLINES.)

The Church and the Papacy.—The Church had preserved the unity of religion among the inhabitants of the Roman empire and gradually extended it to all the peoples of Europe as they became in turn converts to Christianity. Everywhere the clergy introduced the same ceremonies, the same moral laws, the same religious books, and the same language, Latin, which became the general language of culture throughout Europe. Everywhere the clergy were established on a common organization, the bishops in the cities (placed there for the express purpose of becoming the focus for a diocese), monasteries on the great estates, and the priests in the parishes. The clergy recruited in a barbarian society paid little regard to a rule of discipline which imposed upon them so different a life from that of the layman. It was this tendency of the clergy to take their morals from the age in which they lived which provoked the reform of the monastery at Cluny in the 10th century (*see* MONASTICISM), and which brought about, in the 11th century, during the papacy of Gregory VII., the fight against simony (*q.v.*) and the marriage of clergy.

The pope, who had become powerless in the 10th century, regained his authority over the clergy in the 11th century. In the 12th century he freed himself from the power of the emperor by organizing the college of cardinals; and asserted his authority over the layman by submitting him to ecclesiastical jurisdiction in matters of marriage and inheritance, and above all in criminal jurisdiction against heretics. After the crusade against the Albigenses (*q.v.*), the pope set up an extraordinary tribunal called the Inquisition (*q.v.*), charged with the extirpation of heresy. The Lateran council, in 1215, imposed upon all princes the duty of exterminating heretics and upon all the faithful, the obligation of confession. Two orders of friars were created—the Franciscans and Dominicans (*qq.v.*)—who, instead of retiring from the world, lived in the cities among the people and carried on work as preachers. The uniform system of repression, supervision and preaching, was established in every country in Europe, and thus European unity was set up under the absolute authority of the pope, after the model of the imperial Roman system. A Byzantine writer remarked that Pope Innocent III. had become the successor of Caesar rather than of St. Peter (*see* PAPACY).

The Crusades.—The crusades were an enterprise undertaken in

common by the laity and clergy of Europe for the deliverance or defence of the sepulchre of Christ, the object of the veneration of all Europe (*see* CRUSADES). The pope preached the first crusade and superintended its conduct through a legate; the other crusades were preached by monks and priests. The princes and the knights assembled their forces for the conquest of the Holy Land. The Italian seaports—Venice, Genoa, Pisa furnished the siege-engines for attacking fortified towns and ships to transport the crusaders. Knights from all the different countries of Europe, united for the first time, learnt to know each other and to organize themselves to work together.

The first result of the crusades was the creation of little ephemeral kingdoms that the Mohammedans were not long in destroying; the indirect results are still matters of controversy. The 19th century tended to exaggerate them. There is no longer any means of estimating the part played by the crusades in the social and political evolution of Europe, and we cannot even attribute to them the establishment of commercial relations between Europe and the Levant, nor the introduction into Europe of the industries and arts of Eastern lands like sugar, paper, drugs and articles of luxury. For contact with Arabian civilization had been established on the Mediterranean sea-board through commerce with Moorish Spain, Sicily, Egypt, and the Byzantine empire.

Chivalry and Courtesy.—From the 12th century onwards the knights organized themselves into a close corporation to which no one was admitted except by a ceremony of initiation. Its members were inspired by an *esprit de corps* and spared each other mutually in battle. They conducted themselves in accordance with the rules of chivalry, which were inspired before all things by the idea of personal honour. The knightly ideal was that of bravery and loyalty and the sanctity of the pledged word. Later still there was added to this the duty of succouring the weak and the oppressed. The customs of chivalry and the knightly ideal permeated throughout Europe and laid the foundations of a common morality for the whole aristocracy of the continent.

The princely courts, where large numbers of noble courtiers lived in close contact, became under feminine influence the centres of that polite usage known as courtesy, which spread gradually into all the European courts and became the model for the whole aristocracy of Europe. Out of this there arose a new member of society—the lady—a personage unknown to antiquity or to the East, and remaining ever since one of the most original characteristics of European society. Before the close of the 12th century there arose in the French courts a new relationship between the sexes, the *amour courtois*, which was founded on a respect displayed towards a lady to which expression was given in the feudal terms of homage and the service of love. From being a court custom this practice passed into the knightly ideal and was disseminated by means of romances and poetry, under the form of gallantry, amongst the whole aristocracy of Europe. It introduced into European manners, regard and respect for women, and thus helped to raise the condition of women in European society to a higher level than that attained by them among other Christian societies.

The Universities and the Colleges.—The clergy alone knew how to read and write as long as Latin was the sole medium of communication. The clergy were the professional scribes of the period, to which the persistence of the name "clerk" bears witness. The majority of the clergy received only the tonsures and entered only the minor orders, and very many were married. Masters and pupils living in the same town united to form an association called a University. The University of Paris, founded in the 13th century, was divided into faculties, according to the subjects taught. The biggest was the faculty of arts and was composed of teachers who gave the preliminary instruction in Latin necessary to enable the scholars to study theology and law. The younger scholars were organized in colleges and subjected to a discipline modelled upon that of the monasteries. The courses of study were divided into grades (or degrees) and in order to pass to a superior degree the pupil was subjected to a test called examination (*examen*).

The University of Paris became the centre of international scholarship. To the lectures came scholars and professors from all Europe, and the most celebrated of its teachers were foreigners, like Thomas Aquinas, Albert the German, Duns Scotus from the British Isles, and Raymond Lulle from Spain. The University of Paris furnished the model for those in England, Germany and all the countries of Europe, with the exception of Italy. Thus Europe had attained to a common system of teaching which differed profoundly from that of antiquity and the East—a system which has persisted to the 20th century, with its same peculiar terms (university, faculty, college, rector, bachelor, master, doctor, examination, thesis), and even with its academic dress and insignia. It remains the foundation of the intellectual unity of Europe.

Another form of intellectual unity was afforded by arts and letters. Gothic architecture, originating in France in the 12th century, was introduced into all the Roman Catholic countries of Europe and along with Gothic sculpture, prevailed throughout western Europe, down to the end of the 15th century.

Books written in Latin—the international language of Europe—were addressed to a European public. They treated principally of theology and philosophy (*see* SCHOLASTICISM) and chiefly emanated from the universities. In common with scholasticism and the universities, they possessed an international character. Books in the vulgar tongue were primarily addressed to a national public. But certain poems written in Romance, lyrics or epics, songs or ballads were translated or imitated in the languages of other European countries. Thus there arose under French inspiration a common European literature, which is the origin of the prose romance, the distinctively literary form of Europe.

The Revival of the Towns.—The towns that in ancient days had been the centres of European civilization had been reduced during the dark ages to the condition of small fortified strongholds in which the few inhabitants lived under the absolute authority of, or even in personal service to a lord. By degrees, as the use of money was restored in Europe, the towns reopened their markets and became once more centres of manufacture. The populations increased and became richer and less dependent upon a lord. The merchants organized a transport system chiefly by sea or along the rivers.

The renaissance of the towns began in Italy in the Mediterranean ports, which had commercial relations with Constantinople and the Arabic countries which were then more civilized than Europe, and it penetrated into France and Germany through the seaports or towns situated on the highways of international commerce. In eastern Europe, which remained agrarian and but half civilized, the towns developed much later and only began in the 14th century to model themselves on those in the more civilized countries, above all Germany, and were inhabited in part by foreigners who brought with them and kept their own customs and languages.

The political organization of the towns widely differed in accordance with their degree of independence towards their respective lords. Two Italian seaports Venice and Genoa, and Florence, the centre of the woollen industry, were organized as sovereign States governed by an aristocracy of merchants. The towns in Italy and Germany nominally owing allegiance to the emperor, became under the name of "free cities" or "imperial cities" small independent republics which raised their own troops and coined their own money. The towns organized on a communal basis by an association of the citizens under the charter of the lord, acquired little by little the power of the lord and were governed by a council and elected magistrates. The towns that formed part of the royal domain in England, France and Spain continued to be governed by the king's representatives. A common characteristic of all European towns was the fixing by a written code of the taxes, fines and penalties due from the inhabitants.

The inhabitants of fortified towns received a new name, in Latin *burgenses*, from the German word *burg* meaning a fortress. They formed an intermediary class between the nobles and the peasants. For the most part they consisted of artisans who in the northern countries set up corporations for each particular trade (*see* GILDS), which laid down regulations for its conduct and supervision. Above the mass of the population there existed an aris-

tocracy of merchants, lawyers and officials which in France finally came to be known by the name of *bourgeois*.

The Decline of the Empire.—The emperors, backed by the prestige of their title and of the extent of territory nominally rendering them obedience, long sought to compel the monarchs of the various European States to submit to their authority. In this they were not successful, although the Hohenstaufen emperors at least exacted obedience from the German princes. From the time of the Great Interregnum (1254–73) the title of king of Germany which it was necessary to possess in order to become emperor, ceased to be held permanently by one family; the princes threw off all authority and Germany became a chaos of dukes, counts, lords and prelates, each of whom governed his own territory as a sovereign lord. Rudolph of Habsburg, who was elected king in 1273, used his power to acquire the duchy of Austria and the surrounding territories which came to form the hereditary domain of his family with Vienna as capital. The emperor Charles IV., who was descended from the French house of Luxembourg, published the Golden Bull (*q.v.*) which regulated the system of election to the empire and reduced the electoral princes (*Kurfürsten*) to the number of seven. But the emperor in fact enjoyed only a nominal authority, and the countries of central Europe, which had become a dependency of the empire, Germany and Italy, remained divided up into small States until the 19th century.

Growth of the Royal Power.—In western Europe the kings enlarged their domains and increased their power throughout the 14th and 15th centuries. The English king reduced Wales to submission, and Edward I. and Edward III. increased their authority by their conquests. In France, however, the royal authority was checked by the Hundred Years' War (*q.v.*), which opened a period of defeat (Crecy, Poitiers, Agincourt), by English invasions and disastrous treaties which on two occasions, in 1358 and 1422, ceded to the king of England a great part of France. But at the end of the 15th century the French king succeeded in uniting to his royal domain nearly all the provinces, as well as a great part of the country between the Rhone and the Alps. Moreover, the feudal service of the vassals no longer sufficed to carry on wars of long duration and the kings therefore enlisted companies of fighting men to whom they gave pay (*solde*); from whence arose the name of soldier (*soldat*). This professional soldiery was often at the service of the highest bidder.

In Spain the king of Aragon, who had at his command the naval forces of Barcelona, conquered Sicily and Sardinia. The two great kingdoms of the peninsula were united by the marriage of Ferdinand of Aragon with Isabella of Castille in 1474—a marriage which led to the establishment of the Spanish monarchy.

In eastern Europe the three Scandinavian kingdoms were united under the sceptre of the Danish king by the Union of 1397. The grand-duchy of Lithuania (*q.v.*) was united to the kingdom of Poland (*q.v.*) through the grand duke's marriage in 1387 with Hedwig, the heiress of Poland. Separated from Germany during the Hussite wars Bohemia formed a national State which was united under the same dynasty with the kingdom of Hungary.

Legislative Assemblies.—During the later 13th century kings of England had been in the habit of assembling the great men among their subjects in order to receive their counsel and assistance in times of grave crisis. The lords and the prelates came in person; the gentlemen and the townspeople were represented by deputies. This custom was gradually adopted by kings and princes throughout nearly the whole of Europe. The assemblies took names in different countries: parliament in England; *cortes* in Spain; *états* in France; *Landtag* in Germany; and in the central European kingdoms the Latin name of diets. These assemblies were ultimately divided into sections that differed in the number and composition of their membership. Thus in England, Hungary, Castille and Poland they became divided into two chambers—the lords and the commons; in France into three—clergy, nobles, bourgeois; and in Germany into lords, gentlemen and towns. The kings chiefly employed these assemblies for the purpose of augmenting the revenues, adding to the products of their domains by the taxes which the assembly consented to levy on their subjects. At first temporary, these taxes became permanent in character and were the means of enabling the rulers to maintain a permanent army.

The Crisis of the Papacy.—While the power of the kings and princes increased, that of the papacy was weakened by a series of crises. After the quarrel of Boniface VIII. and Philip IV. the popes took up their residence at Avignon where they lived under the tutelage of the French kings—a period known to Italians as the Babylonish captivity. The return of the pope to Rome in 1377 brought about the great schism between the pope living in Rome and a rival pope in Avignon, and while each excommunicated the supporters of the other, Europe was divided into two hostile camps. This quarrel had the effect of lowering the clergy in the eyes of the laity and in making the latter alive to the abuses that crept into the Church. The Councils of Constance and Basle, which were composed of prelates and doctors from all Europe, sought to reform the Church by restoring the authority of the Canon law; they claimed to represent the Church Universal and to be superior to the pope. The Council of Constance was successful in re-establishing unity in the Church by electing a pope in 1410, but both councils failed in their attempts to reform and in their endeavour to suppress the Hussite heresy. (*See* Papacy; Basle, Council of; Constance, Council of; etc.)

Fall of Constantinople, 1453.—The capture of Constantinople by the Turks was a startling occurrence and spread terror throughout Europe. It has long been taken to mark the close of the middle ages. But the results which have been attributed to it had already made their appearance before the fall of the city. The Turks were already masters of the Balkans and had made an end to the trade of the Italian cities with the Black sea ports. The works of Greek writers had been introduced into Europe by the Byzantine scholars who attended the Council of Florence at which it was sought to bring about the reconciliation between the Greek Church and that of Rome.

The Turks continued to threaten Europe; they were organized for continuous warfare, and they possessed an infantry and artillery superior to those of the Western European States. The invasion reached the plain of the Danube and twice, in 1529 and 1683, the Turkish army stood before Vienna.

ABSOLUTE MONARCHIES AND THE REFORMATION

Establishment of Great Monarchies.—Towards the end of the 15th century the three great nations of western Europe—England, France and Spain—formed each a national state, united under the unrestricted authority of a single sovereign, reigning by hereditary right. He judged his people in his courts, controlled them through his officials and taxed them. In France and Spain he maintained an army whose commanders he nominated. He determined peace or war.

The French king, who ruled over the most populous and fertile of the three kingdoms, was possessed of ample revenues and an exceedingly powerful army. He took part in the Italian wars (1494–1513) in order first to conquer the kingdom of Naples and then Milan. His plans were frustrated by a coalition of the Italian States and subsequently by Ferdinand, king of Aragon, who was already master of Sicily, and Pope Julius II., who was supported by the Swiss and the emperor. As a result the French armies were driven out of Italy.

The Habsburg family had been possessed of but a small hereditary domain, but its importance was increased by its imperial elevation in 1439, and it soon raised itself to the first rank by marriage alliances, following the method epitomized in the half line: *Tu, felix Austria nube*. Maximilian (*q.v.*) had married, in 1477, the duchess of Burgundy, who was heiress of the Low Countries, and her son, Philip, married Joanna, heiress to the two Spanish crowns, who transmitted the whole inheritance to her eldest son, the emperor Charles V. The younger son, Ferdinand, married the heiress of Bohemia and Hungary and brought these two kingdoms into the hereditary possessions of the Habsburgs, who thus came to rule over a great part of Europe.

The Renaissance.—The Renaissance (*q.v.*) was a European event in the sense that it gave rise to an artistic technique and

ideal, common to all Europe. It was preluded by the invention of printing which made possible the publication of the Greek and Latin classics, and by facilitating their study gave birth to the Humanism (*q.v.*) that was the essential characteristic of the Renaissance.

The task of the Renaissance was not only to foster the arts which had been flourishing since the 12th century, but also to imitate classic art as the Italians knew it. The Renaissance rejected the pious and ascetic Christian ideal of the middle ages and returned to a pagan worship of beauty in the study of the nude and of mythology. It replaced Gothic sculpture and architecture by imitations of Roman statues and monuments; and in literature writers returned to the literary forms of the ancient world—tragedy, comedy, epic. The Renaissance began in Italy in the 15th century and there reached its zenith after the beginning of the 16th century with Raphael and Michael Angelo; it spread during the early 16th century into Germany and France, reaching England towards its close during the lifetime of Shakespeare, and entering Spain at the beginning of the 17th century in the days of Cervantes and Velasquez.

The Renaissance caused a cleavage in the artistic and literary life of Europe by creating an informed and highly polished literature and art that could not be understood by the uneducated, but were for those alone who had received a training and education preparatory to their enjoyment. The most famous artists and writers worked solely for a privileged public and their works never reached the mass of the people, who were forced to be content with popular forms of literature and art that were scorned by the learned.

The Reformation.—The reforms demanded in the 15th century by the councils for the purpose of restoring discipline in the Church, although they upheld the principle of papal authority, were frustrated by the opposition of the popes. The Reformation in the 16th century took the very different form of a revolt against the pope, and involved a far-reaching change in the organization of the clergy and the rites of the Church (*see* REFORMATION). It was the work of theologians who sought to restore the purity of Christian belief by establishing it on the study of the Holy Scriptures.

The clergy, who were in possession of powerful weapons for the discovery and destruction of heretics, had always been successful up till then in suppressing revolts. The reformers were able to preach their doctrines and organize churches only in countries in which they were supported by the secular power. All the great monarchs were opposed to them. The reformed churches of Luther in Saxony, of Zwingli at Zürich, of Calvin at Geneva, were all established in countries nominally dependent on the empire; and the propagation of the Reformation was rendered possible only by the continuous warfare between the monarchs of the several States and by their quarrels with the pope.

The Lutheran Reformation was adopted by nearly all the secular princes and towns in Germany because, through it, they profited by seizing the ecclesiastical estates and freeing themselves from ecclesiastical jurisdiction; and it was also accepted by Denmark and Sweden. Calvinism spread at a later date, in spite of the opposition of the rulers, in France, Scotland, the Netherlands, and in Hungary, Bohemia and Poland. After sudden changes of policy, the English kings established the Anglican Church which, while preserving much of the traditional ceremonies and organization, adopted a Protestant attitude.

The Counter Reformation.—The clergy, disorganized and at variance among themselves, were unable to prevent the growth of the Reformation. The opposition was first promoted by the monastic orders, chief among which was the order of the Jesuits (*q.v.*) who placed their entire resources at the service of the pope; then by the Council of Trent (*see* TRENT, COUNCIL OF), summoned by the pope with the support of the kings of Spain, France and Germany. This council did not re-establish the unity of the Church as had been hoped; but it maintained the authority of tradition, confirmed all the rites of the middle ages, and preserved intact the organization of the clergy. It reformed the Church, but only in the sense of re-affirming already accepted practices. Bishops were instructed to supervise the conduct of the clergy, and the teaching of the catechism, and to establish seminaries for the education of the priests. Then followed the movement known as the Counter Reformation, directed by the pope and the Jesuits, with the object of regaining the ground lost to the Reformation. It was successful in all the dominions of the house of Austria, and in Poland, Belgium and Ireland; and Calvinism in France was sensibly weakened. The religious unity of Europe was broken for ever. The Roman Catholic Church maintained its power in all the Latin countries, in most of France and in Poland and the Habsburg lands. In the northern countries the reformed churches, which were classed together as Protestants, prevailed. Germany was divided between the two.

Conflict Between France and Austria.—The two most powerful monarchies in Europe took part in a contest which, under three different forms, lasted from 1521 to 1648. It opened with the personal rivalry between Francis I. and Charles V. Francis, when defeated, allied himself with the opponents of the Church, the Lutheran princes in Germany, and with the enemies of Christianity, the sultan of Turkey and the Corsairs. Although Francis was unable to hold his conquests in Italy, his successor, Henry II., with the help of the princes, defeated the attempt of Charles V. to render Germany submissive. The defeat of the emperor was acknowledged in the Peace of Augsburg in 1555, which recognized the independence of the princes and their right to impose the Lutheran religion upon their subjects.

The war which had been going on between the French and Spanish kings was finally ended by a peace, concluded in 1559, for the purpose of extirpating Calvinism. This task was undertaken by Philip II. of Spain, who, after his conquest of Portugal in 1580, sought to re-establish Catholicism in England, France and the Netherlands, and to establish his supremacy in Europe. Philip sought to take advantage of the religious wars in France that lasted from 1562 to 1598 and of the conflict between Elizabeth and Mary Stuart over the succession to the English throne.

He leagued himself with Henry of Guise, the head of the League, and with the Jesuits and the English malcontents. After he had reconquered Belgium he made ready to attack Henry III. and Elizabeth simultaneously. But the disaster of the Armada ruined all his plans in 1588, and all the people whom he had threatened —English, French, Dutch, German—allied themselves against him. Spain was ruined, unable to reconquer the Netherlands, and incapable even of defending her coasts against the English fleet. Henry IV. revived the royal power in France and forced Spain to sign the Peace of Vervins in 1598.

The Thirty Years' War.—The German branch of the house of Habsburg, which held the title of emperor, was greatly weakened by quarrels between the archdukes and by revolts on the part of the Protestant nobility in Bohemia, Moravia, Hungary, and even in the archduchy of Austria. The German princes were divided into two hostile camps; the Protestant Union, which was established in 1608, and the Catholic League, established in 1609. The unity of the Habsburgs was restored on the accession of Ferdinand II. in 1618; but in that year the revolt of the Protestant nobility in Bohemia—who chose as king the elector palatine, leader of the Protestant Union—opened the Thirty Years' War (*q.v.*). Led by Maximilian of Bavaria and Philip III. of Spain the Catholic League allied itself with the emperor. The war was successively waged in all parts of Germany. Wallenstein (*q.v.*), who had raised an army for the service of Ferdinand, supported it by levies exacted from the country he occupied and used it in an attempt to re-establish the arbitrary authority of the emperor over the German princes. Ferdinand became powerful enough to confiscate the territory of the duke of Mecklenburg and to take away from the princes the Church lands which they had seized.

The war was extended by the intervention of Gustavus Adolphus, king of Sweden and ally of France, who invaded Germany and forced the Lutheran princes to make common cause with him. His victories destroyed the hopes of the emperor; but after his death in 1632 the reverses sustained by the Swedish

armies and by the German princes, determined the French king to take part in the war in 1635 and to fight simultaneously the Habsburgs in Germany and in Belgium. Sweden, the United Provinces, and the Protestant princes of Germany allied themselves to a Catholic France, directed by a cardinal, and thus the war lost its character of a contest between two religions. Spain was rendered powerless by a revolt in Portugal and Catalonia in 1640; and after many abortive attempts France and Sweden undertook a common action on the Danube and in Bohemia directed against Vienna. The war ended in the defeat of the emperor and of the last attempt at hegemony in Europe on the part of the house of Habsburg.

Treaties of Westphalia, the Pyrenees and Oliva.—The Congress of Westphalia (*see* Westphalia, Treaty of), where peace was concluded in 1648, marks an epoch in the history of Europe. This congress was the first at which representatives from the great majority of the European States were assembled. Its acts were drawn up in Latin as being the international language of the day. At this congress the order of precedence among the States was established and the precedents that have since been followed in European diplomacy were there created (*see* Diplomacy). The treaty left the emperor with merely a nominal sovereignty over Germany; it confirmed the independence of the princes, lords and towns (to the number of about 300) and recognized their right of making laws, of declaring and carrying on war and of concluding treaties with foreign Powers.

Ravaged and depopulated by the war, Germany lay broken up and at the mercy of an invader; but war went on between France and Spain; and Charles X. of Sweden, already master of a great part of the Baltic sea-board, plunged into war against Poland (which was, for the moment, at his mercy), Russia and Denmark, and almost captured Copenhagen. The elector of Brandenburg seized the opportunity to make himself master of the duchy of Prussia. War in the west of Europe was terminated by the Treaty of the Pyrenees in 1659, which left Spain finally ruined and incapable of defending her possessions. The northern war was brought to a close by the Treaty of Oliva in 1660, which left the control of the Baltic in the hands of the king of Sweden.

Louis XIV.—Richelieu and Mazarin had broken the opposition of the nobles and the *parlements* and had established an absolute monarchy in France. Louis XIV. profited by their work throughout the whole of his long reign (1643–1715). He ruled over the most populous kingdom in Europe, possessed the greatest army of the day, the most experienced generals and the cleverest diplomats. He took up his residence in the palace which he built at Versailles, where he organized a court ceremonial which rendered the person of the monarch the object of a form of worship, and his court became the focus of society and fashion. The princes of Europe, above all in Germany, dazzled by the magnificence of Louis XIV., sought to model themselves upon him. Versailles became the pattern for all courts, its etiquette the precedence for all ceremonial, and French fashions were copied in every country. Famous writers who sang the praises of the great king aroused throughout Europe an admiration for French literature and French customs; French became the language of polite society and, after the Congress of Nijmwegen in 1678, the language of European diplomacy.

Revolution in England.—The two English revolutions had political consequences of lasting effect in Europe. The Great Rebellion began with the Bishops' wars (*q.v.*) with Scotland and a revolt occasioned by a dispute over the liturgy and episcopacy. Its outcome was a republic ultimately founded on new principles—the sovereign right of the people, the electoral nature of power, and the equality of civil rights—principles which were put into application in two American colonies, Connecticut and Rhode Island. It was the origin of a type of government new to the world—democratic representative government.

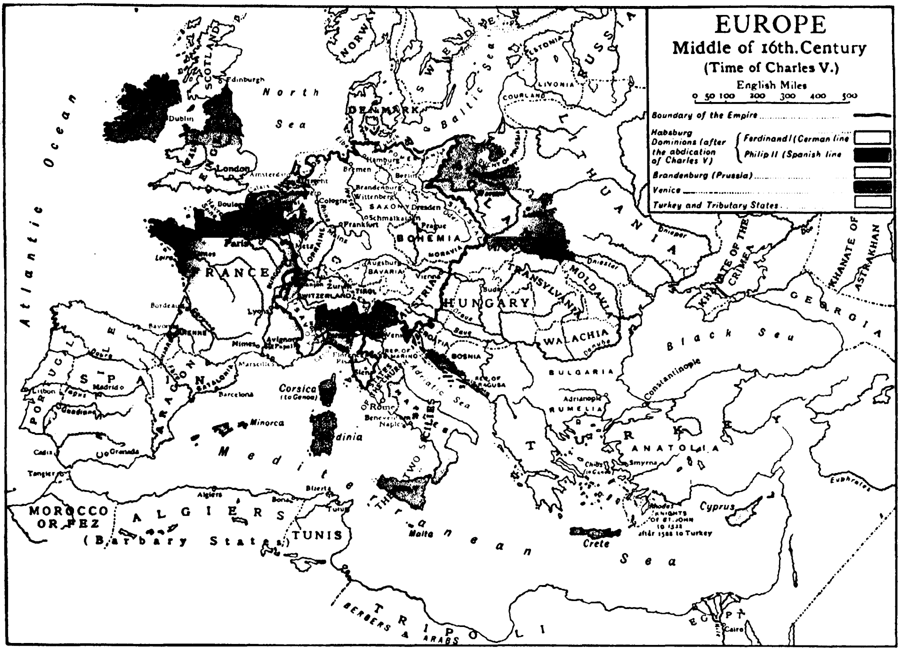
The revolution of 1688 was a revolt of the English Protestants against a Roman Catholic king who sought to make Roman Catholicism the religion of England. It finally turned the English monarchy into a constitutional monarchy controlled by parliament. Locke, a survivor of the first revolution, formulated in 1689 the theory of limited monarchy, and of religious toleration in 1690; the basic principles of the political philosophy of the 18th century. Thus in the zenith of the absolutism of the 17th century the English nation had already laid the foundations of the political system of 20th century Europe.

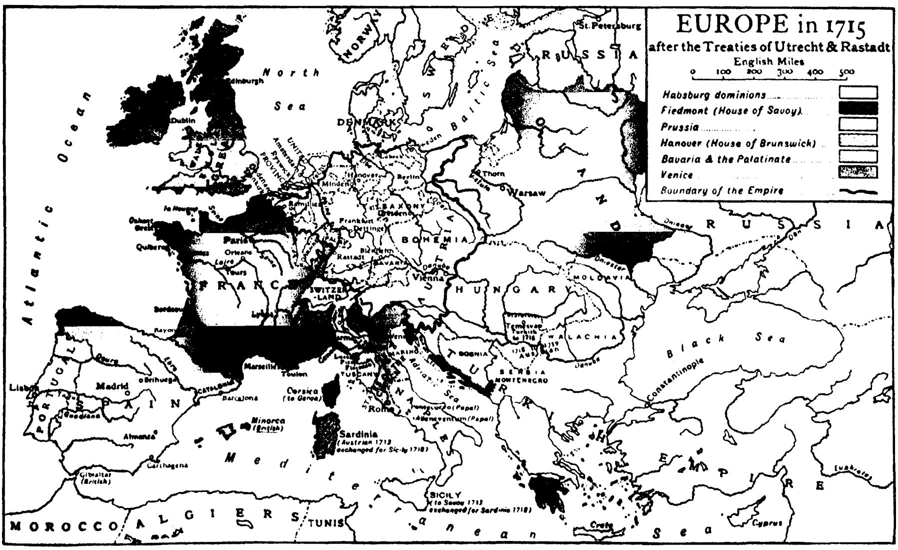
Louis XIV. and the Supremacy of France.—Europe was now divided up between a number of powerful military States and a number whose feebleness was due either to their small size or to their being too disorganized to be capable of defence. The powerful States sought, by conquest or marriage, to acquire the territories of the weak ones. These arenas of war and of diplomatic intrigue covered the small divided States of Italy and Germany, and, in eastern Europe, the shores of the Baltic and the valley of the Danube. The once powerful Spain had become incapable of defending her external possessions, and the approaching extinction of the dynasty aroused the rivalries of the various claimants. France had an advantage over the other Powers in that the emperor was occupied in repelling the Turks, and Charles II. of England was not ambitious of engaging in Continental wars. Unable to obtain the succession to the Spanish crown in the name of the Infanta, his wife, Louis XIV. went to war in order to conquer a part of the Netherlands. The intervention of Holland checked him in 1668, and he invaded that country in 1672. His further progress was arrested by a coalition of the United Provinces, the emperor, the German princes, and Spain, which forced him to evacuate Holland and to transfer the war to the district of the Rhine and Moselle. But the coalition proved too weak to overthrow Louis XIV., and the Peace of Nijmwegen in 1678 was concluded at the expense of Spain. In 1683, when the emperor, the German princes and Poland were fully occupied in repelling the Turkish invasion, and the forces of Austria were engaged against the Turks in Hungary, Louis XIV. seized the opportunity to extend his territory through the *Chambres de Réunion* and also annexed Strasbourg in 1681. The German States could only reply with the defensive League of Augsburg (1686).

The political situation was completely altered by the English revolution of 1688 which brought England and Holland into the coalition concluded at the Hague. Henceforward, even his victories proved useless to Louis XIV., and with his finances and his armies exhausted, he was compelled to sue for peace. By the Treaty of Ryswick in 1697 he restored all the territories which he had annexed in time of peace, with the exception of Strasbourg. By the Treaty of Carlowitz in 1699, the emperor forced the sultan to surrender all Hungary; and, mistress of the Danube, Austria became once more a great Power.

Louis XIV. appeared to have regained the hegemony of Europe when the succession to the Spanish crown was secured by will to his grandson, the duke of Anjou. But the Spanish and French monarchies were not to be united under one sovereign. The emperor undertook the War of the Spanish Succession with only a few German princes for allies. Louis XIV., through his hostile measures, aroused the indignation of the English and the Dutch and caused them to enter into a new coalition against him. The ally of Spain and of Bavaria, Louis XIV. had at first the advantage of carrying on the war in Belgium, Bavaria, and in Italy, but after Marlborough, who commanded the Anglo-Dutch army, and Prince Eugene, the imperial commander, had joined forces in Bavaria and won the decisive victory of Blenheim, the French armies were driven out of Germany (1704), and out of Belgium and Italy (1706). When the Allies invaded an exhausted France, Louis XIV. sued for peace from 1709 onwards, without being able to obtain acceptable conditions; and he was only saved by the advent to power of a Tory ministry which withdrew England from the war in 1711, and negotiated the Treaty of Utrecht in 1713. In 1714 the victories obtained by the French armies over the imperial troops, compelled the emperor to accept the peace of Rastadt.

The Entry of Russia into Europe.—United since the 17th century under the sceptre of the tsar of Moscow, Russia has continued separate from Europe by religion and custom. The Russian people held the Orthodox faith and had adopted oriental


EUROPE
Middle of 16th. Century
(Time of Charles V.)
English Miles
0 50 100 200 300 400 500
Boundary of the Empire
Habsburg Dominions (after the abdication of Charles V)
Ferdinand I (German line)
Philip II (Spanish line)
Brandenburg (Prussia)
Venice
Turkey and Tributary States
Atlantic Ocean
North Sea
Baltic Sea
SCOTLAND
Edinburgh
Dublin
London
NORWAY
DENMARK
SWEDEN
ESTONIA
LIVONIA
COURLAND
RUSSIA
LITHUANIA
Hamburg
Berlin
Bremen
Brandenburg
Wittenberg
Cologne
SAXONY
Dresden
Schmalkalden
Frankfurt
Prague
BOHEMIA
MORAVIA
Paris
FRANCE
Augsburg
BAVARIA
Vienna
TIROL
SWITZERLAND
Zurich
AUSTRIA
HUNGARY
Buda
TRANSYLVANIA
MOLDAVIA
WALACHIA
KHANATE OF THE CRIMEA
KHANATE OF ASTRAKHAN
GEORGIA
Black Sea
Constantinople
BULGARIA
RUMELIA
Adrianople
BOSNIA
REP. OF RAGUSA
Adriatic Sea
Bordeaux
Lyons
Avignon
Nîmes
Marseilles
PORTUGAL
SPAIN
ARAGON
Madrid
Lisbon
Barcelona
Corsica (to Genoa)
Rome
Naples
Minorca
Sardinia
Granada
Cadiz
Tangier
Mediterranean Sea
TWO SICILIES
Malta
MOROCCO OR FEZ
ALGIERS
(Barbary States)
TUNIS
Algiers
TRIPOLI
BERBERS & ARABS
ANATOLIA
Smyrna
Chios (to Genoa)
Rhodes (KNIGHTS OF ST. JOHN to 1522 after 1522 to Turkey)
Cyprus
Crete
Euphrates
EGYPT
Cairo


EUROPE in 1715
after the Treaties of Utrecht & Rastadt
English Miles
0 100 200 300 400 500
Habsburg dominions
Piedmont (House of Savoy)
Prussia
Hanover (House of Brunswick)
Bavaria & the Palatinate
Venice
Boundary of the Empire
St. Petersburg
RUSSIA
NORWAY
SWEDEN
Baltic Sea
North Sea
Edinburgh
Dublin
Atlantic Ocean
DENMARK
UNITED PROVINCES
Amsterdam
Hanover
Minden
Berlin
SAXONY
Dresden
Frankfurt
Dettingen
BOHEMIA
Thorn
Warsaw
POLAND
Dnieper
Dniester
MOLDAVIA
Paris
Orleans
Loire
Tours
FRANCE
Blenheim
Rastadt
BAVARIA
Danube
Vienna
AUSTRIA
HUNGARY
SWITZERLAND
Lyons
Bordeaux
Bayonne
Temesvar
WALACHIA
Black Sea
Constantinople
BOSNIA
SERBIA
MONTENEGRO
Marseilles
Toulon
Madrid
Brihuega
CATALONIA
SPAIN
PORTUGAL
Lisbon
Barcelona
Corsica (to Genoa)
Minorca (British)
Sardinia (Austrian 1713 exchanged for Sicily 1718)
Almanza
Carthagena
Gibraltar (British)
Rome
TUSCANY
Adriatic Sea
Benevento (Papal)
NAPLES
SICILY (to Savoy 1713 exchanged for Sardinia 1718)
Mediterranean Sea
MOROCCO
ALGIERS
TUNIS
TURKISH EMPIRE
Euphrates
Crete
Cyprus

customs like long robes, the seclusion of women and the knout. Peter the Great (1689–1725) took the European title of emperor and sought to transform his empire into a European State. He compelled his subjects to adopt European clothes and European customs; he opened communications with Europe by conquering the Baltic provinces; he built in this Europeanized land a capital with a German name, St. Petersburg (Leningrad). He created a navy on the English model, an army on the German model, a senate in imitation of the Swedish senate. He organized the Russian Church after the Lutheran pattern and divided Russian society into classes in imitation of European society—an aristocracy composed of landowners, a middle-class composed of merchants.

Peter the Great made war on Sweden, compelled her to cede its Baltic provinces, thus making an end to Swedish supremacy in the Baltic and in 1709 destroyed her army. In 1717 he forced Poland to enter into an agreement which, by limiting the strength of the Polish army, placed the country in the power of Russia. Although the immense country of which he was lord was very thinly peopled (the census of 1723 reckoned the population at 14,000,000), Peter the Great possessed a large and disciplined army recruited from the peasants, and the Russian empire was henceforth one of the great Powers of Europe.

Balance of Power.—The Treaties of Utrecht and Rastadt marked the close of French hegemony in Europe. England retained possession of her conquests of Gibraltar, Minorca and Nova Scotia. The Habsburgs acquired the scattered possessions of the Spanish monarchy—Belgium, the Milanais and the kingdom of Naples. But France, though conquered, suffered no loss of territory. Two new kings, in Germany the king of Prussia, and in Italy the king of Sardinia, founded two kingdoms of no great size but possessing powerful armies which enabled them to play a part in diplomacy and war, and caused them to become, in the 19th century, the rallying points of German and Italian unity.

Henceforth relations between the European States were based on the principle of the balance of power (*q.v.*) between the great Powers, England, France and Austria, later joined by Russia and Prussia. Henceforth policy had no other aim than "the interest of the state," by which was implied aggrandisement and the great Powers sought to acquire new territory at the expense of the lesser, seeking at the same time to prevent any one among them from becoming supreme by maintaining a balance between themselves. Whenever a Power was seen to be growing over-strong, the others demanded a "compensation," to increase their strength and thus to preserve the equilibrium.

The establishment of the balance of power was followed by the peace (1714–40) which arose out of the accord between the British Government under Walpole, and the French, which was in the hands of the regent and Fleury. Only a few crises disturbed the general peace; the intrigues of Elizabeth Farnese, queen of Spain, who sought to obtain kingdoms for her two sons, involved Spain in very brief wars and in changes of alliance which called for the diplomacy of all Europe; and the election of the king of Poland in 1733 resulted in a short war against the emperor, which assured the kingdom of Naples to Charles of Spain and the reversion of Lorraine to France.

The Anglo-French and Austro-Prussian Wars—1740–1763.—Before the middle of the century, however, Europe was dragged into war by two distinct disputes that arose from different causes, but became artificially connected as one European war, viz., the rivalry between Great Britain and France in America and India, and that between Austria and Prussia in Germany. The result was two wars of the same duration, both broken by an interval of peace. The first began in America and was occasioned through the English trade with the Spanish colonies. It was fought between England and Spain, the ally of France, simultaneously with the war waged in Germany against the emperor by France and her allies, the German princes. The British king took part in the latter as the ally of Austria, while the king of Prussia seized the opportunity to conquer Silesia. This war of the Austrian Succession (*q.v.*) ended in the Treaty of Aix-la-Chapelle in 1748, peace being restored to Europe at no heavier cost than the cession of Silesia to Prussia, of a small part of the Milanais to the king of Sardinia, and of the duchy of Parma and Placentia to the second son of the queen of Spain.

The second war, the "Seven Years' War" (*q.v.*) lasting from 1756 to 1763, also had its origin in the quarrel between the French and British colonists in America, and was accompanied on the European Continent by a war directed against the king of Prussia by a coalition of three great Powers, France, Austria and Russia, joined by Sweden and the German princes. In order to guarantee Hanover, the British Government in 1756 concluded with the king of Prussia a treaty which transformed itself into an alliance.

This change in the system of alliances, which was in marked contrast to the traditional French policy of hostility to Austria, was confirmed by the Franco-Austrian *entente*, resulting in the marriage of the archduchess Marie Antoinette with Louis XVI. Frederick the Great attacked by Austria, Russia and France overcame each of them in turn; but his tiny kingdom was exhausted, and on three occasions, 1757, 1759 and 1761 he believed himself lost. He was saved by the death of Elizabeth, empress of Russia, in 1762; and in the following year the Treaty of Paris, which deprived France of Canada, set the seal upon British supremacy in America and on the seas, while the Treaty of Hubertusburg, by which Silesia was ceded to Frederick, crowned that monarch's achievement in making Prussia a great power (1763).

The Doctrines of the 18th Century.—The practice of political liberty and religious toleration, which had been established in England since 1688, not only inspired the teaching of Locke but also as the "natural religion" of the free-thinkers, spread among the educated classes. It was founded on belief in the goodness of God and in the immortality of the soul and, in opposition to ascetic Christianity, which believed human nature to be essentially evil, held that it was good, simply because it was a creation of a benevolent deity. This optimism became the common foundation of natural philosophy and political economy and overthrew, among thinkers throughout Europe, the moral concepts formed by a long tradition of Christian theology. In Germany it was disseminated under the name of *Aufklärung* and became the inspiration of such classic poets as Lessing, Goethe and Schiller; and it justified the new economic doctrine of *laissez faire, laissez passer*, which had been formulated by the French physiocrats and systematized by the Scotsman, Adam Smith. The French "philosophes," by their writings, were chiefly responsible for the spreading of these new ideas through Europe; and they were admirers of England, where many of them had lived and which they held up as an example to the world. Montesquieu was above all interested in political liberty; Voltaire specially advocated religious toleration; and such writers won a European reputation, their works helping to create in the sphere of politics and morals a common public opinion among the intellectual aristocracy of Europe.

The effect of these doctrines upon the sovereigns and their ministers since the middle of the 18th century was very unequal. Even when they admired Montesquieu they cared little for political liberty, and religious toleration was dearer to them only because it weakened the power of the clergy. Nevertheless, they were nearly all influenced by humanitarian ideas, which they sought to put into practice by founding charitable institutions, abolishing torture and cruel punishments, and adopting measures likely to result in the welfare of their subjects. A few even agreed to the liberty of industry and commerce for which the economists clamoured while protesting that their political ideal was that of the paternal despotism obtaining in China; all were agreed in upholding the absolute power of the State and hence it came about that this form of government received in Germany the name of "enlightened despotism." This was the inspiration of Pombal in Portugal, Tanucci in Italy, Florida Blanca in Spain, Turgot in France and of the sovereigns, Frederick II. in Prussia, Catherine in Russia, Leopold of Tuscany, and above all of Joseph II. of Austria, who received the nickname of "the crowned philosopher."

The Eastern Question.—The countries which had taken part

in the great wars above mentioned were successful in maintaining peace for a quarter of a century, and the peace so established was only disturbed in Europe by the two attempts of Joseph II., in 1779 and 1785, to conquer Bavaria, for the War of American Independence, in which France fought against England in America and on the seas, did not much disturb the peace of Europe.

But in eastern Europe a serious crisis arose when Catherine II. dispatched troops to Poland to subdue the Poles. The accidental invasion of Turkish territory by Russian troops, led to the war (1770–74) between Russia and Turkey. Austria entered into occupation of part of Poland, and Frederick II. took the opportunity to propose to Catherine a scheme that resulted in the first partition of Poland (1772) between Prussia, Russia and Austria —the partition inspired by the principle of "compensations" (*see* POLAND). The peace that was concluded with Turkey in 1774 at Kutchuk Kainardji gave Catherine an excuse for seizing the Crimea in 1783, while the war at sea afforded her the opportunity of forming the armed neutrality of the North (1780), directed against British naval supremacy.

So weak did the Ottoman empire appear that Joseph II. and Catherine entered into an alliance to partition Turkey in Europe. But the war against Turkey turned out disastrously. Austria was paralysed by revolts in Hungary and Belgium against the reforms initiated by Joseph II. and Russia was held in check by the attack made upon her by Gustavus IV. of Sweden. Catherine and Joseph were compelled to abandon their project and to conclude with the sultan the treaties of Sistowa in 1791, and of Jassy in 1792. (*See* also EASTERN QUESTION.)

THE FRENCH REVOLUTION

The revolution of 1789 at first amounted to no more than a national attempt to establish in France a régime of political liberty under the guarantee of a Constitution after the American model, and to abolish the rights possessed by the nobles over the peasants. Nothing was further from the thoughts of the leaders of the movement than armed intervention in Europe, and the Constituent Assembly proclaimed its intention of never engaging in a war of conquest. But the French émigrés and Louis XVI. sought help from the European sovereigns in order to restore the *ancien régime,* and the emperor and the king of Prussia, who had been reconciled to one another at Reichenbach in 1790, made common cause against the revolution. Both the Girondins, who desired war in order to effect the destruction of the king, and a ministry which equally desired it for the strengthening of the royal power, influenced the Assembly to declare war upon Austria in April 1792. The French armies, leaderless through their officers being *émigrés,* were on the point of dissolution, and when the Prussian army invaded France it was only checked at Valmy (Sept. 20, 1792). Thereafter France took the offensive and French armies occupied Belgium, the left bank of the Rhine and Savoy, and stirred up the populations to emulate the French in destroying the *ancien régime.* After the execution of Louis XVI., England, Holland, Spain and Sardinia formed a coalition directed against France. Russia took no part because Catherine preferred to employ her army against the Poles, who had just set up a Constitution on the French model in an endeavour to throw off the Russian yoke.

In 1793 France was invaded on all sides, but the large conscript armies that she raised were successful, first in freeing French territory, and then in occupying Belgium and the left bank of the Rhine. France then annexed all the country west of the Rhine and the Alps, which from that time were described as her natural frontiers, while Catherine took advantage of the opportunity to destroy Poland by means of the partitions of 1793 with Prussia and of 1795 with Prussia and Austria. France invaded Holland in 1795 and northern Italy and southern Germany in 1796, and the coalition was destroyed by the Treaty of Basle in 1795 with Prussia and Spain, and by that of Campo-Formio with Austria in 1797. The countries beyond the Rhine and the Alps, which were occupied by the French armies, were organized into republics on the French model; the Batavian republic arose in Holland, the Helvetian in Switzerland, the Ligurian at Genoa, the Cisalpine in Lombardy, the Roman in Rome and Parthenopean at Naples. England was left to carry on the war alone, and France prepared to invade Ireland and dispatched an expedition to Egypt in 1798.

A second coalition between England, Russia and Austria succeeded in reconquering Italy, but was checked by the defeat of the Russians in Switzerland and the failure of the English invasion of Holland (1799). The French victories over the Austrians in 1800, in Italy at Marengo, and in Germany, at Hohenlinden, compelled Austria to sign the treaty of Lunéville by which France remained mistress in Italy, and in 1802 England concluded peace with France at Amiens. (*See* FRENCH REVOLUTIONARY WARS.)

Napoleon.—Master of France since 1799 Napoleon extended his power over all neighbouring countries. He regulated the affairs of Germany in agreement with the German princes who, on the pretext of indemnifying themselves for the loss of possessions on the left bank of the Rhine, annexed the territories of the princes of the Church, of the towns and of the landed gentry, in 1803. Aroused by the colonial and maritime ambitions of Napoleon, England resumed the war in 1803. Napoleon prepared to invade England, but was forced to abandon his idea after the victory of Trafalgar, which finally assured to the British the mastery of the seas. He turned the army in readiness at Boulogne against Austria, which had just formed the third coalition with Russia and England. The surrender of the Austrian army at Ulm, and the defeat of the Austrians and Russians at Austerlitz in 1805, compelled Austria to sue for peace. The Holy Roman Empire was destroyed in 1806 when the emperor took the title of emperor of Austria; the diet was suppressed, and a great part of the German States united in a confederation of the Rhine under the protection of Napoleon; the most powerful princes, those of Bavaria, Württemberg and Saxony took the title of king.

The peace negotiations with England led to no result. Prussia, which had entered into the war on account of Hanover, was defeated at Jena in 1806 and subsequently invaded, the whole country being occupied. The Treaty of Tilsit, which was concluded in 1807 after a personal interview between Napoleon and the tsar, Alexander, deprived Prussia of her Polish provinces, which were made into a grand-duchy of Warsaw. Prussia was to remain in the occupation of the French troops until a heavy indemnity had been paid, and she was forced to reduce her army to 40,000 men. For the purpose of striking at British commerce, Napoleon decreed his Continental System (*q.v.*) to which the British Government replied with the Orders in Council. All commerce was forbidden between the British Isles and the countries under the influence of Napoleon, but nevertheless, trading relations with Great Britain continued under the guise of contraband, with the assistance of the inhabitants of these countries. The British dispatched to Copenhagen a squadron which captured the Danish fleet in 1807, and when Napoleon invaded Portugal the British navy conveyed the royal family in safety to Brazil. Napoleon, who had now become emperor, transformed the neighbouring republics into kingdoms (Holland, Italy, etc.); created in Germany the kingdom of Westphalia; conquered the kingdoms of both Naples and Spain, and gave the crowns to his brothers and brother-in-law. To make the blockade effective he annexed Holland, the shores of the North sea and the western coast of Italy, and thus the French empire extended over part of Germany and Italy.

Indifferent to the sentiment of nationality Napoleon enraged the Spaniards by giving them his brother Joseph as king, and he irritated the Germans by his repressive rule. The Spaniards took up arms against him and involved him in a war that wore out his armies; the king of Prussia chose for his ministers men who reformed the army and the civil Government; and when Austria made an appeal to the patriotism of all Germany, Napoleon declared war upon her, defeated her at Wagram in 1809, dismembered her, and in 1810 married an Austrian archduchess, who in the following year bore him a son, whom he called the king of Rome. Napoleon sought to make Paris the capital of Europe and regarded himself as the successor of Charlemagne; when he went to war with Russia he compelled Austria and Prussia to become his allies and supply him with troops; his domination

extended over the whole of Europe with the exception only of Russia, Sweden, Great Britain, Sicily, Sardinia (where the kings of Naples and Sardinia had taken refuge), Portugal and the heel of Spain. But he had used up successively two immense armies.

Fall of Napoleon.—This far-reaching empire collapsed suddenly. The army with which Napoleon invaded Russia was composed of representatives of all the European nations; at Moscow it became demoralized through too long a sojourn and was completely destroyed in 1812 during the retreat from Russia. The Prussian troops went over to the Russians, but although Napoleon commanded only a hastily recruited army, he succeeded in checking the Russo-Prussian forces in Saxony. But Austria now joined the general coalition, and on Oct. 18, 1813, the armies of the Great Powers—Great Britain, Russia, Austria and Prussia, won the victory of Leipzig, compelling the French to evacuate the whole of Germany. The allies invaded France and despite the opposition of Napoleon reached Paris in 1814. Europe was freed from the tyranny of the foreigner; France lost all her conquests.

But the influence of the revolution survived the Napoleonic empire. In all the countries which he had controlled or occupied France had destroyed the authority of the Church, abolished the privileges and rights of the nobles, and set up religious toleration and the equality of all citizens before the law. The empire had carried on the work begun by the republic, and it is in this sense that Napoleon has been called the Apostle of the Revolution. Europe emerged from this crisis transformed, the whole conditions of her political life—in Belgium, Holland, Switzerland, Spain, Italy, Germany and even Prussia—being completely changed. (*See* NAPOLEONIC CAMPAIGNS.)

THE CONCERT OF EUROPE AND THE POLICY OF INTERVENTION

The defeat of Napoleon put an end to the attempt to unite Europe under the domination of a single State. The four great Powers—England, Russia, Austria and Prussia—who in 1814 assumed the title of allies, decided the fate of Europe. The allies determined to confine France within the frontiers of 1790 and to restore the dynasty of the Bourbons. With the restored king of France they signed the Treaty of Paris of May 30, 1814, and announced their intention of establishing "a firm peace, based on a just equilibrium of strength between the Powers." The great Powers were united in their determination to keep the peace of Europe by maintaining the balance of power, and, as they alone possessed power, they agreed among themselves on the measures to be taken and imposed their decision on all the other States.

The Congress of Vienna.—The Treaty of Paris restored to the allies all the territories that had been annexed to France since 1790, as well as those of the States created by Napoleon (Belgium, Holland, the left bank of the Rhine, Italy, Germany, the grand-duchy of Warsaw) and also the kingdom of Saxony which the allies themselves had conquered in 1813. The allies summoned to Vienna a general congress of the representatives of all the States which had taken part in the war, to regulate the re-distribution of these territories (*see* VIENNA, CONGRESS OF); but in a secret article they reserved to themselves the right of determining between them the arrangements for the countries evacuated by France. They only referred to the congress the definitive settlement of Germany and Poland.

The congress thus appeared as a sovereign assembly of the representatives of all Europe, who for the first time gave a body to European unity. But in truth the congress did little more than register the decisions of the allies. The representatives of small States were not even permitted to discuss them. The discussions over the territories of the king of Saxony became so violent that the concert of the allies was temporarily broken and agreement was only restored by a compromise which gave Prussia four non-contiguous districts in place of Saxony. No question was discussed in the congress and all the arrangements were effected in the form of separate treaties between the different States and summed up under the title Final Act of the Congress of Vienna.

The deliberations had not yet reached their conclusion when Napoleon, who had escaped from Elba, restored the empire. The representatives assembled at Vienna declared, in the name of Europe, that Napoleon Bonaparte was "the enemy and disturber of the peace of the world," and undertook to preserve against all attack the order so happily re-established in Europe (March 24, 1815).

Territorial Settlement in Europe.—The territories annexed by France in Italy and Germany were restored to their former and legitimate sovereigns, but none of the States which had been suppressed in Germany in 1803 were restored. The king of Bavaria received the Palatinate on the left bank of the Rhine; Prussia took the Polish province of Posen, received as indemnity three German provinces (Saxony, Westphalia and the Rhine Province), and acquired the remainder of Swedish Pomerania. Germany was formed into a confederation of sovereign States represented by a diet. In Italy the Genoese and Venetian republics were not restored, and Genoa was annexed to the kingdom of Sardinia. Austria received the Milanais and Venice, which were united in a Lombard-Venetian kingdom, and in Germany she received the ecclesiastical domain of Salzburg. Switzerland acquired the former bishopric of Basle and a piece of Savoy; Belgium and the kingdom of Holland were united into the kingdom of the Netherlands; and Norway, which was taken away from the king of Denmark, was given to the king of Sweden. Russia and England retained their conquests; England kept Malta and Heligoland, the protectorate of the Ionian Islands, and, outside Europe, the Dutch colonies in the Cape as well as Ceylon and Mauritius, while Russia retained Finland, which she conquered from the Swedes, and Bessarabia, which she had taken from Turkey. These arrangements were made secretly by the Governments, and without consulting the peoples of the countries concerned; they were based on the claims of legitimate princes and the denial of any right on the part of the peoples to determine their own destiny.

The Holy Alliance.—The tsar Alexander wished to strengthen the political alliance between the sovereigns by one of a mystic nature, and hence arose the agreement known as the Holy Alliance (*q.v.*), by which the European monarchs undertook to regard themselves as appointed by Providence to rule the three branches of a single family. It was a pact of Christian brotherhood; but, while Louis XVIII. adhered to it, out of regard to the tsar, the British Government refused their assent, and it resulted in a mere demonstration, having no practical effect. The public, however, confused it with the Quadruple Alliance, formed in 1814, and were thus in the habit of calling the coalition of the allies against France "the Holy Alliance."

Treaties of 1815.—The events of the Hundred Days (*see* WATERLOO CAMPAIGN), determined the allies to adopt new measures in regard to France, and by the treaty of Nov. 10, 1815, they forced her to surrender her frontier fortifications, to pay an indemnity, and to submit to the occupation of a part of French territory until payment had been made. Napoleon and his family were for ever excluded from the French throne, and in certain secret articles the four allied sovereigns agreed to hold, at stated intervals, conferences for the prosecution of common interests and the examination of the means of maintaining the peace of Europe. Their ambassadors at Paris were to meet once a week to enquire into the condition of France and to give advice to the French Government; the conference was presided over by Wellington, the commander-in-chief of the allied army of occupation, who was informed by his Government that the allies had promised Louis XVIII. to uphold him by force of arms against all revolutionary movements. Thus there came into being a permanent European institution destined to furnish legitimate monarchies with an instrument for "intervention" in their internal affairs, and these measures—which were specially directed against France—stamped upon French public opinion a violent hatred of the treaties of 1815, which for half a century was to be a cause of anxiety to Europe.

Metternich.—The Vienna treaties only guaranteed the maintenance of the territorial *status quo* in Europe; but the allies felt that to maintain peace, which they conceived to be threatened by the spirit of revolution, it was necessary to uphold the internal established governmental system of the States by supporting

"legitimate" sovereigns against their subjects. Of all the allied Governments, that of Austria was the most hostile to innovations. The emperor Francis said, "My empire is an ancient edifice; if it is touched it may crumble."

Metternich, who directed the foreign policy of Austria, summed up the theory in general formulae and extended the principle to the whole of Europe. "The basis of contemporary politics," he wrote in 1817, "is and must be peace and quiet"; he regarded every "constitution" as a potential means of disorder devised by those whom we should now call "the intellectuals," and held that "the people at large dreaded the movement"; it was the rich, the civil servants, the writers, the lawyers and teachers who, with their battle cry, "the Constitution!" were really aiming at innovation and disorder. "The aim of the agitators," he wrote, "is the *overthrow* of everything by law existing; the guiding principle of kings, on the contrary, should be to *conserve* everything by law existing." This maintenance of the *status quo* is the policy known as "Metternich's system."

Liberal Movement.—Ever since 1814 the same political system had obtained throughout almost the whole of Europe; with the exception of France, the Netherlands, Switzerland, Sweden and Norway, all the European States were absolute monarchies in which the power of the throne was uncontrolled by any Constitution or elected assembly. As lands had been distributed among princes without regard to the feelings of the peoples, Europe had been divided into States irrespective of nationalities. Germany, Italy and Poland had thus been dismembered, while a single State—the Austrian empire—united under one Government many nationalities.

This system was intolerable, both to those who desired to set up a Constitution as a means to political liberty, and to those who sought to create States on a basis of nationality. These malcontents formed an opposition, henceforward called Liberal, and one which was later to be known as National. The Liberals and the Nationalists, in struggling against the same enemy, united in an attempt to destroy the system set up in 1815, and as all the European Governments were in agreement in seeking to maintain it, the opposition in each country had common interests with those in other countries and sought to act in concert with them. Since the Governments made it impossible for the oppositions to act in accordance with the law, they pursued illegal courses, by means of secret associations, murder and intrigue. (*See* CARBONARI.) Their most efficacious method was to win over officers of the armies in order to compel the Government by means of military revolts to grant Constitutions.

The Congress.—The Tsar Alexander had retained the liberal and humanitarian fancies that had at first brought him into conflict with Metternich in Germany and Italy. In order to discourage the opposition, Metternich wished to make plain to Europe the agreement of the great Powers. When Wellington declared that France could be evacuated without danger to the peace of Europe, the allies arranged the evacuation at the conference of Aix-la-Chapelle (*q.v.*) in 1818. By inviting the king of France to enter into the alliance of the great Powers and by terminating the permanent session of the ambassadors' conference in Paris, the allies put an end to the exceptional position hitherto occupied by France. But by secret convention they agreed to make common cause in the event of a revolution in France which might menace the security of her neighbours. This conference was a decisive success for Metternich; for Alexander, disquieted by the French elections in 1819, and enraged by the assassination, by a German student, of the Russian agent Kotzebue, became a convert to the policy of intervention.

For some years Metternich directed the policy of Europe. He took advantage of demonstrations on the part of German students and afterwards of four military revolts in 1820 in Spain, Portugal, Naples and Sardinia to assemble congresses, which always met on the Austrian soil, at which the great Powers took steps for intervention in the internal affairs of other States. The congress of Carlsbad in 1819 imposed on all the German States a system of police surveillance of the universities and the press; the congress of Troppau in 1820, which was subsequently transferred to Laibach, decided the intervention of the Austrian army in the Neapolitan kingdom; while the congress of Verona in 1822 determined the French armed intervention that restored absolute monarchy in Spain. The three great autocratic Powers—Austria, Prussia, Russia—signed a declaration by declaring that any European State in a condition of internal revolution should remain excluded from the concert of Europe until law and order had been restored, and they reserved to themselves the right of using force to re-establish that order. Thus there came into international law the principle of intervention, and the Governments which were united in their common battle against the revolution sought not only to maintain by force the territorial settlement of 1815, but also the autocratic form of government. They established themselves as the supreme political court of Europe for the control of international affairs. (*See* TROPPAU, CONGRESS OF; LAIBACH, CONGRESS OF; VERONA, CONGRESS OF.)

The English Policy of Non-intervention.—The policy of the English government was in direct opposition to that of the other great Powers. In 1818, at Aix-la-Chapelle, Castlereagh repudiated the idea of a consolidated alliance which would compel each State to maintain the succession and would defend the Government and internal administration of every state against attack, on the ground that "such an alliance would pre-suppose a collective Government capable of constraining all kings and nations to one code." In 1820 Castlereagh declined to adhere to the declaration of Troppau which in his view amounted to an invitation to all the states to submit to the jurisdiction of the alliance. On the occasion of French intervention in Spain (1823), Canning declared that the "alliance had been formed against the military domination of France and not for the purpose of governing the world or of superintending the internal affairs of other states"; he protested against the "system of policing Europe" and added that England "should insist on the right of nations to choose for themselves the form of government that they judged best." Thus to the principle of intervention Canning opposed non-intervention and to the ancient right of legitimate monarchies the new right of nationalities. It is true that by "nations" he meant only the State within the territorial limits established by the treaties of 1815, and it never occurred to him to recognize a right in any State to adjust its frontiers in accordance with national sentiment. Nevertheless, his formula—the right of nationalities—was to be a factor in the complete transformation of the map of Europe. (*See* LONDONDERRY, SECOND MARQUESS OF; CANNING, GEORGE.)

Weakened by the attitude of England, the European concert was broken up by revolutionary crises that arose in two countries which had not been affected by the settlement of 1815: the Spanish colonies in America and the Ottoman empire. The government of the United States set the example by recognizing the independence of the republics founded by the colonists who had revolted against Spain. (*See* MONROE DOCTRINE.) Canning refused to be a party to this recognition while at the same time he declared that any attempt at intervention on the part of France in America would be looked upon as a *casus belli;* and, in 1824, in order to open Spanish-America to British commerce, he recognized the new American republics as independent states in opposition to other Powers who wished to support the king of Spain. But the policy of intervention finally came to grief in the Greek revolt. The Ottoman empire had never been a party to the treaties of Vienna, and Europe had not guaranteed its territory; moreover, the tsar Alexander disliked the idea of forcing Christians to submit again to the yoke of the Infidel. Public opinion throughout Europe was aroused to enthusiasm on behalf of the Greeks. At first the European Governments remained neutral, but, in 1823 Canning recognized the belligerency of the Greeks. A conference summoned by Alexander offered the sultan the mediation of the Powers (1825), but without success. Nicholas I., newly on the Russian throne, entered into an agreement with England to put an end to the anarchy in Greece by an intervention to which France was also a party (1827); and the unexpected result of this policy was the battle of Navarino which led to war between Russia and Turkey, the invasion of Turkey

by the Russians in 1829 and the establishment of a small Greek kingdom.

The Crisis of 1830.—The 15 years that had elapsed since 1815 had been for the internal policy of Europe a period of repression and silence in the autocratic monarchies and of torpor in the two constitutional monarchies. In England these years were occupied by agitation for reforms and in France by discussions in the chambers. But economic prosperity brought to the fore new Liberal leaders who were ready to take office in England and France and who had formulated the theory of parliamentary government, in which the sovereign power of a constitutional monarch is transmitted to an assembly by the intermediary of responsible ministers.

The crisis began in France in the conflict between Charles X. and the chamber, and led to a Parisian insurrection against the Bourbons under cover of the tricolour. The revolution of 1830 ended in the accession of Louis Philippe who summoned the middle classes to power and accepted parliamentary government. Belgium, following the example of France, also had a revolution, the result being the creation of the kingdom of Belgium; and the same example led in Switzerland to an agitation that brought the Radicals to power in many cantons. The crisis which arose out of the agitation for electoral reform gave the British government into the hands of the Liberal party, who finally introduced into British political life their system of responsible government.

Europe was thus divided between two opposing groups, of which the one was led by the parliamentary monarchies of France and England, and the other by the three autocratic monarchies. Each of these groups sought to interfere in the internal affairs of its neighbours in order to support therein the political system which it practised itself. Thus England and France recognized the Belgian kingdom and in 1831 defended it against the army of the king of the Netherlands; they also aided the supporters of constitutional monarchy in Portugal and in Spain. Austria, on the other hand, dispatched an army to destroy the Provisional Governments that had been established in the Italian duchies and the Romagna, and, in agreement with Prussia, repressed liberal and democratic agitation in the small German States; while the tsar in 1831 crushed with a heavy hand the nationalist rising of the Poles.

The Eastern Question.—The Eastern Question (*q.v.*) brought Russia and England into opposition; for while Russia sought to obtain the paramountcy at Constantinople and to open the Dardanelles, the British Government believed that any attempt on the complete independence of the Ottoman empire would threaten the route to India. A Turkish internal crisis in 1832 brought the question to the front, for when the sultan, who was alarmed by the victory won by Mohammed Ali (*q.v.*), the pasha of Egypt, appealed for help to the tsar, the latter dispatched an army and a fleet to defend Constantinople: in the following year the sultan signed a treaty with Russia undertaking to close the Straits to the navies of other powers, thus creating a Russian protectorate in disguise.

The sovereigns of Austria, Russia and Prussia strengthened their *entente* at the interview at Münchengrätz followed by the secret treaty of Berlin (Sept.–Oct. 1833). In view of the dangers with which the order established in Europe by international law and the treaties of 1815 were threatened, they declared themselves unanimously resolved to re-affirm their conservatism as the unalterable basis of their policy, and added that every independent sovereign has the right, in cases as well of trouble within his kingdom as of dangers threatened from without, to call to his aid any other independent sovereign. This amounted to a solemn affirmation of the doctrine of intervention. Henceforth the Powers who had formed the concert of Europe were grouped into two opposing camps. Supported by a hardy public opinion in Great Britain, Palmerston led the Liberal States while Nicholas, proud of his military strength, supplanted the aged and weakened Metternich in the command of the Absolutists.

The Quadruple Alliance.—Spain and Portugal were in the throes of a war of succession between two queens who were minors, Maria of Portugal and Isabella of Spain, and their uncles, Miguel of Portugal and Don Carlos of Spain, both supporters of absolute monarchy. The Liberals took the part of the young queens and the British Government intervened in their behalf. Palmerston induced Portugal and Spain to ally themselves with England and he could not deny to France the entry into this quadruple alliance (1834); and in both countries the civil wars ended in the establishment of constitutional monarchies under the protection of England and France although the Carlists and Miguelists had the moral support of the Allies of Münchengrätz.

The Eastern Question in 1840.—It was, however, difficult to maintain an entente between England and France, seeing that the respective Governments had to reckon with the national vanity of a sensitive public, excited by memories of the old established rivalry between the two nations. Louis Philippe, on his part, wishing to be admitted into the "family of sovereigns" sought to make friends with the Continental monarchies. In Greece, Spain and Portugal, the British and French Governments each supported one of two opposing parties. The rupture could no longer be concealed when a new crisis was provoked by the Eastern Question. Mohammed Ali (*q.v.*), attacked by the sultan, once more occupied Asia Minor in 1839; and the Powers determined to intervene. But the British and French Governments were unable to agree upon the conditions to be imposed on the belligerents. The French people were enthusiastic supporters of Mohammed Ali whom they looked upon as a protégé of France. Palmerston secretly negotiated with the three other great Powers and concluded with them and the sultan the Convention of London in 1840, which delivered an ultimatum to Mohammed Ali, and France found herself isolated before a coalition of the allies of 1815. The Eastern Question had created a European crisis and Nationalist passions awoke in the middle classes and the literary world. In France there was talk of destroying the treaties of 1815 and reconquering the Rhine frontier to which the German reply was an anti-French agitation for a defence of the "German Rhine." The crisis terminated in the submission of Mohammed and in the Straits Convention (1841) by which the sultan undertook to close the straits to warships. The Russian minister, Nesselrode, congratulated himself on having re-established "the federative system of the European States on its old basis." (*See* also EASTERN QUESTION.)

France and England.—The entente between France and England was officially re-established by the Conservative Government of Peel. This was the *entente cordiale* to which expression was given by an exchange of visits between Queen Victoria and Louis Philippe (1843–45). Nevertheless the two nations continued to disagree, as was shown by the opposition of the chamber in the affair of the right of search and in the affair of the payment of an indemnity to the missionary Pritchard, at Tahiti, and by the British protests against the project of a Franco-Belgian customs union. In 1845 France and Great Britain made common cause in attempting to settle the question of the marriage of Queen Isabella of Spain and her sister the Infanta Louise. But the French and English ambassadors at Madrid, who were personal rivals, worked in a sense contrary to the instructions of their Governments. Palmerston, who had returned to the Foreign Office in 1846, complicated the question by a protest against the arbitrary Government of the Queen Regent, Christina. Louis Philippe, however, who was aiming at securing the succession to the Spanish throne for his descendants, ignored the convention of 1845 by which he had promised not to permit the marriage of his son to the infanta until the queen had been married to a Spanish Bourbon, and an heir born to the throne. The marriage of the Duc du Montpensier with the infanta was celebrated on the same day as that of the queen, and thereupon Palmerston broke off the entente with France. (*See* SPAIN.)

Liberalism and Nationalism.—Embroiled with England, Louis Philippe made common cause with the absolute monarchies. England remained isolated. Palmerston took upon himself the rôle of protector of Liberalism in Europe. He sent Lord Minto on a special mission to encourage the Italian princes to undertake reforms in their States against the wish of the Austrian

Government. For long he engaged in negotiations with the great Powers who wished to intervene in Switzerland in support of the Catholic league or *Sonderbund,* in its conflict with the Federation, and thus gained time to enable the Federal Government to end the war by destroying the *Sonderbund.* (*See* SWITZERLAND.)

During the long peace new parties arose in Europe in opposition to the existing political, national, social and ecclesiastical systems. Their agitation prepared a way for a radical change in the conditions of national life. As early as 1817 a struggle had commenced in England between the Radicals, who demanded universal suffrage, and the supporters of the existing electoral system, by which the right to vote was denied to all save the privileged classes. The first victory of this campaign, which became general throughout Europe, was won by the Radicals in some cantons in Switzerland, in 1830. Shortly after the Parisian insurgents, who had conquered the Bourbons, revived the republican traditions of 1793, and attempted, by means of insurrections, to overthrow hereditary monarchy and establish a republic. These aspirations towards political equality, which usually displayed themselves under the guise of republicanism were collectively described by the vague term "democracy." Their supporters were to be found, above all, among the youth of the great cities, and these were organized into an international party by the Italian, Mazzini (*q.v.*). He established a secret society called Young Europe, which was divided into national sections and had for its object the establishment everywhere of democratic republics.

In countries in which the sentiment of nationalism was wounded by the political system the agitation for unity or autonomy became more intense through alliance with democratic agitation. Victorious in Belgium in 1830, crushed in Poland, Italy and Germany, it reappeared in Hungary in the union between the Magyar nobles and the democratic orator Kossuth (*q.v.*); in Germany after 1840, with the connivance of the princes; in Italy, under the form of the *Risorgimento,* with the protection of the sovereigns of Sardinia and Tuscany; in Bohemia, under the leadership of Professor Phalacky; and in Croatia under the inspiration of the journalist, Gay.

The industrial revolution, which began in England in the 18th century with the growth of great industries, had brought to life, in countries where industry was highly developed, a new class of workers who had no security within the established order of society. They lived from day to day as propertyless wage-earners unattached to the soil. Philanthropists and philosophers in England and France had drafted plans of reforms which, about 1830, came to be known as "Socialism." Their doctrines were disseminated in England among the workmen in the great industries by the agitation promulgated by Robert Owen (*q.v.*) and in Chartism (*q.v.*). In France they attracted the republican secret societies who, in the tradition of Babeuf, reverted to the name of Communism and adopted a new revolutionary emblem, the red flag, which was destined to become the banner of international revolution. Socialism won converts among the German workers living in France who subsequently spread it among the workers of western Germany. The creation of the Socialist ideal had already been achieved in 1848 by the common efforts of Englishmen and Frenchmen. The latter had made their contribution mainly in the criticism of existing social institutions: ownership, inheritance, commercial competition, and by theories such as the right to work, social democracy, anarchism, the emancipation of the proletariat and progressive taxation. The English contributed practical methods of reform such as trade unions, co-operative societies, congresses of delegates, the general strike, and a labour party based on class warfare. Karl Marx, a German Jew, who was first a refugee in France and then in England, reduced this mass of theories and ideas to a scientific system which he and Frederick Engels gave to the world in the "manifesto of the Communist Party" (1848) terminating with an appeal for the union of revolutionary workmen throughout the world.

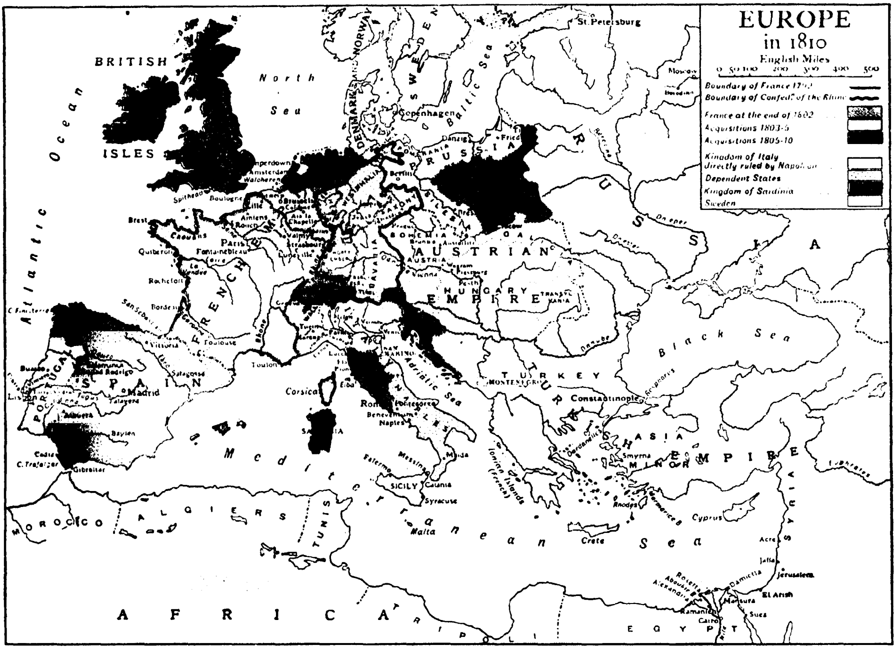
The traditional policy of the Catholic clergy had been to keep on good terms with the secular government for the sake of mutual support. About 1830 there grew up in Ireland, France and Belgium a party of "Catholic Liberals" which was condemned by the pope. In the Catholic cantons of Switzerland there arose a democratic Catholic party which recognized the supremacy of the Pope over the secular power.

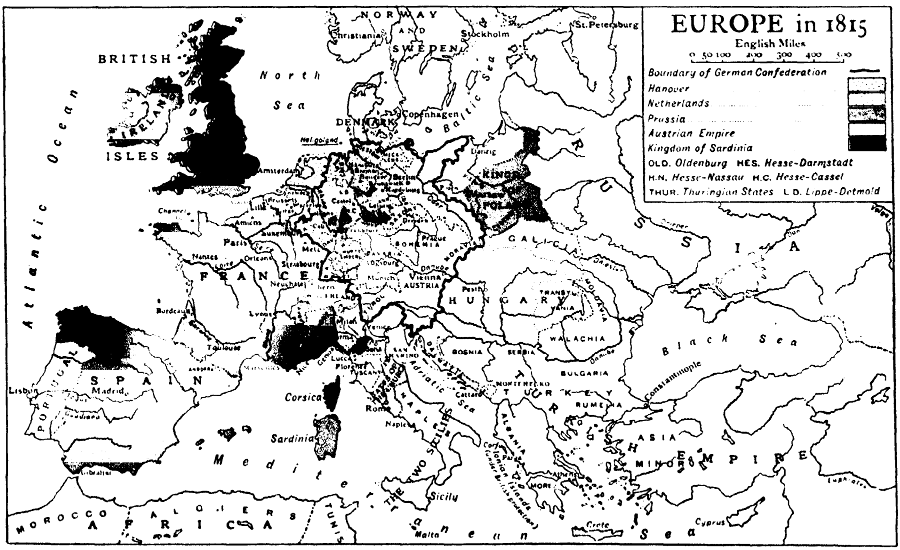
WAR AND REVOLUTION

Revolutions of 1848.—A revolutionary movement of a democratic and nationalist character common to nearly all the European States completely transformed the political life of Europe. It began in Italy with a local revolution in Sicily in Jan. 1848, and after the revolution of Feb. 24 in France the movement extended throughout the whole of Europe with the exception of Russia, Spain and the Scandinavian countries. In Great Britain it amounted to little more than a Chartist demonstration and a republican agitation in Ireland. In Belgium, the Netherlands and Denmark it manifested itself in peaceful reforms of existing institutions; but democratic insurrections broke out in the capitals of the three great monarchies, Paris, Vienna and Berlin, where the Governments, inexperienced in the art of repression and rendered powerless by their fear of "the revolution"—to them a mysterious and irresistible power—did little to defend themselves. The revolution was successful in France alone; a republic and universal suffrage were established, but the quarrel between the supporters of the *république démocratique* and the partisans of *république démocratique et sociale* culminated in a workers' insurrection in June 1848. In Austria where the new ministers promised to grant constitutions, the monarchy withstood the storm, and in Prussia King Frederick William, who led the movement for the unification of Germany, hoisted the black, red and gold flag that had become the symbol of German unity. The German Governments agreed to the convocation of three constituent assemblies at Berlin, Vienna and Frankfurt by which democratic constitutions were to be drafted for Prussia, Austria and Germany. In Italy, at first, the revolution only took the form of a nationalist rising against Austria led by the king of Sardinia under Italian tricolour, the "white, red and green." The republic was proclaimed in 1849, and then only in Rome and Tuscany. Within the Austrian empire the nationalities subjected to the German Government of Vienna agitated for a national government and Hungary succeeded in organizing itself on an autonomous basis.

This upheaval seemed to indicate a redistribution of the territories of Europe. In the name of the Provisional Government in France, Lamartine declared that the treaties of 1815 were no longer valid in the eyes of the French republic, but he added that he accepted the territorial delimitations effected by those treaties. France did not lend her support to the revolutionaries in Europe.

Reaction in Europe.—The restoration had commenced even before the revolution was over and it was accomplished by the armies that had remained faithful to their respective Governments. Military repression was first employed in Paris by Cavaignac against the insurgents in June, and by Windischgrätz on June 17th against the Czechs in Prague, and later by the Austrian army in Lombardy and in Vienna; then in Berlin in December, and in 1849 by the Prussian army in Saxony and Baden. Order was only restored in Rome by French intervention, and in Hungary with the help of the Russian army. The king of Prussia, having refused the title of Emperor offered to him by the assembly, sought to achieve the unity of Germany by a union between the German princes. Austria and Russia, however, compelled him to abandon his design by the Convention of Olmütz in 1850. The immediate result of the reaction became manifest in the withdrawal of liberal democratic or nationalist concessions which had been made during the revolution: universal suffrage, liberty of the press and of assembly. Absolute monarchy was re-established in Germany, Austria and Italy, and the Governments, in alliance with the middle classes and the clergy, who were terrified by the socialist proposals, strengthened the police forces and organized a persecution of the popular press and associations which paralysed political life. In France the reaction led to the *coup d'état* against the assembly on the part of


EUROPE in 1810
English Miles
0 50 100 200 300 400 500
Boundary of France 1792
Boundary of Confed. of the Rhine
France at the end of 1802
Acquisitions 1803-5
Acquisitions 1805-10
Kingdom of Italy
Directly ruled by Napoleon
Dependent States
Kingdom of Sardinia
Sweden
BRITISH ISLES
Atlantic Ocean
North Sea
Baltic Sea
St. Petersburg
Copenhagen
RUSSIA
AUSTRIAN EMPIRE
HUNGARY
FRENCH
SPAIN
PORTUGAL
Madrid
Paris
Black Sea
TURKEY
Constantinople
ASIA MINOR
Mediterranean Sea
Adriatic Sea
Corsica
SICILY
Malta
Crete
Cyprus
MOROCCO
ALGIERS
TUNIS
AFRICA
EGYPT
Cairo
Jerusalem


EUROPE in 1815
English Miles
0 50 100 200 300 400 500
Boundary of German Confederation
Hanover
Netherlands
Prussia
Austrian Empire
Kingdom of Sardinia
OLD. Oldenburg HES. Hesse-Darmstadt
H.N. Hesse-Nassau H.C. Hesse-Cassel
THUR. Thuringian States L.D. Lippe-Detmold
NORWAY AND SWEDEN
Stockholm
St. Petersburg
BRITISH ISLES
IRELAND
Atlantic Ocean
North Sea
Baltic Sea
DENMARK
Copenhagen
Heligoland
Amsterdam
RUSSIA
GALICIA
FRANCE
Paris
AUSTRIA
Vienna
HUNGARY
SPAIN
PORTUGAL
Madrid
Lisbon
Black Sea
Constantinople
TURKEY
BOSNIA
SERBIA
WALACHIA
BULGARIA
RUMELIA
ALBANIA
ASIA MINOR
Corsica
Sardinia
Sicily
THE TWO SICILIES
Mediterranean Sea
Adriatic Sea
Malta
Crete
Cyprus
MOROCCO
ALGIERS
TUNIS
AFRICA

Prince Napoleon on Dec. 2, 1851, and the re-establishment of the hereditary empire in 1852.

The restoration, however, was not complete, universal suffrage was not abolished in France; in Prussia, the Constitution of Jan. 1850, which established an elective assembly, and, in Sardinia, the Constitution of March 1848, were retained; the signorial rights were not restored in Austria.

Napoleon III.—The proclamation of the French empire was a violation of the treaties of 1815 by which the house of Bonaparte had been for ever excluded from the French throne. The great Powers recognized Napoleon III. because he re-established the monarchy in France and because he promised in a secret protocol to maintain the *status quo*. Nicholas of Russia, however, sought to address him only as "bon ami" instead of the customary "cher frère." Absolute master of France, Napoleon abandoned a policy of peace. As the enemy of the treaties of 1815 which had been directed against his own family and as the friend of the Italian patriots who were exasperated by Austrian domination, Napoleon wished to destroy the work of the allies of 1815, to expel the Austrians from Italy, and to obtain an increase of territory as a recompense. It was his desire both to help nationalities to become states and to annex territories to his empire. For this two-fold purpose he worked with the revolution, and was ready to go to war in order to rearrange the map of Europe. He knew that his ministers did not approve of his policy and so he concealed his plans and actions from them, and by means of secret agents made moves that were in opposition to the official policy of his Government.

Crimean War.—Proud of having kept Russia free from revolution, Nicholas proposed to England (Feb. 1853) a plan for the division of the Ottoman empire but encountered a decided refusal. Next, on the pretext of regulating the conflict which had arisen over the holy places in Palestine, he despatched to Constantinople a special mission for the purpose of intimidating the sultan; but the arguments of the British ambassador, Stratford Canning, decided the Turkish ministers to reject the secret treaty offered to them by the tsar, whereupon Nicholas broke off diplomatic relations with Turkey and sent troops to occupy the Rumanian principalities. The British government intervened, and Napoleon, although quite indifferent to Turkey, seized the opportunity to break the allied entente of 1815 and to conclude a treaty of alliance with England and the sultan. For the first time since 1815 the great Powers made war upon one another. The Russians, defeated by the Turks on the Danube, evacuated the principalities, and the scene of war shifted to the Crimea, where the conflict went on until the capture of Sebastopol. (*See* CRIMEAN WAR.) The Austrian Government took no part in the war, but discussed with the allies the conditions of peace to be imposed in Russia. Napoleon took advantage of the Franco-British alliance to enter into federal relations with Queen Victoria who visited him in Paris; this being the first occasion on which an English sovereign had set foot in Paris since the 15th century. The charm of the emperor's personality made a strong impression on the English queen.

Nicholas I. died in March 1855, and his son Alexander II. agreed to the terms proposed by Austria: peace was concluded in Paris by a congress of representatives of the great Powers, the sultan and the king of Sardinia who had sent troops to the Crimea. The Powers guaranteed the integrity of the Ottoman empire, and the sultan, in return, promised to introduce reforms; the Black sea was neutralized and closed to ships of war; Rumanian principalities were declared autonomous; a part of Bessarabia was restored by Russia to Moldavia; and the concert of Europe was re-established and completed by the entry of the Ottoman empire. Acting as the representative of a united Europe, the congress laid down (1856) the rules of maritime international law in time of war and forbade states to give letters of marque to privateers; this maritime declaration marks a stage in the creation of a recognized system of international law.

The congress of Paris was a personal triumph for Napoleon who had for the first time welcomed a European Congress to France. His house which had been proscribed in 1815, was restored to the society of reigning families and he saw the time was ripe for seeking to obtain the aid of one of the great Powers in the execution of his plans in Europe. He approached Russia with a promise to assist her in ameliorating the terms of the treaty of 1856; and in order to quiet the apprehensions of England, which were aroused by his friendship with Russia, confided his plans to Prince Albert in 1857. In the same year he met Alexander at Stuttgart; a project of alliance was drafted, Napoleon proposing to ally himself with Russia so long as he was not forced thereby to embroil himself with England. The interview was abortive, for while Napoleon sought allies to destroy the treaties of 1815, the European sovereigns would only negotiate with him to maintain them.

The Union of Italy.—Thus frustrated, Napoleon determined to act alone. He met Cavour, the foreign minister of Sardinia, secretly at Plombières and promised him to free Italy up to the Adriatic; in exchange he demanded Savoy and Nice. Daunted by the opposition of his ministers, his court, and the other sovereigns, Napoleon did not dare to take the initiative in making war. Victoria implored him in the name of the welfare of Europe to respect the treaties; and it was the Austrian Government which summoned Sardinia to disarm and commenced the war. The Italian war ended in the expulsion of the Austrian from Lombardy. (*See* ITALIAN WARS.) But when Prussia mobilized her army on the French frontier, Napoleon ceased operations and sought an interview with the Austrian emperor at Villa Franca where (July 1859) they arranged the terms of the peace that was subsequently signed in November at Zurich. Austria ceded Lombardy but retained Venetia—a cruel disappointment for the Italians. All the Italian States were to be united in a confederation. It appears that Napoleon did not wish for the unification of Italy, but only to establish a confederation of States on the German model.

The Provisional Governments set up in the States that had revolted against their princes in Tuscany, Parma and Modena, and against the Pope in Romagna, desired annexation to the kingdom of Sardinia. Napoleon gave way but demanded the cession of Savoy and Nice which he annexed to France, notwithstanding his promise of 1859 that he would seek no personal advantage from the war. The annexation of Nice and Savoy aroused the mistrust of Europe, and France found herself henceforth isolated. The unification of Italy was achieved by the Sicilian expedition of the republican Garibaldi (*q.v.*) and by the occupation of a part of the Papal States by the Sardinian troops. These states were now annexed to the kingdom of Sardinia and Victor Emmanuel took the title of king of Italy, after a plebiscite had revealed that the annexation had been made by the will of the people and in accordance with their right to decide their own destiny. A revolutionary principle was thus introduced into international law.

The kingdom of Italy, which had thus been formed in violation of the treaties and by revolutionary means, was condemned by the Pope and was at first recognized by England alone of all the Powers. The Liberal British cabinet had recognized the right of a people to overthrow tyrannical government, and from this time dates the permanent friendship between Italy and England. Napoleon, who feared to arouse the dislike of the French Catholics by withdrawing his troops from Rome, vainly endeavoured to reconcile the pope with the king, but his policy inspired among Italians a dislike for France who had been the opponent of Italian unity.

Bismarck.—William, who had been king of Prussia since 1861 had undertaken the task of strengthening the Prussian army, and for this purpose had engaged in a conflict with the elective Chamber, who had refused him military credits in the name of the Constitution of 1850. Having failed to find ministers who would undertake the task of governing without the support of a legal budget, William was on the point of abdicating. His son Frederick, whose wife was the daughter of Queen Victoria, was ready to acknowledge the right of the Chamber and if he had been in the place of his father he would have permitted Prussia to evolve parliamentary government on the English model. But William at last found a minister who was prepared to govern in face of the

Chamber. In 1862 Bismarck (*q.v.*) took control of the foreign policy of Prussia and immediately declared that German unity was only to be won "by blood and iron."

Poland.—The Poles who had revolted against the tsar appealed to the great Powers. England protested in the name of the treaties of 1815 and, in agreement with France and Austria, sent Russia three successive notes in 1863, in which she asked for an amnesty on their behalf and a change in the administration of Poland. Alexander was furious and threatened to make war upon Austria. Bismarck took advantage of the opportunity to sign a military convention with Russia, on Feb. 8, 1863, which had for its object a common action on the part of the Russian and Prussian armies against the Poles. Thus Prussia won the gratitude of Alexander and the benevolent neutrality of Russia during all the wars in which she was subsequently engaged.

The Danish War 1864.—The Schleswig-Holstein question (*q.v.*) which had become acute in 1848 with the revolt of the Germans in Holstein, was temporarily suspended by the Treaty of London of 1852 which guaranteed the possession of the duchies to the king of Denmark. It was re-opened when Christian IX., the heir in the female line, became king of Denmark in 1863 and was compelled by a national Danish party to annex Schleswig. Frederick of Augustenburg, of the male line, was recognized heir to the duchies by the German diet. Prussia and Austria separated themselves from the other German States, protested in the name of the Treaty of London against the annexation of Schleswig, and then made war against Denmark in 1864. The British Government proposed intervention to Napoleon, but Napoleon in return asked what support England was prepared to give to France should the latter be attacked on the Rhine. England took advantage of an armistice to assemble a conference of the Powers in London, but she was unable to obtain agreement for a plan of partitioning Schleswig, and the war ended with the cession of the duchies. Bismarck having failed to obtain them for Prussia sought to impose on the duke of Augustenburg conditions that would have rendered him a minion of Prussia, while Austria protested that the Confederation could only admit equal and independent princes.

The Austro-Prussian War.—Prussia was determined on war and Bismarck went to Biarritz to satisfy himself as to what Napoleon's attitude would be. Next he concluded a treaty of offensive alliance in 1866 with Italy. The public rupture with Austria arose from the administration of the duchies. The leading German States took the side of Austria and the rest remained neutral. War was decided with a rapidity that disconcerted all the governments of Europe by the single battle of Königgrätz. At the request of Austria Napoleon offered to mediate but he was not strong enough to frighten Prussia and was compelled to accept the peace proposals of Bismarck. By the Peace of Prague, Austria suffered no territorial loss but was compelled to give Prussia a free hand in Germany. Prussia annexed the German States lying between its western provinces and the main body of the kingdom. All the German States were united into a North German Confederation with the exception of the four south of the Main. The duchies were annexed to Prussia with the proviso that the districts north of Schleswig should be returned to Denmark if the population expressed the wish to that effect. This clause which was abrogated in 1878, was carried out in 1920.

Napoleon's Mistakes.—Bismarck had let Napoleon hope for certain territories in compensation for the aggrandisement of Prussia. Napoleon at first demanded the Bavarian lands on the left bank of the Rhine and then Belgium. Bismarck gave him nothing, but revealed these proposals in 1866 to the South German States to induce them to conclude treaties of alliance, and in 1870 he made them public so as to arouse indignation in Belgium and England against France. In 1867 Napoleon entered into negotiations with the king of the Netherlands for the purchase of the grand duchy of Luxembourg where Prussia kept a garrison in the federal fortress. Bismarck made no opposition, but on the project becoming known he made a speech in the *Reichstag* which forced the king of the Netherlands to withdraw his consent, and the grand duchy was neutralized under the collective guarantee of the Powers.

Napoleon was compelled to send troops into Italy to help the pope who had been attacked by the Garibaldians. The French, armed with the new rifle (*Chassepot*), routed the Garibaldians at Mentana (Nov. 3, 1867), and, to inspire confidence in the weapon the Government published the report of the French commander in which occurred the phrase "*Les chassepots ont fait merveille,*" while in the chamber of deputies one of the ministers, Rouher, declared that Italy should never be allowed to enter Rome. These two phrases aroused among the Italians a hatred against France which has ever since embittered the relations between the two nations.

In France, the Government sought to prevent the unity of Germany and spoke of avenging Sadowa on a Prussia that threatened her supremacy. Napoleon sought a *rapprochement* with Austria where the Ministry for Foreign Affairs had been entrusted to an enemy of Prussia, Beust, a former minister of Saxony. Napoleon proposed to Austria and to Italy an alliance which would restore Austria to her former position in Germany, and the negotiations resulted in an exchange of autograph letters between the three sovereigns in which they proclaimed their intention of holding to the idea of a triple alliance which should strengthen the peace of Europe (1869). The archduke Albert was sent to Paris, and the French General Lebrun to Vienna, to arrange a plan of campaign against Prussia (1870). The new French ministry which came into power on Jan. 2, 1870, proposed to ensure peace by a reduction of armaments, but when England transmitted the proposal to Berlin, Bismarck declared that it was incompatible with Prussian military law.

The Workers' International.—While accord between governments was broken by a succession of wars, a profound transformation in the conditions of industrial life prepared the way for a *rapprochement* of a new nature between the peoples. The progress due to science increased, in an unprecedented manner, the productivity of industry and the activity of commerce. Europe became covered with a network of railways and telegraphs which rendered communications and transport far quicker and less costly. England took the lead in this new movement and surpassed Europe in wealth, density of population and industrial experiments, and gave the example of free trade and commercial treaties which stimulated international commerce. The first international industrial exhibition was opened in London in 1851. The exhibition in London in 1862 brought representatives from French working classes and the leaders of English trade unionism together. They were of one mind in wishing to extend throughout Europe the labour association, on lines which had already been tested in England. In 1864 the International Working Men's Association (*see* INTERNATIONAL) was founded in London by an assembly attended by delegates from Britain, France, Germany, Poland, Italy, etc. The rules were drafted by Karl Marx. It was organized as a federation, and held annual congresses, generally in Switzerland or Belgium.

The Franco-German War.—The war between France and Prussia broke out suddenly as the result of an unforeseen incident. Bismarck, at the instigation of King William, worked in secret to secure the election of a Hohenzollern prince to the throne of Spain. When the scheme came to light the French minister for foreign affairs, Gramont, declared that France would never allow a Hohenzollern on the throne of Charles V. The French ambassador, Benedetti, finding nobody at Berlin able to answer him, was sent by Gramont to importune King William at Ems, where he was taking the waters, and try to make him declare that he disapproved of the candidature of the prince. When the prince's father had withdrawn his candidature, Gramont, being mistrustful of Bismarck, asked the king to promise that he would never again authorize this candidature. William refused to enter into any such engagement, and put an end to the irregular negotiation by telling Benedetti that he considered the incident was at an end. The "Ems telegram" whereby William authorized Bismarck to communicate his refusal to the press, gave him the chance to announce the refusal of the king in a shortened form in a semi-official journal, and to allow France to regard herself as having been insulted. France declared war on Prussia. The South German States joined Prussia with whom they were allied by treaty; Aus-

tria and Italy declared themselves neutral; the tsar maintained a benevolent neutrality towards Prussia.

The issue of the war was quickly decided by the three battles round Metz, which resulted in the confinement of the main French army in Metz, and the French defeat was completed by the capitulation of her last army at Sedan. The republican revolution of Sept. 4, 1870, in Paris, created the "Government of National Defence," which put Paris in a state of defence, and created armies in order to attempt to raise the siege.

Italy took advantage of the withdrawal of the French troops to occupy Rome on Sept. 20. The South German States entered into the federation which took the name of the German *Reich;* the king of Prussia was proclaimed German emperor in the palace of Versailles, Jan. 18, 1871. The war came to an end with the surrender of Paris on Jan. 28. The Peace of Frankfurt, May 10, ceded to Germany Alsace and part of Lorraine, which were annexed to the German empire, in spite of two protests on the part of the elected representatives of the country, in 1871 to the French National Assembly and in 1874 to the German *Reichstag.* (*See* FRANCO-GERMAN WAR; BISMARCK; NAPOLEON III., etc.)

The Treaty of London.—Russia took advantage of the war to declare, Oct. 31, 1870, that she no longer felt herself bound by the treaty of 1856 to observe the neutrality of the Black sea (*see* STRAITS QUESTION). England protesting that no power could, independently, rid itself of treaty engagements. But the States of Europe, feeling powerless, accepted a conference of the signatories in London (Jan. 1871), which annulled the Black sea clauses, at the same time laying down the principle that no contracting party can free itself from the engagements of a treaty without the consent of its co-signatories. This deference to a principle proved that at bottom international law depended, not on respect for treaties, but on the strength of the Powers. In order to justify Russia, Gorchakov wrote: "It would be difficult to maintain that the written law founded on respect for treaties as the basis of international relations, has preserved the same moral force it formerly possessed." Beust said in 1871: *Je ne vois plus d'Europe.*

ARMED PEACE

The Preponderance of Germany.—The concert of Europe, damaged by these wars among the great Powers, was replaced by the preponderance of the new German empire founded on an undisputed military superiority. All the European Powers remodelled their armies on the Prussian pattern by adopting universal military service; they increased their establishments and their military expenditure. The small neighbouring States, Holland, Belgium, Switzerland, Denmark, lived in constant fear of aggression. But Bismarck, who was directing the policy of Germany, did not wish to enlarge her borders; he said "Germany is surfeited." He wished to use military power, so he said in 1872, only to "maintain peace and the state of affairs created by the Treaty of Frankfurt." Because Germany could only be defeated by the collective forces of several powers, as Napoleon I. had been, Bismarck had a "coalition nightmare," as the Russian envoy, Shuvalov, told him in 1878. His policy consisted in preventing the formation of a coalition by allying Germany to the States which accepted her supremacy, and in isolating the powers which he feared to see coalescing against her. During the 20 years in which he dominated the policy of Europe, relations between the States, except in the Balkan peninsula, were reduced to interviews between the chief statesmen, to newspaper articles, to diplomatic combinations, and to agreements or defensive alliances which were in effect inoperative.

In 1866 Bismarck had secured that Prussia did not take any Austrian territory, so that no ill-feeling was left behind, but the creation of the German empire prevented Austria from having any idea of recovering her former position in Germany. The *entente cordiale* between the two countries was achieved when the old enemy of Prussia, Beust, was replaced at the Ministry of Foreign Affairs in Austria by Andrássy, the representative of the Magyars allied to Germany against the Slavs (Dec. 1871). In Russia, Alexander recalled, in a toast to William, the old friendship between the German and Russian armies, and the close relations of the two sovereigns. Italy was disquieted by Catholic demonstrations in France in favour of the temporal power of the pope, and the crown prince, Humbert, paid a visit to the emperor in Berlin (May 1872). The governments of the three empires struck by the insurrection of the Commune (*q.v.*) in Paris, wrongly ascribed to the action of the International (*q.v.*), wished to concert measures in common against the social revolution, as they had done in 1815 against the political revolution. Bismarck took advantage of this to pave the way for an entente. The interview of the three emperors at Berlin (1872) appeared to the world as a gesture of European importance. Their ministers for foreign affairs, Bismarck, Gorchakov and Andrássy, considered means whereby the peace of Europe might be maintained. It was decided that in all matters of international import, the three Powers should consult among themselves in order to work in concert. This agreement, called "the alliance of the three Emperors" (*Dreikaiserbund*) was not safeguarded by any formal treaty. It was officially defined as an alliance for the maintenance of peace without written engagements, and Bismarck declared that "Europe will recognize the new German empire as the bulwark of general peace."

The entente was broken by the rivalry of the two ministers, Bismarck and Gorchakov. Bismarck, who had become very irritable, complained that Gorchakov treated him "like a servant who does not come quickly enough when called"; he wrote to him begging him to consider him "no longer as a pupil in the art of diplomacy, but as a colleague responsible for the policy of a great empire." From that time the two rivals sought to checkmate each other. Gorchakov took advantage of the strained relations between France and Germany. The German general staff held that the law voted in France to create new battalions was a sign that France was preparing for the next war. An aide-de-camp of the emperor, Radowitz, was sent to St. Petersburg on a secret mission (Feb. 1875); rumour ran in the diplomatic world that he had come to ask if Russia would remain neutral in a war against France. An official German newspaper published an alarming article "War in Sight," April 9. The French ambassador in Russia, Gen. Le Flô, obtained an audience with Alexander and asked him if he would cover France with his sword. Alarm however soon subsided. But it began again after the *démarche* of the German ambassador in Paris, Prince Hohenlohe, who told the French minister for foreign affairs, Decazes, that his Government regarded the French armaments "as a threatening act." Decazes asked for Russian help. The general uneasiness of the diplomatic world affected the British Government. When the tsar paid a visit to William in Berlin, May 11, the British ambassador there, Odo Russell, was instructed to support the Russian ambassador at the interview between Bismarck and Gorchakov and a stop was put to the rumours of war. Gorchakov sent a circular to Russian agents dated from Berlin in which he said "*Now* peace is assured." There remained in France the impression that the tsar had protected France when she had been threatened by Germany. Bismarck explained the affair as a deliberate arrangement between Gorchakov and Gontaut-Biron by which they could pose as the saviours of peace. He retained a certain ill-feeling against Gorchakov, which put an end to the entente between Russia and Germany.

The Turkish Crisis, 1876–77.—The Russian Government was interested in the Christian peoples of Turkey in Europe, not only because they were Christians but because they were Slavs (*see* PANSLAVISM); it allowed a society to be created, called "the Society for the liberation of the Slavs," which roused the Slav subjects of the sultan in Bosnia and Bulgaria. An insurrection of the Slavs of Hercegovina (July 1875) against the extortion of Turkish officials led to the intervention of the three empires in concert. Austria was entrusted with the presentation of a note containing the reforms demanded of the Ottoman government (Dec. 31, 1875). The intervention of the Powers failed, the crisis grew more grave and resulted in a war with Montenegro, and then with Serbia (*see* SERBIA; BOSNIA; HERCEGOVINA; TURKEY; ANDRÁSSY; ANDRÁSSY NOTE), complicated by the massacre of European consuls at Salonika (May 1876) and the "Bulgarian atrocities." (*See* BULGARIA.)

The Eastern Question (*q.v.*) thus was opened again in critical circumstances for the Ottoman empire. Alexander had already

consulted with Austria at the interview of Reichstadt, July 8, 1876. Francis Joseph wished to obtain compensation for the loss of his territories in Italy by acquisitions in the Balkan peninsula; he accepted a convention allowing him compensation in Bosnia, if territorial changes took place. No European Government was prepared again to trust the promises of reform made by the Turks; control by European agents was required. Disraeli, though harassed by the agitation of Gladstone, adhered to the traditional British policy in favour of the Ottoman empire and sent a fleet to the neighbourhood of Constantinople; Alexander mobilized and forced the Turks, who had been victorious in Serbia, to grant an armistice; and England also accepted a conference of the ambassadors of the great Powers at Constantinople, which drew up a scheme of reforms. This intervention was paralysed by the promulgation of the Turkish Constitution planned by Midhat Pasha, the Turks declaring that they were contrary to the Constitution.

Alexander reaffirmed his agreement with Austria by a treaty of April 1877 and began the war. England alone protested, but added that she would only interfere to safeguard "her vital interests," the Suez canal, the Straits, Constantinople. Alexander wished to limit himself to a war north of the Balkans, but was led into an invasion which took the Russian armies within striking distance of Constantinople, when the sultan asked for peace. The British Government was divided; the queen wished for war; Derby wanted peace; Disraeli contented himself with warlike manifestations in order to appease the excited Londoners, and refused to withdraw the British fleet. The grand duke Nicholas replied by advancing his headquarters to the suburbs of Constantinople. There the Russian plenipotentiary, Ignatiev, imposed on the sultan on March 3, the Treaty of San Stefano, the latter ceding all the land occupied by the Bulgarian population in order to allow the formation of a "big Bulgaria" under the protection of Russia.

The Congress of Berlin, 1878.—Bismarck demanded that the treaty should be revised by the great Powers. Gorchakov, who did not wish the creation of a "big Bulgaria" to be called in question, proposed a conference at Berlin, in which each State should reserve full liberty of action; England demanded that the whole treaty should be submitted for revision. Alexander was short of money and needed peace; he yielded and sent Shuvalov on a special mission to Bismarck, and thence to England where he concluded a secret convention (May 30). Russia undertook to submit "the whole contents of the treaty" to a European congress. England concluded with the sultan a secret treaty (June 4) undertaking to defend the Ottoman empire in Asia Minor in exchange for the occupation of Cyprus. Bismarck had declared in the Reichstag that he merely wished to play the part of "an honest broker." The congress held at Berlin under his presidency was a tribute to the dominant position held by Germany (*see* BERLIN, CONGRESS OF). It imposed upon the sultan an Austrian occupation of Bosnia, and destroyed "big Bulgaria" by cutting it into three pieces. England made public the treaty which ceded Cyprus to her. Waddington, the French minister, protested; in order to appease him Salisbury made some allusion to Tunis. The three tributary Christian principalities of the sultan in Europe were declared to be sovereign States. Greece was promised a rectification of frontier, which did not take place until 1881.

The Austro-German Alliance, 1879.—The Russians did not receive an adequate reward for the sacrifices they had made in comparison with Austria, which, without having gone to war at all, became a Balkan power and a rival of Russia in the Balkans. Alexander recalled the fact that in 1871 William had written to him that Germany owed to him the happy issue of the war and had signed himself "Your ever grateful friend"; Gorchakov wrote to his ambassador at Vienna, Feb. 4, 1879, "It is unnecessary to say that in our eyes the alliance of the three emperors has been broken by the conduct of our two allies." William himself remained outside the conflict, and had a secret interview with Alexander (Sept. 3, 1878).

Bismarck made overtures to Austria; giving as his reason for so doing that he feared an agreement between Russia and Austria, and wished to prevent it by a close alliance with one of them; he preferred Austria because she would be willing to allow Germany to be the predominant partner, and the matter was concluded by a secret treaty in the form of an alliance for the maintenance of peace and mutual defence, should one of the two be attacked by Russia, while if the attack came from any other power, they only engaged themselves to maintain a benevolent neutrality. William maintained his friendship with Alexander, and insisted that he should be informed of the treaty. He had

MAP OF BALKAN PENINSULA SHOWING MODIFICATIONS OF FRONTIERS AGREED UPON IN THE TREATY OF BERLIN, JULY 13, 1878

The nations participating in this Treaty were Great Britain, Germany, Austria, France, Russia and Turkey. Main alterations on the treaties of Paris, 1856, and San Stefano, March 3, 1878, were: (1) Bulgaria was created an autonomous and tributary state under the sultan of Turkey; (2) the province of Eastern Rumelia was formed, to remain under military and political control of the sultan; (3) Bosnia and Herzegovina were to be occupied and governed by Austria-Hungary; (4) Montenegro and Servia were to be independent

several personal interviews with him, and Alexander drank to the health of "his best friend William" in March 1880. Bismarck, not wishing for a permanent misunderstanding entered into negotiations with the Russian Government for a defensive alliance.

The Triple Alliance, 1882.—Ill-feeling against Germany showed itself in Russia in newspaper articles favourable to France, while the idea of a Franco-Russian entente took hold of public opinion in France, which hoped to find a protector against Germany. Italy was divided between opposition to France, where the Catholics upheld the temporal power of the pope, and enmity towards Austria, the possessor of *Italia irredenta.* From the time that the republican party came into power the Italian Government drew nearer to France; and allowed the "irredentists" to make demonstrations against Austria. The establishment of a French protectorate over Tunis, 1880, made an abrupt change in Italian sentiment. The Italians held that they themselves had rights over Tunis, as the near neighbour of Sicily, where many Italians lived, and the Italian Government had protested in advance against operations in Tunis. Gambetta and Waddington had assured them that France would not undertake any course of action without coming to a preliminary agreement. Public opinion in Italy became hostile to France. The Government drew closer to Austria and King Humbert paid a visit to the emperor (Oct. 1881) during which he asked to be admitted into the defensive alliance of the two monarchies. After long negotiations Italy concluded two secret treaties of defensive alliance with Germany and Austria. If Italy were attacked by France, her allies promised to support her; and Italy undertook to support her allies in a war against two Powers. A special protocol (May 20, 1882) declared that the treaty could in no circumstances be directed against England. The Triple Alliance therefore appeared as a guarantee for

the peace of Europe and the maintenance of the *status quo*, at the same time preserving the traditional friendship between Italy and Great Britain. Rumania adhered to it by a secret treaty with Austria, the personal work of King Charles, which he communicated only to one minister (1883) and to which Germany and Italy later acceded by engaging to defend Rumania. The Triple Alliance was reduced in practice to a defensive agreement between the central European powers against the warlike intentions attributed to their neighbours, France and Russia. But it reinforced the predominance of Germany, the most powerful of the partners, and gave the impression of a compact coalition in the centre of Europe against the isolated powers outside. The Concert of Europe was replaced by the hegemony of the German empire.

Alexander III., emperor of Russia since 1881, did not love the Germans, but wished for the maintenance of peace. He gave the direction of foreign affairs to a Baltic German, de Giers, who was in favour of an entente with Germany. In reply to a telegram of congratulation he called William "this venerable friend to whom we are united by common ties of deep affection." Bismarck also hoped to avoid a breach with Russia. A secret treaty was concluded at Berlin for three years (June 11, 1881) between the "three courts" of Austria, Germany and Russia, which bound them to work in concert in matters relating to the Balkans. This treaty was kept so secret that before the publication of the Austrian secret archives it was believed that it was not concluded until 1884. At its renewal in 1884 the agreement was shown to the world by an interview of the three emperors at Skiernewicze, Sept. 1884. This treaty, which Bismarck called the "re-insurance treaty," combined the Triple Alliance with the Alliance of the three emperors. England had entered into conflict with France, who was creating a colonial empire in Africa and Indo-China, over Egypt in 1882, and with Russia over Afghanistan in 1884. Bismarck profited by these rivalries to improve the relations of Germany with the rival powers. He encouraged French enterprise in order to keep her attention occupied outside Europe. He said to the French ambassador: "I wish to see you come to the point when you will forgive Sedan as you have forgiven Waterloo"; he even suggested an alliance "to establish a kind of maritime balance of power." He caused to be held the Conference of Berlin, which settled the rules for the occupation of lands outside Europe (1884); and when the Eastern Question was re-opened by the union of Rumania and Bulgaria (*see* BULGARIA) in 1885, he supported Alexander in his refusal to recognize the union. Austria encouraged her protégé Milan, king of Serbia to embark on war with Bulgaria. On the side of France relations were strained by the manifestations of Gen. Boulanger (*q.v.*) and his followers. Frontier incidents in 1887 irritated public opinion; France and Germany both talked of war; and Bismarck increased the effectives of the army and guaranteed Germany on the side of Russia by renewing in 1887 the re-insurance treaty. The Triple Alliance treaties, originally concluded for five years were renewed and completed. Italy complained, in the words of the minister Robilant, of being "always left out in the ante-room." She obtained from Austria the assurance that she would not modify the territorial *status quo* in the East except on the principle "of reciprocal compensation for every advantage" obtained by the one or the other (May 10, 1887). The British Government accepted the suggestion of Italy to act in concert for the maintenance of the existing state of affairs in the Mediterranean and the adjoining seas.

The Franco-Russian Entente.—Bismarck had not been able to prevent the entente weakening between Germany and Russia. The idea of a *rapprochement* with France grew more popular in Russia, starting in the realm of finance; the German Government retaliated by forbidding the Reichsbank to accept as collateral the Russian State funds which were, however, accepted with alacrity by the Paris Bourse. Alexander hesitated for some time to enter into close relations with France, and had a long interview at Berlin (Nov. 1887) with Bismarck, whose fall (1890) changed the policy of Germany, while the establishment of a stable ministry in France broke down one of Alexander's objections to a *rapprochement*. William II. had taken over the direction of German policy. He refused to renew the treaty of 1887 with Russia and tried to come to an agreement with the western States. He entered into cordial relations with the Salisbury ministry and concluded a treaty whereby England gave up Heligoland in exchange for concession in East Africa (1890). He made advances to France, and his mother came to Paris to prepare the way for a *rapprochement* on the neutral ground of art. But the visit of the empress-dowager led to demonstrations on the part of Parisian nationalists and made relations worse with France (Feb. 1891). French opinion, uneasy because France was isolated in face of Germany, ardently desired to obtain the protection of Russia, whose military power she exaggerated, and Alexander at length allowed himself to be drawn into a permanent understanding. His resolution was made public by the reception of the French fleet at Kronstadt (Aug. 1891). The understanding was not completed in the form of a treaty; the tsar insisted on keeping it secret, and President Carnot could not guarantee that he would not be obliged to present it to the chambers. The two Governments considering that the maintenance of peace was bound up with the balance of power in Europe engaged themselves to act in concert on all questions which jeopardized the cause of peace, and if peace was menaced by the initiative of the Triple Alliance to use their forces simultaneously. The French Government insisted on the conclusion of a military convention. This plan was accepted by Russia and signed by the chiefs of the general staffs of the two countries in July 1892; it arranged, in case of a "defensive war," a simultaneous mobilization to be directed against Germany. Alexander left the scheme in suspense for a year; then he indicated his decision by the dispatch of the Russian fleet to France (Oct. 1893) and a telegram to the president. The convention was "definitely adopted" by the exchange of letters in Dec. 1893. This purely defensive agreement which is called "the Franco-Russian Alliance" did nothing definite but maintain the state of things established by the treaty of Frankfurt, which was also the object of the Triple Alliance; but it reassured French public opinion and it gave Europe the impression that European balance, broken by the Triple Alliance, had been restored.

Policy of William II.—Bismarck, preoccupied with the maintenance of German supremacy in Europe, had been little interested in the expansion of Germany in the rest of the globe. This old man's policy did not satisfy William, who was young, anxious to shine in the world, and to use his power. The population of Germany was growing rapidly, as were also her industries, her trade and her riches; her commercial agents, supported by her banks, sought outlets for her products throughout the whole world; her mercantile marine carried the German flag in all seas. The Germans were aware of their growing power and found themselves restricted in Europe; and they aired their need for expansion in formulas—*Mitteleuropa* (the union of all the countries of Central Europe under the economic direction of Germany) *Drang nach Osten* (expansion in the Balkan and Mohammedan East) *Colonialpolitik* (the creation of colonies outside Europe), and particularly in the creation of a navy to support German commerce and raise German prestige, all of which objects found an enthusiastic leader in the Emperor, who had, from his youth, been devoted to navigation and travel. It is this policy which has received the title of *Weltpolitik*. *Weltpolitik* brought Germany into rivalry with the two great colonial powers, England and France, for both had forestalled her by occupying almost all the available countries, and Great Britain was uncontested mistress of the seas. Thus the balance of power was upset by this new policy of expansion in the rest of the world.

Since 1889, when he had paid a visit to the sultan at Constantinople, William II. had devoted himself to promoting German influence in Turkey. A permanent mission of German officers directed in Constantinople the technical instruction of the Turkish army. Abd-ul-Hamid, feeling himself protected by Germany, freed himself from the obligations into which Turkey had entered in 1878 under the British guarantee and massacred his Armenian subjects in Asia Minor and at Constantinople (1894–96).

Nicholas II. who had ascended the Russian throne in 1894 and who lacked strength of character, fell under the influence of Wil-

liam II. and entered into an intimate correspondence with him which was published after the Russian Revolution. William wished to take advantage of this to bring together under his influence the two opposing groups of States into which Europe was divided—the Triple Alliance and the Franco-Russian Alliance. He induced Nicholas to intervene in the Far East where Japan had just defeated China, and out of regard for the tsar, the French Government joined with Germany and Russia to enforce the annulment of the treaty concluded by Japan with China (1895). The tsar then induced the French Government to add French ships to the foreign squadrons attending the celebration of the official opening of the Kiel canal. Further, William sought to take advantage of a conflict which arose between England and France over the district of the upper Nile, and since 1894 had suggested to France that she should make a united protest with him against the treaty concluded between Great Britain and the Congo Free State. After the Jameson raid on the Transvaal (*q.v.*) and the dispatch of his famous telegram to President Kruger, the kaiser, with a view to limiting "the insatiable appetite of England," proposed to France a treaty by which Germany and France should mutually guarantee each other's territories. But the French Government repelled the suggestion, seeing that would have been interpreted as an assent to the annexation of Alsace; for French public opinion, although it was strongly opposed to war, had never accepted the annexation of Alsace which had been carried out against the wishes of the inhabitants.

The Cretan massacres of 1897 were stopped by the landing of marines from the ships of the European States with the exception of Germany who refused to take part in an intervention that resulted in the establishment of an autonomous Christian Government in Crete. The war which followed between Greece and Turkey rapidly ended in a resounding victory for the Turkish army whose success was ascribed to the work of its German instructors. The kaiser undertook a triumphal journey in Syria in order to reveal to the world the extent of German influence in the East, and at Damascus announced himself as "the friend of 300,000,000 Mohammedans" (1898).

Owing to her preoccupations in the Far East Russia seemed to have lost interest in the Balkan peninsula; Austria took advantage of this to establish her preponderance there. In May 1895 Austria concluded an understanding with Russia for the purpose of maintaining the Balkan *status quo*, Russia reserving for further examination the future projects of Austria in Bosnia and Albania; in 1896 the secret treaty between Austria and Rumania was renewed, and about the same time Serbia, which was governed by the Obrenovitch dynasty, delivered up the kingdom to Austrian financiers and behaved as the protégé of Austria. It became the habit of Austrian diplomacy to treat Serbia more as an Austrian province than as a sovereign State, and it was this conception that underlay the Austrian ultimatum in 1914. The prince of Bulgaria, Ferdinand of Coburg, a Catholic, and formerly an officer in the Austrian army, had reconciled himself with the tsar by inviting him to be godfather to his son Boris, but at the same time his relations with the Viennese Government were more intimate than with Russia. Austria and Russia were moving towards a partition of the Balkan peninsula into two spheres of influence; and the Russian general Kuropatkin, who was sent on a special mission to Vienna, even proposed that a line should be drawn from north to south and that the Russian sphere of influence should lie to the east and the Austrian to the west. In reality the whole peninsula had become an Austrian sphere of influence.

Armed Peace.—Russia simultaneously made known her entente with France by an exchange of visits between the imperial family and the president of the republic, and her understanding with Germany by an exchange of visits between the tsar and the kaiser (1896–97). Italy announced that she interpreted alliance as a "pacific act which permitted to the allies the most friendly relations with the other Powers." The Italian crown prince married the daughter of the prince of Montenegro, who was a protégé of Russia, and Italy signed with France an agreement concerning Tunis and her fleet collaborated with the French fleet in Crete. All these alliances and *rapprochements* seemed to assure peace in Europe; and all the governments protested their devotion to peace but not one had any confidence in the assurances of the others, seeing in the pacific declarations of his neighbour only a cloak to conceal offensive designs. No nation felt secure. The war of 1870 had revealed that it was not enough to wait until war began in order to place armies in motion. Mobilization had become so rapid and the advantage to be gained from taking the offensive so overwhelming that every Government felt it its duty to secure the advantage of the offensive by keeping its army always ready for an immediate war. Thus the effective strength of the armies in time of peace came to equal their former strength on a war footing. Moreover, the rapid progress that had been made in military technique compelled each State, in order not to be inferior to the others, to renew constantly its equipment and artillery and to increase its fighting strength. Thus the military budgets rose swiftly higher and higher. The efforts of the International League of Peace on behalf of arbitration (*q.v.*) produced no effect on public opinion except in the United States and Scandinavia; the great Powers remained indifferent. Europe lived under "an armed peace," or peace with all the military and financial burdens common to war, and lacking all sense of security.

The Hague Conference 1899.—Nicholas II., who had been impressed by *War,* the work of a Russian financier, J. von Bloch, and whose Government was struggling with the military expenses of the operations in Asia, sought to reduce expenditure by obtaining a concerted action among the powers for a reduction of armaments. Russia invited all the States to send representatives to a Conference at The Hague to consider the means of effecting this, and the project was welcomed by public opinion which gave The Hague Conference (*q.v.*) the name of "Peace Conference." It did not obtain any limitation of armaments, but it secured three international conventions on the conduct of war on land and sea, and on voluntary arbitration between States. A permanent Court of International Justice was established at The Hague and the principle was propounded that any State had the right to offer its mediation or good offices to States in disagreement with one another. For the first time an international assembly representative of the governments of the world, met to discuss an abstract question of general interest, and in a modest form they created the first permanent international institution for the purpose, no longer merely of regulating the re-distribution of territory in accordance with the balance of power, but also of making an end to disputes by the application of international law. It was the embryo of the association of States which the French delegate, Leon Bourgeois, had already named a "Society."

Change in British Policy.—Great Britain had for long maintained herself in a position of "splendid isolation." Her relations with France had been strained by conflicts that arose between officers and agents of the two countries in all parts of the world in which they were rivals; in Indo-China where the conflict with Siam was only settled by the treaty of 1896; in western Africa over the Niger (*see* AFRICA); and above all in Egypt where the Marchand expedition on reaching Fashoda in 1898 came into conflict with the British. The tension relaxed when the coalition of the Left came into power in France, and Delcassé, who was foreign minister for four years, worked to achieve an understanding with England. With Germany, on the other hand, British relations became strained when William in agreement with his minister of marine, Admiral von Tirpitz, sought to create a navy, and the Reichstag voted credits to carry out a naval programme intended to double the strength of the German fleet (1900).

The second Boer war brought the isolation of England into sharp relief. Germany, Russia and France planned a common intervention to end the war, but did not dare to act. William II. laid aside his former policy, sought to achieve an understanding with England by forbidding German officers to take service with the Boers, and by paying a visit to London where he had an interview with Joseph Chamberlain, then secretary of State for the Colonies. In a speech at Leicester Chamberlain adopted a popular theory and proposed a "new Triple Alliance" between the three Teutonic peoples—Germans, English and Americans (Nov. 1899) and William II. refused to receive President Kruger when he

came to Europe to ask help. But the German press remained hostile to England. The new Chancellor, Prince Bülow, a disciple of Bismarck, believed that an understanding with England would prevent Germany from creating an independent navy, and preferred to retain his liberty to build a fleet against the British fleet, merely taking care to avoid a rupture during "the dangerous period of construction." Baron von Holstein, who was director of political affairs in the Ministry for Foreign Affairs, exercised an occult influence on the policy of Germany and distrusted England. British policy was based upon the principle that Great Britain, seeing that she was unable to feed her population except with the help of imports, must of necessity maintain her maritime supremacy; and this was the meaning of the formula of the "two power standard." The British Government never feared an invasion of England by the German army, a prospect that inspired popular anxiety in England; but it did fear that in a grave conflict with Germany the existence of a powerful German fleet might compel England to give way. The memorandum which was presented with the estimates for the construction of the German fleet said that this fleet should be so strong that "even for the greatest of all maritime powers, a war with it would imply the imperilment of its own supremacy." But by becoming a great naval Power Germany inevitably risked coming into conflict with Great Britain in all parts of the world in which British commerce and policy were deeply involved—Egypt, Persia, India—and should Germany be able to obtain the alliance of other maritime Powers the resulting coalition would threaten the maritime supremacy on which the British empire depended.

English supporters of a German alliance warned the German Government that England did not desire to remain isolated, and that if she was unable to obtain the alliance of Germany, she must seek other allies. But the Germans did not believe in the possibility of a real friendship between "the whale and the bear" (England and Russia) and they feared that England would use Germany for a war against Russia from which England would derive the profit. Abandoning the idea of a German alliance, England allied herself with Japan in 1902 (*see* ANGLO-JAPANESE ALLIANCE).

Queen Victoria's personal sympathies had resulted in strained relations with France, but Edward VII. was in sympathy with France, where he had often stayed as prince of Wales, and he mistrusted his nephew William II. He prepared the way for a reversal of British policy by an understanding with France. He visited the president of the republic in Paris where he was acclaimed by the crowd in May 1901. And at the same time Italy, the enduring friend of England, officially came closer to France. Victor Emmanuel who had been king since 1900, was less attached than his father, King Humbert, had been to the Triple Alliance. Italy had already obtained in 1891 an engagement on the part of her allies regarding Tripolitania, and in 1900 another "in favour of Albanian autonomy." A secret understanding with France (Dec. 1900) guaranteed complete liberty of action to her in Tripolitania. Then, before renewing the Triple Alliance treaty, Italy announced officially that it did not contain any engagement to take part in a war of aggression against France (1901), and Bülow, in order to induce the Reichstag to accept the attitude of Italy, employed a famous simile in saying "In a happy marriage the husband does not make a scene if his wife now and then dances a waltz with a stranger."

The entente between England and France was concluded in the form of a convention (April 18, 1904) to which was appended a number of declarations settling all the questions outstanding between the two states. Of these the principal concerned Egypt, which France abandoned to England, and Morocco in which England professed herself disinterested. Thus ended the long rivalry between England and France, and the balance of power in Europe was once again restored by the Anglo-French entente to which was added the Franco-Russian Alliance.

While the Powers that had hitherto been isolated were thus cementing an entente, the kaiser experienced a series of reverses that irritated German public opinion. The attempt made by Russia, Germany, France and England, to establish colonies in China under the guise of long-termed concessions and to partition China into spheres of influence, led to the national rising of the Boxers, which was repressed by an international expedition in 1900, after which William found himself compelled to abandon his ambitions in China. The submission of the Boers in South Africa (*see* SOUTH AFRICAN WAR) was a defeat for Germany, and in Venezuela, where William had dispatched a squadron to prepare the way for a German penetration of Latin America, his attempt was frustrated through the intervention of the United States. Again, the concession of the Baghdad railway to a German company was rendered nugatory by the refusal of France and England to invest the necessary capital.

Decline of Russia.—The rising of the Christian Slavs of Macedonia (*q.v.*) with the help of Bulgarian insurgent organizations, forced Austria and Russia to take common action, and their ministers hastily drew up a note to the sultan in which they demanded the establishment in Macedonia of a national police force under the command of European officers (1903). Germany refused to be a party to these proceedings, but Russia and Austria, who had hitherto been sole mistresses, were forced to share the command and control of this force with England, France and Italy.

In the Far East, Russia, who had attempted to occupy Korea, was checked by Japan (Feb. 1904) and after a series of naval and military defeats was compelled to sign a peace which ended her Far Eastern ambitions (1905). This disaster was followed by a revolution in Russia which weakened her military power and crippled her foreign policy. William profited by the opportunity to increase his influence over Nicholas and to detach him from the French alliance: "It is certain," the kaiser wrote, "that France wishes to remain neutral and even to give diplomatic aid to England; her policy gives the English a brutal confidence." He urged Nicholas to make use of the Mohammedans—"a trump card in our hand"—for the purpose of ending "British insolence."

The Second International.—Powerless in the face of the great development in the art of peace surveillance and in the equipment of troops, the revolutionaries adopted a new means for furthering their projects. There grew up in all European States Socialist parties, recruited especially from the ranks of the workers and organized on the model of the German Socialist Party which was the strongest and most disciplined in Europe. They reconstituted the International Association of Working Men and this "Second International" to which the British Labour Party gave their support, held eight international congresses in different European cities to determine doctrine and organize a common policy. The sixth international congress at Amsterdam in 1904, acting under German influence, compelled the Socialist parties to transform themselves into sections of the workers' international and to follow a common policy "founded on the Marxian principles of the class struggle, with the object, not of obtaining reforms, but of achieving the social revolution." By this decision the Socialist parties were forbidden to co-operate with bourgeois democratic parties, and were reduced to the position of Doctrinaire opposition.

The trade unions which had been established after the English model and which were inspired by Socialist beliefs were united in each country into confederations, and they founded an international federation of trade unions for co-ordinating the workers of Europe in their conflicts with their employers. These two international organizations not only created among European peoples a bond of a new kind; they intervened in foreign policy by endeavouring to compel the Governments to work for peace.

The Moroccan Crisis.—By the Convention of 1904, England in granting France a free hand in Morocco had left Tangiers under an international administration. France had at that time contemplated only a policy of peaceful penetration. But inevitable conflicts arose with the warlike population of fanatical Mohammedans, enraged by the presence of infidels, and finally turned into a regular military campaign. Lest her good faith should be suspect, England was forced to support France. The German Government had been advised by the French government that conventions had been concluded with England and Spain, but no

official notification had been sent it, and when Russia, weakened by her defeats in Asia, became incapable of giving aid to France, Bülow declared in the Reichstag that he was forced to oppose French policy in view of the economic interests of Germany in Morocco, and at the same time William landed at Tangier for the purpose of visiting the sultan "in his capacity as an independent sovereign" (March 31, 1905). Bülow demanded an international conference over Moroccan affairs, while Delcassé preferred to accept the proposal of the British Government to enter into an alliance for the purpose of common military operations. The French cabinet, however, declined to follow Delcassé, whose resignation was hailed in Germany as a victory (June 12, 1905).

William, who was sailing on the Russian coast, received Nicholas on board his yacht and took advantage of the absence of his principal adviser to induce him to sign with him a secret treaty for an offensive alliance directed against England (Treaty of Björkö, July 1905). When Nicholas wished to inform France, William forbade it. "Only the absolute certainty," he said, "that we are both bound by a treaty of mutual assistance will induce France to bring pressure to bear on England." The Russian ministers did not learn of the existence of the treaty until Germany demanded they should seek to make France a party to it; they thereupon declared it null and void.

The unity of the Triple Alliance was threatened by the policy pursued by Austria towards Italy. The chief of the Austrian imperial general staff, Field Marshal Conrad von Hotzendorf, whose patron was the Austrian heir presumptive, the Archduke Francis Ferdinand, obtained extraordinary credits for the purpose of building fortresses on the Italian frontier, in order, as he put it, "to enable the army to win early victories outside the kingdom" (1904). But the two pacifically inclined ministers for foreign affairs, Visconti-Venosta in Italy and Goluchowski in Austria, prevented an outbreak of war (1905–06). In Serbia Austrian policy suffered a severe reverse when the Obrenovitch dynasty, which was under Austrian influence, was overthrown by an officer's conspiracy and replaced by Peter Karageorgevitch who placed the reins of power in the hands of the Radical-Nationalist party that was inimical to Austria.

The conference (*see* MOROCCO and ALGECIRAS) that had been sought by Germany did not turn out in accordance with her hopes. She was unable to prevent France from obtaining a privileged position in regard to the harbour police and the Bank of Morocco and even Italy, following the English example, voted against the German propositions. Austria alone gave her support. The conference strengthened the union between the Entente Powers and exposed the weakness of the Triple Alliance. German public opinion was enraged and William II. indulged his bad temper at the expense of Austria—whom he congratulated on having played at Algeciras the part of a "brilliant second."

Disturbed by these conflicts the European Governments sought to reassure public opinion by means of pacific manifestations. An international conference at the Hague, which met at the invitation of the president of the United States, failed to bring about a limitation of armaments; but it perfected the conventions that had been concluded in 1899 and discussed the principle of compulsory arbitration, determined to draw up a list of permanent arbitrators, and established an international bureau.

The Triple Entente.—The grouping of the three great Powers in opposition to the Triple Alliance was completed by the conclusion between Russia and England of three conventions which settled their differences in Persia, Afghanistan and Tibet (August 1907). The understanding between England, Russia and France did not take the form of a treaty of alliance; for that would have been inacceptable to the British cabinet; but it was known as the Triple Entente. This union between the three Powers that Bismarck had kept in isolation restored the balance of power in Europe and made an end to German preponderance. In consequence, German public opinion was influenced against Edward VII. whom it accused of having planned the "encirclement" of Germany.

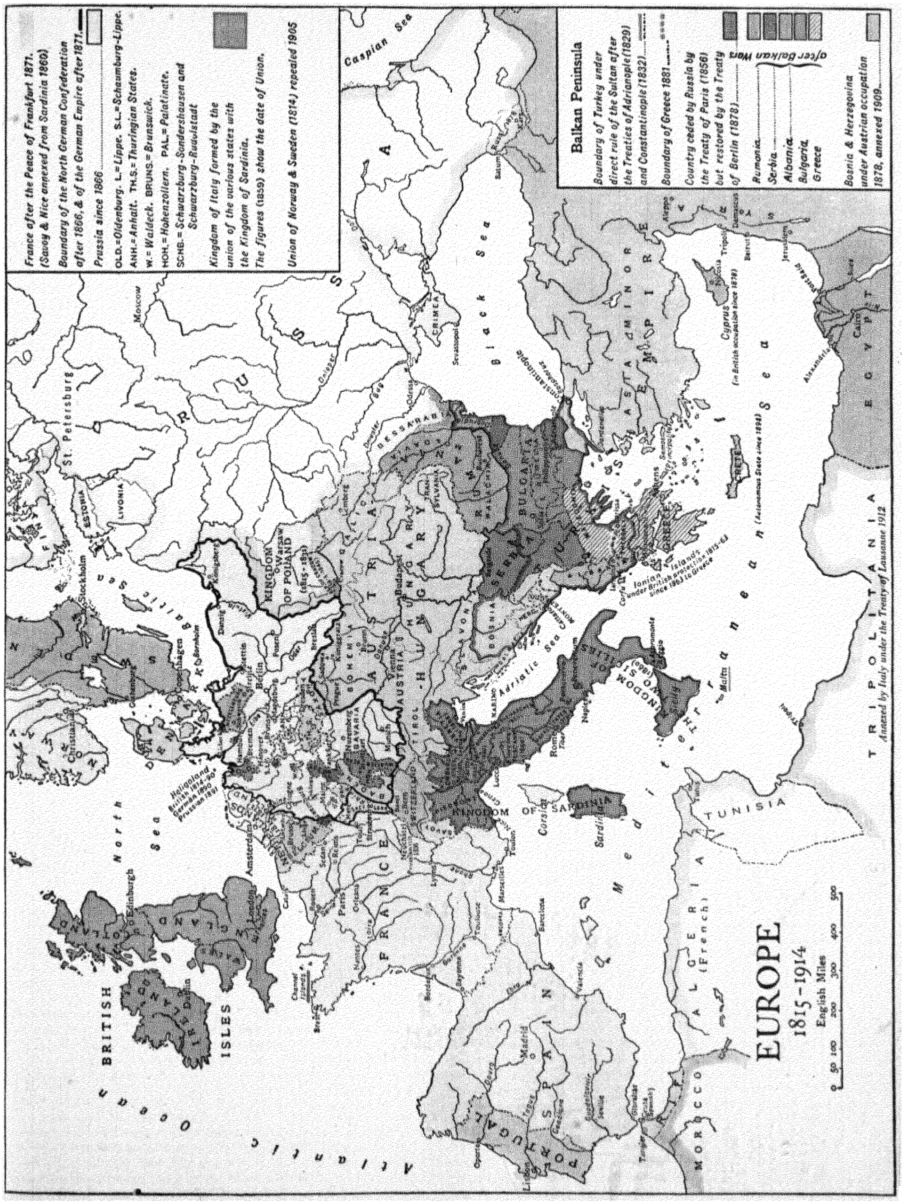
For the purpose of counteracting this impression a friendly interview was arranged between the kaiser and Edward VII., who was on his way to Marienbad, and the kaiser then went to England, where he had conversations with the British ministers (1907); but the German Government refused to agree to the British suggestions and the kaiser, in an interview published in the *Daily Telegraph* in 1908, expressed his regret that his sympathy for England was not shared by the German nation. This statement aroused a burst of anger against him in Germany which revealed the hatred of the Germans for England. In June 1908 the Anglo-Russian entente was confirmed by the visit of Edward VII., to the tsar at Reval.

The Balkan Crisis.—In 1908 the peace of Europe was disturbed by one of the periodical crises in the Balkan peninsula. Baron (later Count) von Aehrenthal, who had lately become Austro-Hungarian minister for foreign affairs, sought to regain Austria's former prestige by the pursuit of a policy independent of Germany. He entered into negotiations with Isvolsky, the Russian minister for foreign affairs, over the question of Macedonian reform; and later, giving up the idea of reform, he concluded a secret understanding with the sultan for the concession of a line of railway joining Bosnia to the Aegean (Jan. 1908).

Within the Ottoman empire the Macedonian insurgents allied themselves with the Young Turk Committee of Union and Progress, which had been secretly organized at Salonika, and forced Abd-ul-Hamid to accept the Constitution of 1876 (July 16, 1908). Hailed with equal enthusiasm both by the Mohammedans and the Christians, this revolution was looked upon in Europe as a victory for modern liberal ideas and the European States withdrew their officers from Macedonia and abandoned the system of control. But in truth, the only modern element in the Young Turk programme was a feeling of national pride; they desired to re-establish the unity of the Turkish empire by welding all the inhabitants into a Turkish nation. They wished to give seats in the Ottoman parliament to representatives of the autonomous districts of Bulgaria, Bosnia, and Crete. Thereupon Ferdinand of Bulgaria entered into an understanding with the Austrian Government for the purpose of rendering Bulgaria and Bosnia independent of the Turkish empire. Aehrenthal had an interview with Isvolsky and made known to him his project, at the same time promising to await a favourable opportunity and giving Isvolsky grounds for hoping that Austria would lend her support in opening the Straits to Russia.

All of a sudden Europe was startled by the news of the declaration of Bulgarian independence (Oct. 5), and on the following day the further news that the emperor of Austria had declared his sovereignty over Bosnia. These two declarations were violations of the Treaty of Berlin and the Russian Government demanded the assembling of a conference of the Powers signatory to that treaty, who alone had the right to authorize any alteration in its provisions. Serbia demanded autonomy for Bosnia. Aehrenthal, who was known in Austria as "the Austrian Bismarck," applied the theory of a *Realpolitik* founded on contempt for international law. He claimed that the matter was one that concerned only the sultan in his capacity as sovereign of Bosnia and that it could be settled with him alone. Austria mobilized against Serbia.

Austria and Germany were well aware that Russia was too weak to support Serbia in making war but William II. was annoyed at Aehrenthal's action because it risked giving the "signal for plundering" the Ottoman empire, which William regarded as being under his own protection. Bülow, however, calculated that Germany could not afford to dispense with Austria and he did not wish to enter any conference in which Germany would find herself in the minority as at Algeciras. Hence he induced Turkey to negotiate with Austria; and Russia renounced her support to Serbia but to retain her influence in the Balkans, gained the friendship of Bulgaria by according to Prince Ferdinand the royal title of tsar and by contributing to bring about the conclusion of an agreement with the Turkish Government. Dissatisfied with the personal policy of Aehrenthal the German Government took the initiative in making a decisive démarche. The German ambassador, Count Pourtalès, presented a peremptory demand to Russia to accept the abrogation of the article in the Treaty of Berlin relative to Bosnia. Russia gave way and agreed to the new arrangement. Thus Ger-



EUROPE
1815-1914
English Miles
0 50 100 200 300 400 500
France after the Peace of Frankfurt 1871.
(Savoy & Nice annexed from Sardinia 1860)
Boundary of the North German Confederation after 1866, & of the German Empire after 1871
Prussia since 1866
OLD.=Oldenburg. L.=Lippe. S.L.=Schaumburg-Lippe.
ANH.=Anhalt. TH.S.=Thuringian States.
W.=Waldeck. BRUNS.=Brunswick.
HOH.=Hohenzollern. PAL.=Palatinate.
SCHB.=Schwarzburg-Sondershausen and Schwarzburg-Rudolstadt
Kingdom of Italy formed by the union of the various states with the Kingdom of Sardinia.
The figures (1859) show the date of Union.
Union of Norway & Sweden (1814) repealed 1905
Balkan Peninsula
Boundary of Turkey under direct rule of the Sultan after the Treaties of Adrianople (1829) and Constantinople (1832)
Boundary of Greece 1881
Country ceded by Russia by the Treaty of Paris (1856) but restored by the Treaty of Berlin (1878)
after Balkan Wars
Rumania
Serbia
Albania
Bulgaria
Greece
Bosnia & Herzegovina under Austrian occupation 1878, annexed 1909

many achieved a diplomatic victory by seeming to have imposed her will upon Russia and to have established the supremacy of her ally, Austria, in the Balkans. Isvolsky nursed a desire for revenge, and carried it with him to Paris when he was appointed ambassador to France. Italy was annoyed that her consent had never been asked to the committal of an act that disturbed the balance of power in the Adriatic. Aehrenthal seems to have understood the danger implied in the discontent in Italy; for he induced the emperor to dismiss Conrad, who was the avowed enemy of Italy, as chief of the imperial general staff.

The Agadir Crisis.—France had extended her influence in Morocco by repressing acts of violence by the native population. Public opinion in Germany which was already discontented, was further exasperated at the dispatch of a French expedition to Fez in 1911 for the purpose of repressing the Mohammedan insurrection against the sultan. The German Government claimed that the occupation of Fez was a breach of the Algeciras agreement and announced that Germany resumed her liberty of action. She planned an intervention in the southern district of Morocco (the Sous region) where the authority of the sultan was not recognized, and despatched a gun-boat to Agadir to show that while she was not engaging in a naval operation she wished to indicate her determination to compel France to negotiate. The French Government, which was greatly disquieted, persuaded Great Britain to make a public announcement of its intention to support France and this was done in a speech delivered by Lloyd George.

The dispute was settled after negotiations in Berlin by Germany authorizing France to establish a protectorate over Morocco while Germany received in compensation a portion of French Congo. The compromise failed to satisfy French public opinion, and inflamed the Germans, who blamed their Government for having failed to use the growing power of Germany to obtain for her a place in the world in proportion to her importance.

England and Germany.—William II., together with the chancellor, Bethmann-Hollweg, a man of peaceful disposition who had succeeded Bülow in 1909, worked to establish an understanding with England. Germany was prepared to interrupt her naval programme to allay British anxiety, and sought to assure herself of British neutrality by a reciprocal engagement in which the two States should undertake not to attack each other in event of war. Negotiations, which had been interrupted by the Agadir crisis, were resumed in Feb. 1912, when Lord Haldane, the British minister for war, was sent to Berlin where he discussed with Bethmann-Hollweg the draft convention on these points. The German secretary of state for the navy, Admiral von Tirpitz, refused the suggestion of a "naval holiday" between the two countries, and the idea of a neutrality pact also came to nothing; for the British Government proposed to undertake to remain neutral only if Germany was attacked, whereas the German Government demanded this neutrality should it declare war in consequence of its treaty engagement as a member of the Triple Alliance, and thus would have prevented Great Britain from coming to the help of France. The naval experts of France and Great Britain came to an understanding over the distribution of their navies, and it was arranged that the bulk of the British fleet, which was scattered over the Atlantic and Mediterranean should be concentrated in the North sea, while the bulk of the French fleet, leaving the defence of the Channel to England, would be in the Mediterranean. The desire, however, for good relations between Germany and England continued to show itself in the speeches of the leaders of the British Labour Party and in the good relations that existed between British statesmen and Prince Lichnovsky, the new German ambassador. The negotiations over the Baghdad railway (*q.v.*) and the Portuguese colonies in Africa were on the point of success at the moment when war was declared in 1914. Sir Edward (Lord) Grey, the foreign secretary of the Liberal minister, hoped to settle these difficulties by the frank exchange of ideas, and to prevent a collision between the two groups of Powers. The Germans were eager for a *rapprochement* with England, in order to secure her neutrality in the event of war against France for as long as was necessary to assure them decisive victory.

The Balkan Wars.—The crisis from which the ultimate catastrophe of Europe was to arise was born in that cradle of crises, the Ottoman empire. It began in Africa, where Italy, by means of a succession of agreements had obtained for herself a free hand in Tripolitania. Then, she suddenly went to war without advising her allies, occupied Tripolitania and proclaimed its annexation to Italy in 1911. Austrian opposition prevented her taking operations against Turkey in the Aegean. This Italo-Turkish war weakened Turkey and impaired the relations between Italy and Austria.

The Balkan nationalities profited by the war to bring about the dismemberment of European Turkey, while Russia took the opportunity to re-establish her influence over the Balkan peoples. In great secrecy Bulgaria signed, first with Serbia and then with Greece (March–May 1912), treaties and military conventions that settled the division among them of the lands they were about to conquer; they communicated the treaties to Russia and undertook that in event of disagreement among themselves they would submit to the arbitration of the tsar. This alliance completely upset the balance of power in the Balkans.

The Italo-Turkish war was ended by the Treaty of Lausanne (Oct. 18, 1912). The Balkan states determined to surprise Turkey before she had time to prepare herself, and despatched an ultimatum to the sultan in which they demanded autonomy for Macedonia. Then for the first time the small Balkan States, unaided, made war against the Ottoman empire. The Austrian Government, which had been apprised of their plans, offered no opposition because it counted on the victory of the Turks. But the Balkan allies routed the Turkish army and occupied Thrace, Macedonia, and Epirus; the Bulgarians, indeed, were only checked within sight of Constantinople. The victory of the Balkan States was felt in Europe as a Russian success, a check for Germany, the protector of the Ottoman empire, and a defeat for Austria—inasmuch as the Serbian victory, which was hailed by demonstrations on the part of the Slav subjects of Austria, encouraged the nationalist movement of the southern Slavs against Austria. The Austrians, determined to prevent the Serbs from reaching the Adriatic, threatened Serbia with war and forced her to evacuate Durazzo. The great Powers, anxious to avoid war at all costs, assembled a conference of ambassadors in London and created an Albanian State under the rule of the German Prince of Wied.

Excluded from the Adriatic the Serbs sought an outlet to the sea at Salonika and demanded that part of Macedonia which bordered on the territory conquered by the Greeks. Ferdinand of Bulgaria, however, required this country to maintain contact with Albania, and when Serbia appealed to the arbitration of the tsar, Ferdinand mistrusted Nicholas, who was disposed to favour the Serbs. To gain the advantages of offensive action Ferdinand ordered the Bulgarian army to make a surprise attack on the allied Serbians and Greeks. This resulted in the rout of the former, the invasion of Bulgaria—in which Rumania took part and the Peace of Bucharest which was disastrous to Bulgaria. The unity of the Balkan States was destroyed in this second war which assisted the revival of Austrian influence in Bulgaria.

The Balkan wars, which had taken place in spite of all efforts to preserve peace, awoke throughout Europe the fear of a general European war. The German Government announced in the Reichstag that the disturbance of the equilibrium in the Balkans, where Germany was bound to support Austria, involved an augmentation of its military strength. A huge credit for the war-chest was accordingly voted, whereupon the French Government replied by voting a three years' service. Austria looked upon Serbia as a permanent source of danger to the Habsburg monarchy and desired to reduce it to the condition of a small State dependent upon her; in 1913 she communicated to Italy a plan for the invasion of Serbia to which the Italian Government refused to be a party. The Russian Government wished to consolidate its newly regained influence in the Balkans by supporting Serbia, and it had resumed its plans for expansion towards Constantinople and the Straits. Russia moreover was alarmed at the extent of German influence over the Young Turks and protested when the German general, Liman von Sanders, was given the command of the Turkish army

corps at Constantinople. Isvolsky, who was Russian ambassador in Paris, desiring to avenge himself for his defeat in 1908, established intimate relations with Poincaré, president of the republic since 1913, who appointed as ambassador to St. Petersburg that enemy of Germany, Delcassé. Feeling themselves assured of the support of France the Russian Government reviewed the situation in Feb. 1913 and, confident that their plans with regard to Constantinople could not be realized except after a European war, they ordered the preparation of plans for a landing of troops on the Bosporus. The danger came from Austro-Russian rivalry and in the enmity between the French and German nationalists. It was in vain that the democratic parties endeavoured to avert a rupture by manifestations of Franco-German *rapprochement*, by the socialist conference at Basle and the inter-parliamentary conference at Berne. But the tension was maintained by incidents on the French frontier and by the centenary celebrations of the battle of Leipzig in Oct. 1913.

ORIGINS OF THE WORLD WAR

The Serajevo Crime.—Peace was broken by an event that occurred in the Balkan territory of Austria—the murder of the heir to the Austrian throne, the archduke Francis Ferdinand, at Serajevo, the capital of Bosnia. The murderers were Bosnian Slavs, and subjects of Austria; the weapons they used came from a Serbian arsenal. Long afterwards it became known that these weapons had been supplied to the assassins by a Serbian officer, a member of a secret society known as the Black Hand, which was led by an officer of the Serbian staff named Dimitrievič. The Serbs were inspired by hatred for Austria, who persecuted its orthodox Serb subjects and stood in the way of Serbian national unity. But the report made to the Austrian Government by Wiesner on July 13, 1914, rejected the idea of any complicity in the crime on the part of the Serbian Government.

The Austrian Government was convinced that the independence of the kingdom of Serbia imperilled the existence of the Austro-Hungarian empire, because it provoked the Slav subjects of the emperor to break away from the empire. Austria had already determined to render Serbia harmless by making it again dependent upon her, and she had instituted diplomatic action to isolate her by means of the Balkan league. The murder of the Archduke, however, opened the way for military action and Berchtold, the minister for foreign affairs, announced to Count Tisza, the Hungarian minister president, Austria's intention "to take advantage of the crime" to "settle its account with Serbia." Tisza advised that Austria should await a more favourable time and act only after she had achieved an agreement with Rumania and Bulgaria. The Austrian Government before entering into a war that might lead to Russian intervention wished to assure itself of the support of Germany and Count Hoyos was sent to Berlin with a letter from the emperor which was handed to the kaiser on July 5 by the Ambassador Count Szogeny.

The kaiser replied that Austria could count on "the complete support of Germany"; Russia was not ready for war and would think twice before taking up arms. The kaiser himself made preparations for leaving on the 7th for his annual holiday in the North Sea. He did not hold, as has been thought, a royal council at Potsdam, but confined himself to having an *informal* conversation with the chancellor Bethmann-Hollweg and interviews with certain officers whom he warned to take dispositions, although he did not believe Russia would go to war.

Without giving a definite reply Bethmann-Hollweg told Szogeny and Hoyos that in the relations between Austria and Serbia it was for Austria to judge as to what should be done, and he did not seek to learn the intentions of the Austrian Government (the Bavarian *chargé d'affaires* in Berlin said, on July 18, that Germany had given Austria "a free hand"). The two governments agreed that Italy should not be informed but the Germans advised Austria that it would be necessary to compensate Italy for any advantage which Austria might gain in the Balkans.

The Austrian council of ministers proposed at Vienna, on July 7, to impose on Serbia conditions so inacceptable as to lead only to war; Tisza opposed this policy and threatened to resign. The decision was taken on July 14. The chief of the general staff, Conrad, declared that from a military point of view "all temporizing" would be dangerous. The minister for foreign affairs, Count Berchtold, considered that from a political point of view this decision would be damaging to the prestige of Austria which Germany would tax with weakness. Another council held on the 19th agreed to the terms of the ultimatum to Serbia and discussed the results to be expected from the war. Serbia was to be placed in a state of dependence on the monarchy by a military convention; its dynasty was to be expelled; its territory apportioned between the other Balkan States. On July 21 the emperor gave his approval to the note, but it was determined to delay its dispatch until President Poincaré had left St. Petersburg. The whole operation was conducted in great secrecy. The German Government had adopted a passive attitude and had not made any attempt to induce Austria to modify the terms of the note. Europe received the impression that the Austrian and German Governments had come to an understanding to lull the suspicions of the other governments and take them by surprise.

The Ultimatum to Serbia.—The German Government had refrained from any participation in drawing up the ultimatum, which was, so it is said, "an affair for Austria," and it did not receive the text until the 22nd, although it had twice demanded it. The secretary of state, von Jagow, in the absence of the chancellor examined it and found it too severe; the Austrian ambassador replied that it had already been despatched to Belgrade. The ultimatum which was presented on July 23, taxed Serbia with not having kept the engagement of 1909 to live on neighbourly terms with Austria and with having permitted the development of a subversive movement for the separation from Austria of certain parts of its territory. The ultimatum went on to enumerate the conditions demanded by the Austrian Government among which were clauses compelling the Serbian Government to dismiss all officers and civil servants whose names should be communicated to it by the Austrian Government and to admit to Serbia Austrian representatives who should collaborate with the Serbian Government in repressing the subversive movement. A reply was demanded within 48 hours without any discussion on the terms of the note. The Austrian Government treated the Serbs as a subject people.

The Triple Entente could only conclude that Austria was determined to make war, notwithstanding the opposition of Russia, and that she had taken this decision in agreement with Germany. Berlin believed that Russia was in no condition to go to war and thought that France and England would not intervene; but the German ambassador in London, Prince Lichnowsky, made known to Berlin that the British Government counted on Germany not to associate herself with demands that manifestly had for their object the provocation of war.

On July 24, in London, Paris and St. Petersburg, the German ambassadors delivered a note in which the German Government declared that the Austrian demands were "equitable and moderate" and would, if necessary, be enforced by military measures; the matter was one to be settled exclusively between Austria and Serbia. Germany desired "the localization of the conflict" (this note had been drawn up before the German Government had seen the text of the ultimatum). The French minister replied, merely expressing the hope that Austria would be able to enter into negotiations with Serbia. The British minister, Grey, declared that the Austrian ultimatum "surpassed anything which he had ever seen" and pointed to the danger of a European war "if public opinion in Russia should compel the Government to make war on Austria"; he proposed a mediation on the part of the "Four Powers not directly interested." The Russian minister, Sazonov, refused to accept the localization for, according to him, it was "a European question," but on the following day he declared that Russia was prepared to exhaust every endeavour to avert war. The German Government, however, believed that the Triple Entente would not go to the extent of making war, though the latter, they saw, were determined to maintain the independence of Serbia.

On the advice of Russia and France the Serbian Government replied to the ultimatum accepting the majority of the demands; as for the conditions which violated the rights of a sovereign

State it declared itself ready to submit them to the international tribunal at the Hague. The Austrian minister at once pronounced this reply unsatisfactory, and left Belgrade on July 25.

The German ambassador at Paris proposed to the French Government that it should use its influence with Russia to prevent the spread of the conflict, but he refused the French proposal of concerted action by the Powers both at Vienna and St. Petersburg. Germany wished to prevent Russia from acting and to leave Austria free. The British Government proposed a conference in London of the four Powers which should demand jointly the suspension of all active military operations by Austria, Russia and Serbia. The German Government refused, because it could not—so the chancellor wrote—"drag Austria before a European tribunal," nor could it set itself up as mediator between Austria and Serbia except "in a conflict between Austria and Russia." It persisted in wishing to localize the conflict, that is to say, to hand over Serbia to Austria, and it counted on the inaction of England. The brother of William II., Prince Henry, visited King George in London, and was asked by the king to do his best to keep out of the war. Sazonov proposed a direct negotiation to the Austrian ambassador and Berchtold replied that war had already commenced. This was not true, but Berchtold wished to create a definite situation in order to prevent a further move on the part of the Entente Powers.

On the evening of July 27, the German Government was informed by its ambassador in London that Grey had said to him that any military action on the part of Austria would be a "direct provocation" to Russia and that it was the duty of Germany to hold Austria in check. The British cabinet had ordered the fleet, which was about to disperse, to remain concentrated (July 28). The German chancellor informed Austria that Germany could not refuse all mediation, for it was important that they should appear to be forced into war. But he did not advise Austria to stop her military operations. The kaiser, who had returned to Germany, read the Serbian reply and wrote in the margin "a great moral victory for Vienna, but it dissipates every reason for war." He proposed only that Belgrade should be occupied as a pledge of the execution of their promises by the Serbs (July 28). Bethmann, who was informed by the German ambassador that Berchtold was proposing to dismember Serbia, demanded from him a declaration of his intention to reassure public opinion in Europe. But he advised his ambassador "to avoid creating the impression that we are desirous of resisting Austria."

Declaration of War Against Serbia.—On July 28, 1914 Austria declared war on Serbia by telegram and broke off the conversations in which she was engaged with Russia because they no longer served any purpose; on the 29th she began the bombardment of Belgrade. The Russian Government drew up two mobilization orders, the one a partial one with a view to war with Austria alone, the other a general one. Disagreement now became manifest within the Governments of both Russia and Germany as to the policy to be followed. For military reasons the general staffs desired to hasten their preparations for war in order to assure the advantage of offensive action, while the civilians for political reasons, sought to delay for fear of appearing responsible for breaking the peace. At first the German Government sought to intimidate Russia and its ambassador, Count Pourtalès, declared on the evening of the 28th to Sazonov, that a continuation of the Russian mobilization would compel Germany to mobilize; "it would be nearly impossible to prevent the European war." The Russian Government determined to order a general mobilization but the tsar, who was anxious for peace, cancelled the order and decreed instead the partial mobilization. In Germany on the same day, July 29, the general staff demanded an immediate decision in order not to leave the initiative to the enemy; Bethmann sought to delay the decision.

The Austrian Government finally declared to Russia on July 29 that it had no intention of annexing Serbian territories but that it could not accept the Russian proposal to respect "the sovereign rights of Serbia." Bethmann sought to avert a British intervention by proposing, on the evening of the 29th, to the British ambassador, Goschen, that if England would remain neutral Germany would not annex any French territory. Immediately there arrived a telegram from the German ambassador in London announcing Grey's declaration that if war broke out England could not remain a spectator. The German Government, advised moreover that Italy would not support her allies, during the night sent many communications to Vienna for the purpose of inducing Austria not to reject any project of mediation. The same evening the tsar proposed that the Austro-Serbian dispute should be submitted to arbitration and he despatched a personal telegram to William asking him "to exert very great pressure" on Austria. The kaiser replied that if Russia continued to mobilize he would be unable to influence Vienna: "It is on you that the weight of the decision lies."

The Russian and German Mobilization.—On the 30th the tsar gave way to his general staff, who pointed out that partial mobilization on the Austrian frontier would disorganize the general scheme of mobilization; he, therefore, gave the order for the general mobilization.

The Austrian council of ministers refused to suspend their operations against Serbia, and requested England to stop the Russian mobilization; as yet, it was unaware of the partial mobilization. On the advice of the German general staff, it ordered the general mobilization on the morning of the 31st. Both governments declared that the mobilization was a defensive one and would not preclude negotiations. On receiving information of the Russian mobilization, the kaiser proclaimed a state of war to be imminent and informed Sazonov that if the Russian order was not cancelled within 24 hours, Germany would consider herself at war with Russia. The Russian mobilization had, in Germany, given the impression that Russia was the aggressor; all parties, even the Socialists, united to pass the votes of credit and to defend Germany against the Russian invasion.

The Declarations of War.—On his return to Paris from St. Petersburg, Poincaré had telegraphed to Russia that "France would fulfil her obligations under the alliance," although continuing her efforts to preserve the peace. In order to avoid the risk of a military conflict, the French Government ordered its troops to withdraw to ten kilometres behind the frontier. On the evening of the 31st, von Schoen, the German ambassador, informed the French minister Viviani, that he would return on the following day to learn what would be the attitude of France in event of a war between Germany and Russia. The answer was made to him that "France would act as her own interests required." It has since been revealed that von Schoen was in possession of instructions that if France promised to remain neutral he was to demand the cession to Germany of Toul and Verdun as a guarantee. On August 1 a general mobilization was ordered in France almost simultaneously with Germany.

Realizing that war was inevitable, the French Government called upon England for assistance. But there the Liberal cabinet was divided, and the majority hesitated to launch Great Britain into a continental war in which its interests and its honour were not immediately engaged. Parliament was not in session and public opinion did not seem ready for war. The decision to take part in the war was precipitated by an action on the part of Germany. Great Britain, in common with France, Austria, Prussia and Russia was a signatory to the treaty of 1839 which guaranteed the neutrality of Belgium, and this obliged it to repel with armed force any violation of Belgian territory. In 1868 the Great Powers had similarly guaranteed the neutrality of Luxembourg. Grey had demanded on July 30 an assurance from the French and German Governments that the neutrality of Belgium would be respected. France gave this, but Germany declared herself unable to make any reply. The plan of the German general staff was to make a swift attack on the French army in order to crush France before the Russian armies were ready, and in order to avoid fighting on two fronts. The chief of the Austrian general staff, Conrad, had been informed that the German general staff calculated that the operations against France would be concluded 33 days after mobilization. But to act quickly the German army was compelled to pass through Belgium. On Aug. 2 it occupied Luxembourg.

The German Government declared war on France on Aug. 3,

alleging that the French had violated German territory. The German ambassador in Brussels handed to the Belgian Government a note demanding a free passage for German troops across Belgium, accompanied by a threat that if Belgium refused, she would be treated as an enemy, and adding that it was aware that French troops were about to enter Belgium. The German general staff, however, had actually drawn up this note several days previously and had prepared proclamations to the Belgian people. The Belgian Government refused; the German troops had already crossed the frontier. This intelligence decided the British cabinet to act; three ministers alone refused to support the war and handed in their resignations. The English ambassador, Goschen, delivered an ultimatum in Berlin, calling upon the German Government to respect the neutrality of Belgium; he was refused. The war began the night of August 4–5.

DIPLOMATIC RELATIONS DURING THE WAR

The Question of Responsibility.—The investigation of war responsibility does not lie within the sphere of this article. But after the Treaty of Versailles had declared Germany responsible for the war by calling upon her to pay for its ravages, the reproach of having started the war provoked in Germany an agitation over war guilt which has become one of the factors of European politics. It will be useful to examine the position of this question.

The secret documents published since 1919 do not confirm the opinion that was prevalent during the war that Germany had deliberately intrigued to inveigle France and Russia into a trap prepared for many years with a view to the extension of dominion by war. It is certain that no Government really desired a European war; Austria desired only a local war with Serbia; Germany supported her, as in 1909, in order to frustrate Russia. When the Russian Government had shown itself determined to defend Serbia, the German and Austrian Governments refused to retreat from the risk of a general war. This risk compelled the European States to make military preparations. It was Russia who took the initiative in ordering a general mobilization, and German public opinion has seen in this fact the proof of a determination to make war, and so has thrown the responsibility for the war on Russia. It was Austria and Germany, however, who first declared war; but neither a mobilization nor the declaration show who really willed the war. Undoubtedly international law was violated. It was violated when Austria sent an ultimatum to Serbia containing clauses incompatible with the rights of a sovereign State, and when she invaded Serbian territory in order "to chastise the Serbs," who were not her subjects. It was violated when Germany invaded Luxembourg and Belgium, notwithstanding the neutrality which she herself had guaranteed.

The Governments of the three empires wished to avert a general war but they were too distrustful of one another frankly to consult upon the means of avoiding it; for each feared to reveal its plan lest it should become the dupe of a bluff or ruse. France and England were powerless spectators of the conflict. France was bound by the Russian alliance; the British cabinet did not dare to risk action which had not been approved by the nation. The war was not the work of personal ambitions, but the result of the system of the three military empires, Austria, Russia and Germany. The civil authorities responsible for the acts of their Governments, did not venture to decide on war. Of the three emperors not one desired the war but all three, brought up in an entourage of officers and accustomed to show deference to military opinions, felt obliged to leave to the general staff, not only the decision as to how the war should be conducted but also the moment when it should be begun. The general staffs, eager to take action in order to deprive the enemy of the offensive, which was then considered the decisive factor, extorted from their sovereigns authority to take the initiative. The war was thus the result of a military plan. (*See* WAR GUILT.)

Course of the War.—The history of the war is treated elsewhere. (*See* WORLD WAR.) But inasmuch as military operations exercised a decisive influence upon diplomacy it may be as well to indicate here its general course. The general staffs of all the States were convinced of the great advantage to be derived from taking the offensive, and they each sought to take it in the hope of bringing the war to a speedy conclusion by a decisive victory. But the war lasted for more than four years without any offensive resulting in a lasting success.

The Austrian offensive in Serbia in 1914 was repulsed by the Serbs; the German offensive in France was stopped on the Marne; the Russian offensive in Prussia ended in disaster. The Serbian offensive in Austria and the Russian offensive in Galicia in 1915 were repulsed; the French offensives first in Artois then in Champagne, were arrested with great loss. The Italian offensive against Austria was checked on the Corso, and the British offensive against the Turks in the Dardanelles failed after a massacre of British colonial troops. In 1916 the German offensive at Verdun failed, the Russian offensive was checked on the borders of Galicia, and the Rumanian offensive resulted in the invasion of Rumania. In 1917 the British offensive was checked in Artois, the French in Champagne, the Russian at Tarnepol where the Russian army was destroyed; the Italian offensive was arrested by the *débâcle* of Caporetto (*q.v.*) and the Austro-German counter-offensive against Italy ended on the Piave. In 1918 the supreme offensives of the Germans in Picardy on the Marne and at Rheims were alike repulsed.

The war was decided not by victories but by the exhaustion of the armies and by the failing *morale* that manifested itself successively among the nations—in Austria in the defection of the Austrian Slavs, in Russia after the revolution, in Rumania, Bulgaria, and finally in Germany. In this war between two coalitions the one which possessed the greatest extent of territory, the greatest population, and the most abundant resources, ended by conquering the other, which at the outset had had the advantage of a better trained army, one able to operate on interior lines. But the coalition primarily achieved victory because as mistress of the seas she preserved the means of revictualling her armies and peoples, whereas the central empires had access only to two small ocean-highways—the Adriatic and the North Sea—which were blockaded by the navies of their enemies. Victory did not take the customary form of an invasion of the territory of the vanquished; the victor while yet in occupation of enemy territory had been converted into the vanquished by the exhaustion of his armies and by the demoralization of the civilian population.

The Neutrals.—The war opened between Austria and Germany on the one hand and Russia, France, Great Britain, Serbia and Belgium on the other hand. The Central Empires appealed to their allies. Italy replied that as Austria had taken the offensive, there existed no *casus foederis,* and that she could not give her support except on conditions deemed inacceptable by Austria. King Charles of Rumania was allied to the central empires by a secret treaty but a crown council decided that there was no *casus foederis,* and Rumania remained neutral. Turkey under the influence of the Germanophil Young Turks who were uneasy about Russia's projects against Constantinople, signed a treaty of alliance against Russia on Aug. 2 and on Aug. 6 Germany promised to lend her support in obtaining the abolition of the capitulations (*q.v.*). The Turkish Government permitted two German cruisers to enter Constantinople, but at the same time, in order to veil its intention, proclaimed the neutrality of Turkey. Ferdinand of Bulgaria had negotiated an alliance with Austria but, fearing that if he attacked Serbia, Serbia would be supported by Greece and Rumania, he remained neutral waiting to see which side was going to be victorious.

Turkey Enters the War.—The British and French ambassadors attempted to keep Turkey neutral by a promise to guarantee the integrity of her territory but the Russian Government would have preferred a war with Turkey which would have afforded her the opportunity to carry out her designs on Constantinople. The Turkish Government, foreseeing a victory for Germany, abolished the capitulations (Sept. 9), closed the Dardanelles, and finally despatched her fleet to bombard the Russian coasts. Russia declared war and the tsar in the manifesto of Nov. 2 announced the "solution of the historic Russian problem of the sea-board of the Black sea." The entry of Turkey into the war broke the line of communications between Russia and

her allies by the convenient route of the Black sea and threatened British supremacy in Egypt. England replied by annexing Cyprus and opposing the khedive of Egypt whom she replaced by his son, a protégé of Great Britain.

The Allied Coalition.—In consequence of her alliance with England, Japan entered the war on Aug. 23, and on Sept. 5, 1914, the three Entente Powers, Great Britain, France and Russia pledged themselves by the Pact of London not to conclude peace separately and not to lay down conditions of peace before they had been agreed in common. At the request of the Russian Government the Allies signed an agreement with Russia known as the Constantinople Agreement on March 18, 1915 which promised Russia, Constantinople and the Straits, together with a portion of the hinterland on either coast in Thrace and Asia Minor. Constantinople was to be a free port.

Italy had armed and opened negotiations with both parties. At first she did not demand from Austria more than the cession of the Italian-speaking Trentino, but as the war went on she determined to place a higher price on her support. In April 1915 she demanded from Vienna, as the price of her neutrality in addition to the Trentino, Gorz and Gradisca, numerous islands in the Adriatic, which should be handed over to the immediate possession of Italy, and a declaration of Austria's disinterestedness in Albania. On the advice of the Germans and of Conrad, the Austrian Government continued negotiations. But Italy preferred the offers of the Entente and undertook to support the allies "with all her resources" by the Treaty of London of April 26, 1915. She was promised by this treaty the whole of the Tirol south of the Alps, with its natural and geographical frontiers up to the Brenner; Istria as far as Guarnero and the islands, and the whole of Dalmatia, of which the southern portion was to be neutralized. In event of a partition of the Turkish empire, Italian interests were to be safeguarded in the Near East. On May 3 the Italian Government denounced its treaty with Austria and on May 23 declared war on her. Thereupon Germany broke off diplomatic relations, although Italy did not declare war on Germany until Aug. 1916.

Bulgaria.—The strategic position of Bulgaria and Rumania on a line of communication between Austria and Turkey rendered their support of peculiar value to the Central Empire. Russia brought pressure upon the Serbian Government to make concessions to Bulgaria in Macedonia; she promised Rumania the annexation of Austrian territory populated by Rumanian speaking inhabitants; but the fear of an attack by her neighbours prevented King Ferdinand, who had succeeded Charles in 1914, from committing himself even after the entry of Italy into the war. The Central Empires, requiring the aid of Bulgaria against Serbia, promised her all Macedonia. The Entente was powerless to make offers to Bulgaria without the consent of its Serbian ally, but the *skuptchilna* consented, on Aug. 16, 1915, to the cession of a portion of Macedonia, but subject to Serbia receiving territories to be conquered from Austria. Bulgaria, however, demanded immediate possession, and turning towards the Central Empires, she signed a treaty on Sept. 6, 1915, which promised her the annexation of nearly all Macedonia and that eastern portion of Serbia which she claimed as Bulgarian, and further, in event of an attack being made upon her by Rumania or Greece, she was promised the restitution of the territory she had lost in 1913. The Central Empires thus acquired a line of communication with Turkey, and embarked, in Oct. 1915, on a campaign that resulted in the occupation of Serbia.

Greece.—The Allies could only come to the rescue of Serbia by way of the Greek port of Salonika. The Greek cabinet was divided among itself and Venizelos, who had directed Greek policy since 1911, and who was supported by the majority of the chamber, worked in the interests of the entente. But King Constantine, who was a brother-in-law of William II., and a Germanophil, dismissed Venizelos in March 1915, and dissolved the chamber. After the elections Venizelos, who had returned with a majority, gave the Allies leave to disembark troops at Salonika. Constantine, however, refused to depart from his neutrality and the allied troops were disembarked in Oct. 1915, despite the protests of the Greek Government, and too late to save Serbia.

The Inter-Allied Council.—The Allies soon realized that diplomacy was an ineffectual way of co-ordinating military operations. The French minister for war, Millerand, visited London, and Asquith, the British prime minister, interviewed Joffre, chief of the French staff, at the British headquarters. As a result, the decision was taken to co-ordinate operations by conferences. The first conference was held at Calais in July 1915 by the British and French prime ministers, with the assistance of Lord Kitchener, Lord Crewe, Balfour, Millerand, Delcassé, Augagneur and Albert Thomas. In a single day it made strategical decisions that had been in abeyance for weeks. The second conference in Paris, on Nov. 17, between the chief ministers of the two States, resolved to reinforce the army at Salonika and discussed the question of landing at the Dardanelles. It further resolved to establish a committee for the purpose of co-ordinating allied actions and at a meeting between Briand and Asquith in London, in Jan. 1916, an organization was agreed upon. It was given the character of a consultative body, composed of the prime ministers in office with the collaboration of other ministers and technical experts. The object was to place the control of the military in civilian hands; for all the meetings were preceded by meetings between the general staffs. The first took place in Paris on March 26, 1916, and was attended by the prime ministers of France, Great Britain, Belgium, Italy and Serbia, and the ambassadors of Russia, Japan and Portugal. It passed decisions on proposals made by the general staffs, presented by Joffre, and established an Inter-Allied transport council in London.

A secret agreement concluded by Great Britain in 1915 for the creation of an Arab kingdom should be mentioned here, since it compelled Great Britain to come to an agreement with France for a division of their spheres of influence in Syria and Cilicia. This agreement, known as the Sykes-Picot agreement from the names of the negotiators, was communicated to Russia, but concealed from Italy, whose claims it controverted.

Rumania and Greece.—After the defeat of the Germans at Verdun and the success of the Russian offensive against the Austrians, the Rumanian Government, confident in the triumph of the Allies, signed a treaty of alliance and a military convention on Aug. 17, 1916, which promised to Rumania all Austrian territory inhabited by Rumanian-speaking peoples. Rumania at once entered the war, but its offensive was speedily repulsed and its territory invaded.

The Rumanian disaster gave an added importance to Greece as the sole country by which the Allies were able to invade eastern Europe. The quarrel between Constantine and Venizelos led to a civil war. The latter, supported by the Greek islanders, established a Provisional Government at Salonika under the protection of the Franco-British army and made war in Bulgaria. France and Great Britain were prevented by Russia and Italy from taking action against Constantine, who remained master of the old kingdom. An Inter-Allied conference at Boulogne on Oct. 20, 1916, composed of the Allied chief ministers, for foreign affairs, war, and the marine, commanders-in-chief, and the chiefs of the British and French general staffs, determined to give financial and military assistance to Venizelos. The conflict with Constantine was resolved by the intervention of the French Government, which demanded on Oct. 10, the disarmament of the Greek fleet and the control of the police and the railways. The excitement in Athens, which was encouraged by the king, resulted in a massacre of Allied marines and Venizelists. The crisis was not ended until 1917, when Constantine left Greece and Venizelos, returning to power, brought Greece into the coalition and into the war against Bulgaria.

United States.—In full accordance with their tradition of abstaining from all "entanglements" in European affairs, the United States at first held aloof from the war. President Wilson was led to intervention by the measures taken by the Allies against neutral ships for the purpose of preventing contraband trade with Germany. He announced to the British Government his desire to see the rights and duties of the United States respected in accordance with the principles of international law and

treaty obligations. He protested against the blockade of the North sea and demanded the liberty of the sea. Discussion was continued on the subject of the use of submarines, floating mines, and the seizure of merchant vessels.

The sinking of the "Lusitania" by a German submarine, involving the death of 124 Americans, aroused public opinion in the United States and Wilson informed Germany that he would be obliged to go to war if she continued to take the lives of American citizens. At the same time he promised to use all means at his disposal to raise the starvation blockade. The German ambassador, Count Bernstorff, declared that German submarines had already received orders not to attack passenger vessels. Notwithstanding this, the "Sussex" was torpedoed in March 1916, and American lives were lost. The United States despatched an ultimatum to the German Government, which promised not to sink merchant vessels without affording the passengers an opportunity of saving their lives; the Germans demanded in return an intervention on the part of the United States in London to force England "to recognize the laws of humanity." While he refused any intervention, Wilson exerted himself to the utmost to preserve peace. After his re-election he proffered his mediation to the belligerents on Dec. 18, 1916, inviting them to make known their conditions of peace, and expressing the hope of rendering peace durable by the creation of a League of Nations (*q.v.*).

First Peace Proposals.—After having occupied Russian Poland in 1915, Germany and Austria sought to obtain the military assistance of the Poles by giving them pledges for the future. The proclamation issued on Nov. 5, 1916, promised the restoration of an independent Poland which, however, would be closely united to the two empires. The Russian Government replied with the publication of a promise to establish a Great Poland under the guarantee of the Entente.

The Central Empires were now beginning to feel the privations of the blockade. The emperor Francis Joseph, who died on Nov. 21, 1916, was succeeded by the young and inexperienced Charles, who desired peace, and who communicated his desire to William II., by whom it was approved. The two emperors in a conference with their ministers and chiefs of staff, decided to suggest peace at a moment when their military successes would enable them to dictate conditions. In the name of Germany and her Allies, Bethmann-Hollweg addressed a note to the neutral States announcing "propositions" that should serve as a basis for a lasting peace (Dec. 12). Germany answered Wilson by proposing a direct negotiation between the belligerents in a neutral country.

The Allies denounced this offer as a manoeuvre calculated to promote discord between them. Lloyd George, who had become the head of a coalition ministry, declared that to enter into a conference with a Germany that claimed to be victorious without any notion of the propositions to be made would amount to "placing our heads in a noose." On Dec. 30 the Allies replied that the proposal was entirely unsubstantial, and they demanded expiation for crimes committed, and complete indemnity for all the destruction caused by the war.

On Jan. 10, 1917, they replied to Wilson with a statement of their peace conditions: Reduction of the territory of Germany; dismemberment of Austria by "the liberation of the Italians, Slavs, Rumanians, Czechs and Serbs from an alien rule"; and the expulsion of the Turks from Europe. Further, they announced that they adhered with all their heart to the idea of the League of Nations.

Judging the German reply to be too vague, Wilson invited the German Government to define more exactly its conditions of peace. Bernstorff was instructed to inform Wilson that Germany was unable to accept his offer of mediation because such an acceptance might give to her enemies the impression that the German offer of peace was inspired by fear. Wilson continued to work for a peace "by understanding" and he said, in January 1917, that "only a peace between equals can be durable." His confidant, Col. House, who in 1915 and 1916 had entered into conversations in Europe with the leaders of both groups of belligerents, besought Bernstorff to advise his Government to communicate to the President their terms of peace in order that he might then propose a peace conference. But a royal council in Germany, notwithstanding the opposition of the chancellor, had already determined to embark on unrestricted submarine warfare, which, according to the German admiralty, would force Great Britain to sue for peace in five months.

An Allied conference at Paris on Nov. 15 and 16, 1916, composed of British and French delegates, discussed the critical situation in Russia and later, in conjunction with Russian and Italian delegates, the Polish and Greek questions. The conference in London on Dec. 16 between the British and French statesmen drafted replies to Germany and America and discussed operations in Palestine and the extension of the British front in France. The Rome conference of Jan. 5, 1917, between the four European members of the alliance discussed the military and financial help to be given to Russia, decided the measures to be taken in Greece against Constantine, and the instructions to be given to Gen. Sarrail, commander of the allied army at Salonika.

America Enters the War.—On Jan. 31, 1917, Wilson was informed by Bernstorff that on Feb. 1 Germany would commence unrestricted submarine warfare. Accordingly, on Feb. 3, the President broke off diplomatic relations with Germany. It became known that Germany had offered Mexico her alliance in event of a war with the United States. On April 6, the United States declared war on Germany and in the following December on Austria. The majority of the Central and South American States also declared war, but without taking any military action; on July 22 Siam, and on Aug. 14 China, followed.

The Conference of St.-Jean-de-Maurienne.—The Italian Government, when it learnt of the secret Franco-British understanding about the Arab countries, demanded a precise interpretation of the article of the Treaty of London that dealt with the Italian claims in Asia Minor. Since Italy dominated the line of communication with Salonika, the British and French premiers entered into a discussion with the Italians on April 17, at St.-Jean-de-Maurienne, which resulted in a secret compact by which Smyrna was promised to Italy. France proposed to demand the abdication of Constantine, but Sonnino rejected the proposal.

The Austrian Peace Negotiations.—The emperor Charles and his foreign minister, Count Czernin, in vain endeavoured to dissuade Germany from undertaking submarine warfare. They perceived that the Austrian monarchy was threatened by the revolt of its Slav subjects, and, knowing that the Allies did not desire the destruction of the Habsburg monarchy, they worked to obtain a peace by understanding. When Bethmann-Hollweg visited Vienna in March, Czernin told him that Italy had made overtures of peace and that France seemed disposed to negotiate. Bethmann, while agreeing to everything in principle, objected that France would demand Alsace and that he would not dare to suggest it to the emperor or the German nation; he therefore advised negotiations on the basis of an exchange of territory. Czernin demanded that Germany should cede Alsace to France and receive Poland in compensation; Austria to be permitted to indemnify herself in Rumania. The military commanders who directed the policy of Germany were against this proposal, and wished, on the contrary, to deprive France of the Briey mines and to force Belgium into an economic and military union with Germany. An agreement, concluded at Kreuznach on May 17, between the Austrian and German Governments, guaranteed to Austria the integrity of her territory and certain acquisitions in the Balkans. Germany, in event of obtaining the annexation (*Angliederung*) of Courland and Lithuania and the protectorate (*Anlehnung*) of Poland, was prepared to agree that Rumania should come within the Austrian sphere of influence.

The German Government was ignorant of the secret negotiations with France in which the emperor Charles was already engaged through his brother-in-law, Prince Sixtus of Parme, who had arrived in Vienna following the departure of Bethmann-Hollweg. Czernin did not approve of the proposed conditions, and Charles, without advising Czernin, despatched by Sixtus, on May 24, an autograph letter addressed to the president of the republic, Poincaré, in which he professed himself willing to support in Berlin "the just claims of France to Alsace-Lorraine" and to work

for the re-establishment of Belgium and Serbia as sovereign States; he further agreed to grant Belgium an indemnity and to give Serbia an outlet to the Adriatic. The Allies regarded this letter as a proof of the weakness of Austria and observed that no mention was made of a cession of territory to Italy. At the conference of St.-Jean-de-Maurienne, Sonnino declared that he could admit no discussion of "the aspirations of Italy as recognized in the Treaty of London," and he added that Italy could never conclude a "white peace."

The Russian Revolution.—The March Revolution of 1917, by which the tsardom was overthrown in Russia, left Russia still a member of the alliance of 1914. The Provisional Government carried on the war with the support of all parties—even of the Socialists—with the sole exception of the Bolsheviks. But the regulations introduced by the revolutionaries into the army, and the revolutionary propaganda for the return of the troops to their homes, paralysed the Russian army. The Bolshevik leaders, some of whom had returned to Russia through Germany, established themselves in St. Petersburg and engaged in a violent propaganda against the provisional Government. Socialists throughout Europe gave their support to a proposal of the Germanophil Dutch Socialist, Troelstra, to hold a conference at Stockholm, in a neutral country, for the purpose of concerting measures to compel the belligerents to conclude peace, and to force them to make known their war aims. Kerensky, the Russian president, and Arthur Henderson, the leader of the British Labour Party and a member of the British cabinet, gave their support to the proposal, which was also favourably regarded by Lloyd George. At a conference in London on May 28, composed solely of British and French representatives, any participation in the conference at Stockholm was rejected and passports refused to British and French delegates. This conference further took measures to reorganize the Salonika front.

The collapse of the Russian army forced the Allies to take certain decisions. A great inter-Allied Conference was held in Paris on July 25, composed of representatives of Great Britain, France, Russia, Italy, Greece, Rumania and Serbia. At a further conference, on the succeeding day, were added representatives of Belgium, Japan, Montenegro and Portugal. These conferences decided to grant financial aid to the Government of Venizelos, discussed the proposal of establishing an allied base at Corfu and Italian operations in Epirus.

German Peace Negotiations.—The German nation, which was depressed by the privations of the blockade and the failure of the U-boat warfare, despaired of a victorious peace. On July 19 a majority in the *Reichstag,* which up to then had been the docile servant of the Government, passed a motion proposed by Erzberger, the leader of the Centre, in favour of a peace by understanding, without territorial acquisitions and financial or economic constraints. The resolution demanded freedom of the seas and announced the determination of the German people to fight on for so long as "the enemy Governments threatened Germany and her allies with conquest and oppression." Bethmann-Hollweg, attacked by the majority, resigned, and the new chancellor, Michaelis, deprived the motion of all real effect by his declaration that its objects were capable of attainment within the limits of the motion "as I understand it" a declaration that was regarded by the Allies as a sign of bad faith on the part of the German Government.

The peace negotiations that had been carried on secretly in Switzerland between unofficial agents—Baron Revertera, an Austrian diplomat, and Comte Armand, a French officer—in Aug. 1917, failed on account of the conditions to be imposed upon Germany. The deep resentment that had been aroused in the French and Belgian peoples by the ravages of war and the repressive measures of the Germans against non-combatants—measures that were exaggerated and distorted in propaganda—rendered a friendly understanding with Germany impossible of achievement.

The Pope's Intervention.—In agreement with the German Catholics and in an endeavour to save the Catholic Austrian monarchy, Benedict XV. appealed to the heads of the belligerent States to negotiate on the basis of arbitration, reparation and reciprocal restitution, and liberty of the seas. The Allies returned no reply, and Wilson sent a refusal. The British cabinet stated that it could enter into no negotiation that had not been preceded by an unequivocal declaration on the part of Germany that Belgium would be restored after the war. At a royal council at Potsdam on Sept. 14 it was decided, on Ludendorff's advice, that Germany should stand firm. The German reply to the pope, on Sept. 19, did not even mention Belgium, while a verbal note handed to the papal nuncio at Berlin, stated that Belgium must grant Germany the right to undertake commercial ventures and preserve the separation of Flanders as established by the Germans. Thus the peace-move of the Vatican ended in failure. Nor were the conversations in Belgium between Lancken and Coppée, and the Spanish negotiations attended by any greater success.

The Supreme War Council.—The Caporetto disaster led to the holding of a conference at Rapallo, on Nov. 7, between the French, British and Italian statesmen and the chiefs of staff, at which military measures were taken to avert the threatening danger. On the proposal of Lloyd George the conference determined to set up a central body to direct operations on all fronts. At a general inter-allied conference in Paris, on Nov. 29, a Supreme War Council was established which held its first meeting on Dec. 1. It was a permanent advisory body composed of the heads of the Allied Governments and its recommendations were not put into practice until they had been accepted by the Governments. Since it was composed of representatives of the British Colonies, India and the majority of the Allied Governments, its real authority became very great. Its deliberations have been kept secret. All that is known is that at its meeting at Versailles (Jan. 30–Feb. 2, 1918) it determined to constitute a general reserve for the whole of the armies on the Western, Italian and Balkan fronts, and entrusted the execution of this task to an executive body composed of military representatives of Great Britain, Italy, the United States and France. After the German offensive on March 21, a meeting of the council was held at Doullens, on March 26, at which Marshal Foch was charged with the duty of establishing co-ordination between the French and British armies; and, after the failure of the German offensive, the council, at its meeting at Abbeville on May 1, decided to abolish the military executive and entrusted to Foch the supreme command of the Allied armies.

Renewed Austrian Peace Moves.—In Germany, Count Hertling, the leader of the Catholic Bavarian Centre, became chancellor in Nov. 1917. He was inclined for peace but was powerless against the military leaders, Admiral Tirpitz, who had just founded, in September, the warlike *Vaterlands-partei,* and, above all, Gen. Ludendorff, who was the soul of the general staff. William II., yielding to their counsels, decided to continue the war. In France, Clemenceau, who had become president of the council, exclaimed in the chamber on Nov. 20, 1917 "La Guerre, rien que la guerre," and he adopted repressive measures against the pacifists. In England, Lord Lansdowne pointed out, in a letter to the *Daily Telegraph,* that a continuation of the war would entail the ruin of the entire civilized world and he suggested that the Allies should reconsider their war aims. In December the South African representative, Gen. Smuts, engaged in conversations with the late Austrian ambassador in London, Count Mensdorff-Pouilly, with a view to separate peace with Austria; they failed because Mensdorff's instructions compelled him to act in unison with Germany.

Charles and Czernin saw the Austrian monarchy threatened with a revolt of its Slav populations. In the *Reichsrat,* in May 1917, the Slav majority overthrew the ministry at the first meeting held since 1914. Charles thought that help might be obtained in England, but Lloyd George told the trade union delegates on Jan. 5, 1918, that England would support French democracy to the death in its demand for a "reconsideration of the great wrong of 1871," although she did not make war to bring about the breakup of the Habsburg monarchy. He outlined three indispensable conditions for peace: the re-establishment of the sanctity of treaties; a territorial rearrangement of Europe, based on the right of self-determination; and the establishment of an international organization to limit the burden of armaments and lessen the

probability of war.

Intervention of President Wilson.—The hopes of Charles were destroyed by the publication of Wilson's Fourteen Points (*q.v.*). The central European empires approved of the theoretical clauses, in which were advocated the abolition of secret diplomacy, freedom of the seas in time of war, commercial equality, reduction of armaments and a League of Nations. But their rulers refused to agree to the independence of Belgium, the cession of Alsace-Lorraine, the restoration of Poland and the freedom of the Straits. The Austrian Government, in particular, saw the ruin of the monarchy in the recognition of the right of its subject nationalities to autonomy and the surrender of its Italian-speaking lands to Italy. Wilson's programme imposed all the sacrifice on the Central Empires, while behind it lay the secret agreements between the Allies.

The German Government declared that, in view of the military situation, it was not in a position to negotiate on the bases laid down by Lloyd George, and demanded their revision, letting it be clearly understood that it would not cede any portion of Alsace-Lorraine. The Supreme Council at Versailles answered, on Feb. 4, that this declaration did not propound a suitable basis for negotiations.

Russia and Germany.—The second Russian Revolution of Nov. 1917 brought into power the Bolsheviks, who were eager for peace and enemies of the Ententes. The new Government invited all the belligerent States to conclude an armistice and to enter into negotiations for a general peace. The Allies refused the invitation, which was contrary to the provisions of the Treaty of London, and on Dec. 7, the Russians agreed to a suspension of hostilities with Germany and her allies, and subsequently, on Dec. 15, concluded an armistice to which Rumania was forced to be a party. The peace negotiations were made publicly at Brest-Litovsk (*q.v.*). The Bolsheviks at first embarrassed the delegates of the quadruple alliance by demanding for all nations that right of self-determination which spelt the ruin of the Turkish and Austrian empires; on Dec. 25 the delegates accepted the Russian proposals for a peace without annexation and indemnities, with a reservation that it must also be accepted by the Allies, who were invited to take part in the deliberations on this basis. As they refused, the negotiations were resumed on Jan. 9, 1918, for the conclusion of a separate peace. The leader of the Russian delegation, Trotsky, demanded the evacuation of German troops from the Russian provinces they were occupying, in order to allow full liberty for plebiscites; and he protracted the negotiations to facilitate revolutionary propaganda in the Central Empires.

A delegation from the Ukraine arrived at Brest-Litovsk to demand that Russia should be constituted a federal republic. On receiving a refusal from the Bolsheviks they proclaimed the independence of the "republic of the Ukrainian people" and concluded a separate peace on Feb. 9, in which Austria promised, in a secret clause, to erect into a separate crownland, Ruthenian Galicia. The Ukrainians promised to furnish a million tons of corn. But the Bolsheviks overthrew the Ukrainian Government, and the Ukraine was then occupied by Austro-German troops, who succeeded, with difficulty, in collecting a portion of the promised delivery of grain. Concessions made to the Ukrainians irritated the Poles, and they turned against Austria; a part of the Polish troops in Galicia marched into Russia, whence they were conveyed, under Gen. Haller, to France and there united to the Polish Legion.

In opposition to the German officers by whom the negotiations were conducted, Trotsky announced on Feb. 18 that Russia abandoned the idea of a formal treaty but regarded the war as terminated. Germany at once resumed the war, and forced the defeated Russians to sign the Treaty of Brest-Litovsk on March 3. Russia gave up Courland, Lithuania and Poland to the Central Empires, and pledged herself to accord liberty to Finland, Estonia, Livonia, Ukraine, and to certain Caucasian districts claimed by the Turks. The contradiction between German demands and German peace proposals was exploited by the Allied propaganda.

While concentrating her offensive power on the western front, Germany had left troops in Russia, where the Bolsheviks were threatened by the "White armies," led by generals of the former imperial army. Disquieted by the revolutionary propaganda, the German Government refused to send troops to aid the Red armies. But it signed an additional article to the Brest-Litovsk treaty (Aug. 27), in which it promised not to aid the creation of any new independent State within Russian territory, and received in exchange the right to include Lithuania and Estonia within its sphere of influence.

With almost its entire territory occupied by enemy troops Rumania was forced by an ultimatum to accept the preliminary conditions of the peace of Bufta (March 5), but the victors could not agree upon the distribution of the booty. Peace was not finally concluded until May 7, in Bucharest, by the Germanophil ministry of Marghiloman; Rumania agreed to cede all the Dobrudja (*q.v.*) and place herself in economic dependence upon Germany. This treaty was not ratified.

The Fall of the Austrian Empire.—Germany's allies were annoyed by her separate agreement with the Bolsheviks. The Austrian Government complained that Germany had rendered peace impossible by refusing to make sacrifices in the West. An organization that had been set up in London under the control of Lord Northcliffe in Feb. 1918, for propaganda, announced to the enemy countries that it was "impossible to renounce the liberation of the oppressed peoples of the Habsburg monarchy." The leaders of the Southern Slavs, who were refugees abroad, had united, together with the representatives of the kingdom of Serbia by the Pact of Corfu, July 20, 1917. The Italians who had been rendered more conciliatory by peril, agreed to hold a congress in Rome, in April 1918, for the refugees from all the Slav and Rumanian lands of the Austrian empire. The dispute between the Italians and the Southern Slavs over Dalmatia—a Slav country that had been promised to Italy by the Allies in 1915—was settled by a friendly agreement. A mixed commission of British, French and Italian representatives, directed from the Italian headquarters a propaganda among the Slav troops of the Austrian army.

The danger became more pressing. Czernin, in an endeavour to make known the obstacles to peace, blamed Clemenceau's refusal to renounce the French claim to Alsace-Lorraine. Clemenceau, in reply, stated that the offer of its restoration came from Austria and published the emperor's letter of March 1917. Czernin withdrew. This revelation, that the emperor had sought to betray his allies by concluding a separate peace at their expense, aroused in Germany violent resentment against Charles, who felt obliged to visit the German headquarters at Spa with his new minister, Burian. There they agreed to the establishment of political, military and economic union between the two empires both during and after the war. This agreement was interpreted by the Allies as a movement towards the German domination of the whole of Central Europe. The apprehension that this step inspired won adherents for the idea of a partition of the Austrian empire, which had hitherto been vigorously opposed by the diplomatic world. The French Government recognized the national Czechoslovak council in Paris, presided over by Prof. Masaryk, as the supreme organ of an independent nation (June 1918); and the British Government (Aug. 9) and the United States (Sept. 3) followed its example. The status of an Allied army was accorded to the Czechoslovak legions fighting in Siberia or raised in Italy and France, and the national council at Paris admitted the rights of an Allied Government.

After the failure of the German offensive in France, a conference of German statesmen and generals was held at the general headquarters at Spa, on Aug. 14. Ludendorff admitted that all chance of a victory had disappeared, but added that he hoped to fight a defensive action which might incline the enemy towards peace. Charles and Burian, who had come to Spa, declared that Austria could not face another winter campaign. The Bulgarians and Turks also announced their inability to continue the war, and Hintze, the secretary of State for foreign affairs, sought and obtained authority to open negotiations for peace. But the German Government still hoped for a military success, and wished to negotiate through the intermediary of a neutral State, while

Burian demanded an immediate appeal to all the belligerents. In September, Hintze visited Vienna to negotiate an agreement. When the German army was forced to retreat, Burian determined to act without Germany; and he appealed to all the belligerents to negotiate for peace. But Wilson replied that the American Government was neither able nor willing to agree to a conference on a subject on which he had already clearly defined their attitude.

The Surrender of the Quadruple Alliance.—Bulgaria was the first to sue for peace. After the collapse of her army, the Government under Malinov, a sympathizer with the entente, not having received a reply from the Central Empires, proposed an armistice, which was granted on Sept. 29. Ferdinand abdicated. In Turkey, after the British victories in Palestine, Enver and Talaat, who had supported Germany, fell from power. The British admiral concluded an armistice on Oct. 31 which placed Constantinople and the Straits in the hands of the Entente and obliged the Turks to break off relations with the Central Empires.

Unable to resist the Allied offensive, which had been strengthened by the participation of American troops, Ludendorff at the end of September begged to be allowed to apply for an armistice and in spite of the opposition of the new chancellor, Prince Max of Baden, who would have preferred direct negotiations for peace, was granted permission, with the result that on Oct. 4, the German, Austrian and Turkish Governments appealed to Wilson for an armistice. On Oct. 8 Wilson answered that he could not consult his allies until the Central Empires had admitted their defeat by evacuating all Allied territory. He asked whether the chancellor spoke in the name of "the constituted authorities of the empire who have so far conducted the war." On Oct. 14, he demanded the cessation of submarine warfare and that the evacuation should be carried out so as to provide absolutely satisfactory safeguards and guarantees of the maintenance of the present military supremacy of the Allied armies. On the 16th, the emperor Charles, in order to appease Wilson, published a manifesto in which he announced the transformation of the monarchy into a Federal State; but he preserved the unity of the Hungarian kingdom, that is to say, the domination of the Magyars over the Slavs. On the 18th, Wilson replied that the United States having already recognized Czechoslovakia as a belligerent State, and the "justice of the national aspirations of the Southern Slavs," it was for these people to decide for themselves what they would accept. Before according an armistice, Wilson, on the 23rd, made it clear that none would be granted unless thereby a renewal of hostilities on the part of Germany was rendered impossible, and he declared that "the nations of the world do not, and cannot trust the word of those who have hitherto been the masters of German policy." If he had to continue to negotiate with the military rulers and monarchist autocrats of Germany he must insist, not on negotiations, but on surrender. Thereupon Ludendorff demanded a levy *en masse* for the defence of the Fatherland, and when the other generals declared further fighting useless, Ludendorff resigned (Oct. 26).

The Austro-Hungarian army in Italy, disorganized and routed, requested an armistice and on Nov. 3 signed a capitulation which compelled them to surrender unconditionally and deprived them of any right to appeal to Wilson's Fourteen Points. The Inter-Allied Conference in Paris, from Oct. 31 to Nov. 4, discussed the conditions of the armistice to be granted to Germany on the basis of the Fourteen Points and came to an agreement, with the exception of a reserve as to the freedom of the seas. The note which was sent to Germany on Nov. 5, in the name of President Wilson, announced that the Allies were ready to conclude peace on the conditions and in accordance with the principles laid down by Wilson. Germany was to pay compensation for all damage inflicted on the civilian population and their property. Marshal Foch communicated these conditions to the German delegation. The Germans found them much more severe than they had anticipated, but the general staff declared that resistance was impossible. Germany was in revolution and the chancellor, acting under the pressure of the Socialists, announced the abdication of the kaiser and the crown prince, and on Nov. 9 a republic was proclaimed. The Provisional Government set up by the Socialists announced its willingness to accept the armistice, which was signed on Nov. 11, in the Forest of Compiègne, by a delegation headed by Erzberger, the leader of the Centre Party, and with the approbation of Marshal Hindenburg.

EUROPE AFTER THE WAR

An account of the events which have disturbed the peace of Europe since the World War will be found in the special articles (*see* VERSAILLES, TREATY OF; PARIS, CONFERENCE OF; LEAGUE OF NATIONS; REPARATIONS AND DAWES PLAN; LOCARNO; *see* also DANZIG; VILNA; MEMEL; FIUME; CORFU; SAAR; RUHR; and RHINELAND). It is only necessary here to emphasize the characteristics of the new Europe that emerged from the war and to indicate the general course of relations between the different European States. Not only was the World War the greatest known to history by reason of its extent, the size of the armies engaged, the number of casualties and the greatness of the devastation and cost; it resulted in a political, social and territorial revolution which exceeded in violence and results all previous revolutions. Europe emerged transformed.

The Transformation of Europe.—Nearly all the European States had been involved sooner or later in the war; only Spain, Switzerland, Holland, Denmark, Norway and Sweden had remained neutral. The Napoleonic wars resulted in a general re-distribution of Europe; so, too, the World War resulted in yet another distribution—but in a very unequal manner. The national States formed on the exterior parts of Europe preserved their territories—some intact (Sweden, Norway, Luxembourg, Holland, Switzerland, Great Britain, Portugal and Spain); others, with one exception, increased their territory in accordance with the principle of nationality. Thus France recovered Alsace and that part of Lorraine which she had lost in 1871, Belgium received back the cantons which had been taken from her in 1815, and Denmark obtained the Danish portion of Schleswig. Serbia and Rumania received large accessions of territory through annexation of districts inhabited by Serbian and Slovene or Rumanian-speaking peoples, while Italy not only received Italian-speaking districts of the Trentino, Trieste and Zara, but all the southern portion of the German-speaking Tirol and the Slovenian districts on the Adriatic.

The three military empires, which covered the great central mass of Europe, were reduced or dismembered by the separation of all the districts inhabited by peoples of a foreign nationality. The German empire lost, apart from the districts restored to France, Belgium and Denmark, all its eastern Polish-speaking districts, Posen, West Prussia, the district of the Kashubes, and that part of Upper Silesia which voted in the plebiscite taken in 1921 for annexation to Poland. For economic reasons, Danzig and the Saar mines were the subject of special treatment.

The Russian empire lost all the territories on its western frontier peopled by foreign nationalities:—Finland, which was already autonomous, Estonia, Latvia, Lithuania and Russian Poland were erected into sovereign States. Some parts of White Russia and of Ukrainian Volhynia were annexed to Poland, while Bessarabia went to Rumania.

The Austro-Hungarian empire disappeared, and the two former dominating peoples kept only that territory in which their nationals formed the majority of the population. They formed two little national States—German-Austria and Hungary; of the rest of the empire part was divided among three neighbouring States, Italy, Serbia and Rumania, and the rest helped to build the revived Poland and the new State of Czechoslovakia.

The dismemberment of the Austro-Hungarian empire altered the dimensions of the two Balkan States, whose territory has been extended far beyond the Balkan peninsula; Rumania united within her frontier all Rumanian-speaking peoples; Serbia has become the kingdom of the Serbs, Croats and Slovenes, or Yugoslavia. The rest of the Balkan peninsula was divided between Greece, a diminished Bulgaria and Albania.

This rearrangement of the map of Europe increased the number of sovereign States and upset the balance of power. In 1914,

excluding the Ottoman empire, there were six great Powers. There are now only five; as against one State of moderate size (Spain), there are now five—Spain, Poland, Rumania, Czechoslovakia and Yugoslavia; as against 11 small States there are now 16, including five new States, Finland, Estonia, Latvia, Lithuania, Albania and two created out of the débris of the empire, German-Austria and Hungary; as against two very small States there now remains but one, Luxembourg. Thus the total has been raised from 20 to 27. Europe has never before had so many States of medium size. It has been impossible to exclude them from the European concert, in which they have filled the gap between the Great Powers and the little States.

The Political Revolution.—Only in one part of Europe did the war bring about a political revolution. All the national States other than the Central Powers retained their representative and democratic Constitutions; only three were republics (France Switzerland and Portugal); all the rest were, and have remained, at least officially, constitutional monarchies. The three imperial dynasties, the Habsburgs, Romanoffs and Hohenzollerns have disappeared and their States have, for the most part, been turned into republics on the French model of a democratic parliamentary republic with an elective president, and have extended universal suffrage to women. Hungary alone has sought to retain the monarchy, although she is still without a king.

Russia was organized by the Communist party into a federation of republics, the Union of Soviet Socialist Republics (U.S.S.R.). The proletariat, which is the legal sovereign, is represented by a congress elected on a franchise restricted to proletarians of both sexes. The Communist party wields the dictatorship in the name of the proletariat under the form of an absolute and centralized round. This form of government did not originate in Russia, but in the principles of Marxism, and may be regarded as being not only the national organization of a State, but also an instrument by which to consummate the proletarian revolution throughout the world.

These revolutions have upset the ratio between the types of political régimes. Before the war Europe contained only three republics as compared with 17 monarchical States, and including five great Powers, one medium Power, nine minor States and two very small States. Since Greece has become a republic there remain only 13 monarchies, including the two great Powers, Great Britain and Italy, Hungary, a monarchy without a king and Albania a kingdom since 1928. There are now 13 republics, including three Great Powers, France, Germany and Russia. Thus the greater part of Europe has become republican.

The Financial Revolution.—The war involved the belligerent States in unheard of expenses, of which only a very small part was covered by taxation. The Governments were forced to have recourse to loans of different kinds, and with the exception of Great Britain, the issue of paper money in such quantities that the real value of the legal currency became depreciated in an unprecedented manner. The national expenses were increased by the interest on these loans to a degree which made it impossible to balance the budgets, and upset the value of money, which is the standard for all values. This policy was pursued by nearly all the States, even after the peace and resulted in a chronic deficiency in budgets, the fall of State stock, the depreciation of currency and in three States, Russia, Germany and Poland, ended in complete bankruptcy. England alone has been able to restore her currency to par. Economic life became completely revolutionized by high salaries and high cost of living, sudden fluctuations of exchange, and—in England—by unemployment on a scale never before reached.

The financial and economic crisis became the dominant interest of politicians throughout Europe, and it has been the task of Governments to find expedients to enable them to meet their loan liabilities and balance their budgets. This preoccupation so strengthened the national sentiments that all the Continental States were moved to raise their customs duties to an unprecedented height. It also brought about an augmentation in the wages and pensions of the labouring and commercial classes, weakened the resources of the privileged classes, equalized the standard of life, raised the condition of women, and in brief, Americanized Europe.

The Destruction of the Concert of Europe.—The change in international relations was reflected in the negotiations that resulted in the Treaty of Versailles. Of the six great Powers forming the European concert, three were absent; Austria was destroyed; Bolshevik Russia had become isolated; Germany was the object of the negotiations without being called upon to take part in them. The treaty that has been nicknamed by the Germans "the dictation of Versailles," disarmed Germany, compelled her to submit to a military occupation and deprived her of any active part in European politics. The settlement of Europe was thus regulated by three European Powers, Great Britain, France and Italy, together with Japan and the United States. Wilson had announced that the procedure would follow another method than that employed by the Congress of Vienna in which decisions had been arrived at in secret by "potentates" without any regard for the feelings of the people. He endeavoured to work in public and to put into action the principle of the right of peoples to determine their own fate. But in reality the deliberations were secret, the work was done by commissions whose personnel had been chosen by the Governments, and the final decision was made by a council composed of the Governmental chiefs of the five great Powers. Having little interest in European affairs, Japan left these matters to the four other Powers, who became known as the Big Four, and since the Italians were reduced to play a secondary rôle, the decisions were taken by three great Powers, Great Britain, the United States and France, which meant in effect, by Lloyd George, Wilson and Clemenceau. When the Allies had reached an agreement on the conditions of peace, their agreement assumed the force of a contract which could not be discussed without dissolving their unity, and they imposed it upon the vanquished in five distinct treaties. When Wilson refused to agree to the reserves which the American Senate added to the treaties, the United States withdrew from the concert and the three European Powers, Great Britain, France and Italy, alone remained. This rump of the concert of Europe undertook the application of the treaties and the chiefs of the Governments continued to compose a Supreme Council (*q.v.*) which settled the affairs of Europe in conferences between ministers that were held at Spa, in July 1920, in London in Feb. 1921, and at Genoa in April 1922.

Matters of secondary importance were left to the Conference of Ambassadors (*q.v.*), created in 1920, and meeting in Paris, whose functions were limited to the execution and interpretation of treaties, received the reports of the commissions charged with the delimitation of frontiers, and settled the territorial arrangements resulting from the plebiscites ordained by the treaties. Its members were each responsible to their own Governments and it operated as a clearing house for avoiding the delays incurred in ordinary diplomatic procedure.

The New Organ of International Law.—By accepting the Covenant, which created the League of Nations, the signatories of the Treaty of Versailles introduced into international relations a principle and a new system. From the earliest times the conduct of Governments had been regulated solely by an indefinite tradition, which, even when embellished by the name of international law, consisted solely in variable customs without any obligatory force. Interests of State as interpreted by the sovereign, were the sole rule of policy, and the Governments conducted their relations with other States according to the principles of Macchiavelli, which were revived from Bismarck's time under the name of *Realpolitik*. The European congresses amounted to no more than temporary organizations set up to settle transient matters and were composed solely of representatives of the States whose interests were directly involved.

The war inspired in the European peoples a passionate desire to prevent its recurrence by imposing on their Governments as a duty the maintenance of peace. The League of Nations is an institution radically different from a congress of the European concert. It is a permanent body with a staff of permanent employees holding periodical meetings and always prepared to act

without delay in regulating differences between States before they have had time to develop into dangerous conflicts. Its power is not limited to any region or to any question, and extends over the whole sphere of relations between all the States-members. Neither does it work after the fashion of the congresses, in the tense atmosphere of the capital of a great Power, but at Geneva in the calm surroundings of a neutral town. It is its express mission not to serve particular interests, but to maintain peace by demanding from all States respect for treaties and international law. For the first time the Governments have recognized a moral obligation to submit their activities to the rule of universal justice.

From the former concert of Europe the great Powers have preserved for themselves the privilege to a permanent seat in the executive Council, but they are in a minority as compared with the representatives of States elected by the Assembly, while in the Assembly itself all States are on an equal footing. The discussions of the Assembly and the Council are held in public, and although secret intrigues outside the meetings may not be without influence, the publicity, and the meeting together in Geneva, of statesmen from the whole world has given to the small nations an influence which they could never have attained in the days of the concert of Europe. They use this influence for the maintenance of peace by the creation of an international public opinion which makes itself felt in the Governments of the great Powers. The settlement of difficulties is facilitated by means of the Court of International Justice set up at The Hague in 1920–21.

The League was endowed by the treaties with permanent powers in regard to the colonial mandates, National Minorities, Danzig, the Saar Basin, in virtue of which it has already taken numerous decisions. The great Powers have in addition, by common agreement, entrusted it with the settlement of the Upper Silesian question, which proved beyond the capacity of the Conference of Ambassadors. Its decision, which was put into operation without delay, established a precedent for an extension of its authority. It also regulated with success the differences between Sweden and Finland over the Åland Islands in 1921, the frontier differences between Albania and Yugoslavia, and frontier incidents arising between Bulgaria and Greece.

Conflict with Communist Russia.—War was prolonged in Russia by the campaign carried on by the White generals, supported by the Allies, against the Red armies, while the Moscow Government sought to promote Communist revolutions in the European States. This crisis was of short duration and only a single country, Hungary, was governed for a few weeks by Communists. After they had driven the Polish troops from the Ukraine, the Red armies arrived within sight of Warsaw before they were thrown back in disorder in 1920. The Soviet Government concluded peace treaties at Riga with the Baltic States.

The Communists repudiated the Russian debts, annulled concessions to foreigners, and confiscated their deposits in the banks. At first the European Governments refused to recognize the Soviet. But industrial and commercial interests wished to resume relations with Russia in order to open up her stores of petrol, wheat and minerals. The Bolsheviks appealed for foreign capital to reorganize their industry. The ***rapprochement*** began with the Treaty of Rapallo, which they signed with Germany in 1922, during the Genoa Conference. The Soviet Government was subsequently accorded official recognition by the ministries of Ramsay Macdonald in Great Britain and Herriot in France in 1924; and the other States followed suit. Subsequently Russia kept a diplomatic representative in all the capitals, and made use of them to stir up revolution. The Conservative cabinet in England adopted measures, in 1927, to counteract this propaganda and in May of that year raided the offices of the Soviet Commercial Delegation and broke off diplomatic relations. The Soviet maintained a hostile attitude towards the League of Nations and refused in 1926 to ask to be admitted to membership.

The Successor States and the Little Entente.—The destruction of the Habsburg monarchy, which was an event without precedent in the history of modern Europe, was the work, not of its enemies but of its subjects. The national States, new or transformed, which took the place of the empire, had to reorganize a whole system of institutions, and to build up a political and administrative personnel in countries devastated by four years of war and plunged without preparation into a system radically democratic. The treaties compelled them to grant complete equality of political rights to national minorities of different language and religion; the right of teaching their language in schools and using it in the Church services and law courts was placed under international guarantee and control of the League of Nations (*see* MINORITIES).

The dismemberment of the Austrian empire substituted several States, each with its own independent Government, for one vast united territory; it resulted in internecine conflicts such as were usual in the Balkans; hence the catchword "the balkanization of Europe." But the Governments of the Successor States (*q.v.*) felt themselves to be threatened by the same adversaries, and therefore banded themselves together into what is known as the Little Entente (*q.v.*) without consulting the great Powers. Beneš, the foreign secretary of Czechoslovakia, took the initiative; he concluded a treaty of defensive alliance with Yugoslavia in Aug. 1920, and a similar treaty with Rumania, April 1921, who thereupon concluded a treaty with Yugoslavia, June 1921. The three States, to all of which a part of Hungary had been annexed, thus protected themselves against the protests of the Hungarians. They intervened, Oct. 1921, in order to prevent the restoration of Charles as king.

Rumania, in order to defend herself against Russia, concluded a treaty with Poland, 1921; Czechoslovakia concluded a treaty of guarantee with Austria, Dec. 1921, the first of the kind between one of the victorious and one of the vanquished States. The system of guarantee was completed, 1924, by the Treaty of Rome concluding an alliance between Italy and Yugoslavia and the treaty of alliance between Czechoslovakia, Italy and France. All these treaties were registered by the League of Nations.

The destruction of the economic unity of the Austro-Hungarian empire raised a further problem. Vienna had been the financial centre of the banks, distributing capital and directing commerce in all the territories. Now each of the Successor States regulated as sovereign its financial policy, each wished to create its own industries and to protect them by high tariffs. Commercial ties between the countries were rudely broken; communications were upset by the division of the lines and rolling stock of the railways. Two remedies were suggested; a customs union between the Successor States, and the union of Austria and Germany; they were refused both by the States and by the Great Powers.

Conflicts on the Adriatic.—Italy had not obtained exclusive domination of the Adriatic. The treaty had given Dalmatia to Yugoslavia and made Fiume autonomous. A sudden attack put Italy in possession of Fiume. The Fascist Government of Mussolini after 1922 gave an aggressive air to the policy of Italy by demonstrations devised to appease national *amour propre*, but this was balanced by a prudent diplomatic practice. After the murder of Italian officers belonging to the commission for the delimitation of the Greco-Albanian frontier, he sent a fleet to occupy Corfu; but he accepted the verdict of the Conference of Ambassadors. He concluded with Yugoslavia the treaty regulating the question of Fiume, 1924, by a division of territory. He showed considerable diplomatic activity in eastern Europe by concluding treaties with Hungary, Greece and Rumania, which were interpreted as an attempt to isolate Yugoslavia. He worked for the imposition of Italian influence in Albania by the Treaty of Tirana (1926). The Serbs protested; the quarrel seemed to be made up after negotiations between Italy, France and Yugoslavia, which resulted (1927), in a treaty between France and Yugoslavia.

Polish Disputes.—The treaties had given Poland a large tract of territory without fixing its definite boundaries, which did not become settled until after a series of violent quarrels with her neighbours. The Poles made war on the Ukrainians (1919) in order to subject Lemberg and Galicia, and imposed on these Ruthenian-speaking countries—instead of the autonomy intended by the treaties—a system of occupation which was tolerated by

Europe. The invasion of the Ukraine, pushed as far as Kiev, was stopped by the Russian Red army (1920). On the side of Lithuania, after the sudden attack on Vilna (*q.v.*) (1920), the frontier was drawn by the Conference of Ambassadors, who accepted the *fait accompli*; but Lithuania refused to recognize it. The attempt to form an alliance of the Baltic States against Russian communism made at the Conference of Warsaw (1921), failed on account of a disagreement with Finland. The Russian frontier, fixed by the Treaty of Riga, left Poland in possession of the occupied territory. On the side of Germany the settlement of the frontier necessitated the intervention of the League of Nations over the question of Upper Silesia, where the plebiscite resulted in an open war between the Poles and the Germans.

Relations with Germany.—The chief preoccupation of European diplomacy has been the relations between the Allies and Germany, on which depended the agreement between Great Britain and France. The French formula, "restitution, reparation, guarantee," required a complicated system. The French general staff claimed as a guarantee the indefinite military occupation of the left bank of the Rhine; Clemenceau accepted an occupation limited to 15 years in exchange for an American and British guarantee. But the refusal of the United States to ratify the treaty, annulled this promise; the French Government have therefore been occupied ever since in finding an effective guarantee. French nationalists, who have become influential since the success of the *Bloc National* in the elections of 1919, hoped to make themselves secure by reducing Germany to a state of partition; they hoped to detach from Berlin the Catholic Rhineland. The British Government saw no lasting security except in a reconciliation with Germany, and fought against all schemes for destroying German unity.

The Allied Governments did not desire to fix the sum due from Germany for reparations, for fear of creating too much disappointment in France. They called three conferences, at Spa (1920), London (1921), Genoa (1922), for the purpose of settling with Germany the best means of obtaining her payments and the share each ally was to receive. The French Government tried to work upon Germany by exerting military pressure; they took the opportunity of the dispatch of German troops against the communists in the neutralized zone to extend their military occupation as far as Frankfurt (1920), and then into the Ruhr. The president of the republic, Millerand, intervened to put a stop to the negotiations at Genoa. The accord between Great Britain and France was therefore broken; and Lloyd George, after his resignation, conducted an open campaign against French policy. The Bonar Law ministry tried to re-establish friendly relations at the conference of Paris, Jan. 1923, by a plan which diminished the French debt to England. The Poincaré ministry rejected it and carried out a previously thought-out plan to work German industries under the direction of French engineers, and occupied the industrial region of the Ruhr (*q.v.*). The passive resistance of the Germans ruined German currency and stopped the payment of reparations. At the same time armed bands made "separatist" demonstrations on the left bank of the Rhine with the connivance of the French army of occupation.

The crisis was resolved in 1924 by the adoption of the Dawes Plan (*q.v.*). The victory of the party of the Left at the elections, who represented the peace-loving mass of the French electorate, led to the formation of a ministry which pursued a more pacific policy in foreign affairs and re-established good relations with Great Britain.

The Guarantee Treaties.—The French Radical ministry and the British Labour Government agreed to revive through the League of Nations the scheme for general disarmament promised by the Treaty of Versailles. The French Government saw in this a means to obtain the abortive guarantee of 1919 by making it a preliminary condition of disarmament. Its formula was "security, disarmament, arbitration." The Geneva protocol of 1924 was drawn up in this spirit; the members of the League of Nations were to undertake to support each other against all aggression and to enforce sanctions against the aggressor. But the British Government, representing the whole of the British empire, had to reckon with the repugnance of English opinion to any general commitment, and still more the refusal of the dominions, members of the League, to promise to intervene in purely European conflicts. The protocol therefore was wrecked.

The scheme extended to all the members of the League seemed to be too great; Briand said "In order to ensure peace it is Europe which must be organized." The policy of guarantee was raised again in the form of special treaties, to which the British Government took no exception. The project proposed confidentially by the German to the British Government, March 1925, was accepted by France and discussed at Locarno (*q.v.*) in October. The agreement was signed in London in the form of treaties between Germany, on the one hand, and Great Britain, France and Belgium on the other. The contracting parties engaged themselves to abstain from all aggression, to respect the frontiers established in 1919 and to submit all differences between them to arbitration. Great Britain and Italy engaged themselves to guarantee the treaties by going to the help of any State attacked. This agreement meant that Germany renounced Alsace-Lorraine, but by accepting an arrangement which had in the first instance been imposed upon her by force, she treated with the other Powers on an equal footing. She was to ask for admission into the League of Nations and to receive a permanent seat on the Council.

France wished for an analogous agreement for the eastern frontier between Germany and Poland; this was known as the "Eastern Locarno." But the Germans refused to accept as final either the régime imposed on Danzig, or the Danzig corridor, or the division of Silesia, and the British Government did not wish to undertake to intervene in eastern Europe. Germany merely gave up her claim to go to war to alter the frontiers. She concluded treaties with Poland and Czechoslovakia which submitted all their differences to arbitration; France, by a separate instrument, promised to guarantee them.

The admission of Germany to the League of Nations, proposed at a special meeting at Geneva in March 1926, was delayed by the opposition of Spain and Brazil, who wished to take advantage of the occasion to gain for themselves a permanent seat. The admission of Germany was decided at the session of Sept. 1926. The German foreign minister, Stresemann, took his seat on the Council, where he used his influence in 1927 in the direction of peace and disarmament. Germany had re-entered the Concert of Europe, as France had done in 1818; but she remained under special obligations by the occupation of her territory and the limitation of her military, naval and air forces.

The success obtained by the system of guarantees in the direction of security diminished resistance to schemes for disarmament. Negotiations began again for the "general limitation of the armaments of all nations" promised to Germany at the Treaty of Versailles, and recognized as necessary by Article VIII. of the Covenant of the League. A preliminary meeting at Geneva, Nov. 1927, in which a Russian Soviet delegation took part, set up a commission to report on the conditions for a reduction of armaments.

The autumn session of the League of Nations, 1927, was held in a calm atmosphere. The representatives of Poland and Lithuania, countries in a condition of permanent conflict, declared at Geneva, in Dec. 1927, that their countries were not in a state of war, although Lithuania continued to claim Vilna. The year 1928 opened without grave disagreement in any part of Europe. The Little Entente limited itself to protesting at Geneva against the illegal importation of machine guns into Hungary. Russian revolutionary propaganda was diminished by disunion among the communists.

But the conflict between Poland and Lithuania, continued in spite of the intervention of the League of Nations and was only settled by the Königsberg conferences. In the South Ahmed Zogou, considered as the agent of Italian politics, was proclaimed king of Albania (August) which prejudiced the re-establishment of friendly relations between Italy and Yugoslavia. On the other hand the international atmosphere was lightened by the combined effort of the great Powers in favour of peace. The Kellogg Pact

by which the contracting parties were pledged to renounce war as a political instrument, was signed on Aug. 27, in Paris by the United States and the majority of the European Powers. The 9th Assembly of the League of Nations in Geneva discussed in a pacific spirit the evacuation of the Rhinelands and the Polish-Lithuanian conflict, and the president of the Preparatory Commission for the Limitation of Armaments was invited by the Council of the League to be ready to convoke the commission "in any case" at the beginning of 1929. The favourable impression was, however, a little decreased by the criticisms made by the United States on Sept. 29 on a Franco-British agreement referring to the limitation of war navies, and which American opinion considered directed against the United States.

On Feb. 11, 1929, a treaty was signed between the Vatican and the Italian State, which put an end to the discord of nearly 60 years, and restored to the papacy its states as a sovereign power over a small area of Rome—"The city of the Vatican." See further especially the article PAPACY and also ITALY, PIUS XI., VATICAN, etc.

BIBLIOGRAPHY.—*Cambridge Mediaeval History* (1923–27, bibl.); *Cambridge Modern History* (1901–12, bibl.). It is neither possible nor useful to indicate all the documents and works relating to all the questions dealt with in the present article; they can be found in the bibliographies annexed to each of the articles to which they refer. It is sufficient to indicate certain general works. They are, in addition to the Cambridge histories above cited: Th. Lindner, *Weltgeschichte*, 8 vols. (1901–14), a clear, judicial and well-informed account; *Periods of European History*, 8 vols. (1893–1901), each volume by a different author, a good popular account; E. Lavisse et A. Rambaud, *Histoire generale du IVe siecle à nos jours*, 12 vols. (1894–1902, with bibl.), written by a large number of authors of varying ability.

For history after 1815: A. Stern, *Geschichte Europas seit den Wiener Verträgen von 1815, bis zum Frankfurter Frieden von 1871*, 10 vols. in three series (1894–1924), the most complete and scientific account; C. Seignobos, *Histoire politique de l'Europe contemporaine*, 2 vols. (7th rev. ed., 1925–26), deals with the period 1814 to 1914 (detailed bibl.). For England, the *Cambridge History of British Foreign Policy*, 3 vols. (1922). On the recent period, G. P. Gooch, *History of Modern Europe, 1878–1919* (1923).

For the post-war period the chief documents are collections of documents from archives, for the most part published by different Governments and accounts by statesmen or generals, published in the form of notes, memoirs or correspondence. The enumeration of such documents and works will be found in the bibliographies attached to special articles relating to the World War, Versailles, and the League of Nations. (C. SE.)

INDUSTRY AND TRADE

It is a curious and regrettable fact that much less comprehensive information is available concerning the industries of Europe than about those of more recently developed industrial areas of the world. Thus it is easier to obtain a picture of the state of industry in North America, Australia, New Zealand or South Africa than it is to follow the sequence of events in the continent where modern industrial organization began.

It is not proposed in this article to describe the condition of individual industries in any detail or to trace the vicissitudes through which any particular trade has passed, but rather to show first, the importance of industry as distinct from agriculture or other activities to the whole economy of Europe, secondly, the place which Europe holds in the industry of the world, and thirdly, the character and causes of the broad changes which occurred in the period 1913–28.

Although Europe is the cradle of modern industry, and looks to North America and Oceania for so large a proportion of her food supply, actually a much larger proportion of her population is engaged upon agriculture and fishing than in either of these two areas. There are indeed only five countries in Europe—the United Kingdom, Germany, Belgium, Holland and Switzerland—where industrial workers and miners outstrip in numbers the agriculturists. Indeed, so far as the daily activities of her citizens are concerned, England and Scotland are the only European countries where industry plays an overwhelmingly important rôle. In England and Wales 47·2% of the total population are directly dependent on industry and mining and only 6·8% on agriculture and fishing (1921 census); in Scotland the comparable figures are 47·3 and 10·1%. In Belgium, the most highly industrialized country after Great Britain, nearly a fifth of the population is engaged upon agricultural pursuits. If a map were to be drawn of Europe in which each country was shaded according to degree of its industrialization, the depth of shading would be found to diminish with remarkable regularity from the dense blackness of Great Britain in the north-west to the lightest of greys in the east and south-east. Switzerland, it is true, is more highly industrialized than France, and in the three Scandinavian countries the normal order is reversed, but the exceptions to the general rule are few as the following figures illustrate:

Percentage of Population Engaged in Industry and Mining

Group I.	Belgium, Germany, Gt. Britain, Switzerland .	Over 40%
Group II.	Czechoslovakia, France, Holland	Over 35 and under 40%
Group III.	Austria, Sweden . . .	Over 30 and under 35%
Group IV.	Denmark, Italy, Norway, Portugal	Over 20 and under 30%
Group V.	Hungary	Over 15 and under 20%
Group VI.	Bulgaria, Estonia, Finland, Latvia, Lithuania, Poland, Rumania	Under 15%

While the east and west of Europe interchange foodstuffs and manufactured goods between them, Europe produces more manufactured goods and less agricultural products than she requires. In the 19th century her industrial supremacy was undisputed, and not only did raw materials flow from all parts of the world to be worked up in her factories, but she herself was the greatest producer of coal, minerals and many other of the raw products she required.

Europe as Producer.—In consequence, on the one hand of the rapid development of other parts of the world, the growth of their populations and the discovery of new sources of supply, and on the other of the check which the World War caused to European progress, that supremacy is no longer undisputed. Unfortunately it is not possible to measure Europe's position in world industry as we can measure it approximately in world trade, but some indication of her relative importance as a producer of raw materials may be obtained and some notion of the relative rate of industrial evolution in Europe and elsewhere may be conceived.

For the first purpose may be employed the indices now compiled annually by the League of Nations of the production of certain groups of raw materials. They do not, it is true, embrace all products or the production of all countries and the share of Europe in world output is no doubt somewhat exaggerated. The most important lacuna in the figures is caused by the lack of agricultural data for China. But by comparing the position in two years separated by a sufficient interval of time and by giving at the same time the figures for North America, it is possible at once to see Europe in perspective and to ascertain the character of the changes which have taken place.

Relative Contribution to Aggregate Production

	Europe		North America		World
	1913	1926	1913	1926	
Cereals and other food crops .	46·2	43·3	19·6	20·5	100
Colonial produce, tobacco, hops, etc.	13·7	11·7	14·6	13·4	100
Vegetable oil materials . .	22·6	17·2	18·0	16·2	100
Textiles	16·9	16·7	30·2	33·1	100
Wood-pulp	55·3	46·6	43·9	49·7	100
Fuels	48·0	37·8*	44·9	50·6*	100
Metals	52·1	40·7*	41·5	40·6*	100
Chemicals (Fertilizers) . .	54·9	57·7	15·1	10·9	100
Total production . . .	42·7	36·2	26·1	29·7	100
Foodstuffs	45·6	42·3	19·6	20·9	100
Raw materials	38·6	28·7	35·1	40·3	100

*1925—European production in the following year was seriously affected by the British coal dispute.

The first fact brought out by these figures is the magnitude of European production even after taking into account that most of China's agricultural output is omitted; the second is the decline in her position since 1913. This decline, moreover, has been greatest exactly in those industries, coal-mining and metallurgy, upon which her prosperity in the 19th century was so largely based. In textiles, thanks to the development of artificial silk manufacture, she has nearly maintained her position; in chemicals, as a result of the very rapid progress achieved in the manufacture of azotic fertilizers, she has improved it; but on balance her contribution to the total value of the output of the materials considered has appreciably diminished.

These figures must not, of course, be interpreted as giving Europe's contribution towards total industrial output. They relate either to the products of the soil or subsoil, such as cereals, flax, coal, etc., or such crude or partly manufactured articles as pig-iron, wood-pulp, artificial silk yarn, etc. Nor must it be presumed that she is necessarily poorer because her share in the world production of these foodstuffs and raw materials is smaller than it was. Actually her index of raw material production was slightly higher in 1925 than in 1913. The change in her relative position was due to the rapid progress achieved elsewhere, as is shown by the following figures:

Indices of Production—1913=100

	Europe*	N. America	Asia†	World
Textiles	143	141	125	128
Wood-pulp	154	207	..	183
Fuels (1925)	91	130	159	116
(1926)	80	143	157	116
Metals (1926)	89	146	163	119
Fertilizers	142	178	285	136
Total foodstuffs and raw materials				
(1925)	102	128	121	116
(1926)	98	132	122	116
Total raw materials				
(1925)	98	133	147	122
(1926)	93	144	150	125

*Includes the whole of U.S.S.R. †Excludes Asiatic Russia

In 1925 many countries in Europe were still suffering from the effects of inflation or the commercial depression which frequently follows on currency stabilization. In 1926 British industry was prostrated by the protracted coal dispute. In spite of these temporary difficulties production of basic products was during these two years just about at the pre-war level. But in North America it had increased by over a third and the net value added in manufacture by very considerably more. After the autumn of 1926 a rapid advance was made in Europe, well beyond what had ever been achieved previously. But in the interval between 1913 and these later years a very great change had taken place in the relative importance of different industries—a change which is illustrated by the indices for textiles and wood-pulp on the one hand, 143 and 154 respectively, and those for fuels and metals, which were only about 90. To some extent these changes are typical of what had been happening elsewhere. Thus the world fuel and metal indices are much lower than the others given. But European industry has undergone and is undergoing a change which is in many respects exceptional. The competition of countries more recently industrialized, changes in commercial policy, new scientific discoveries and a number of other factors have weakened the demand for the products of what were formerly her basic industries—coal-mining, heavy metals, shipbuilding, cotton spinning, etc., and directed capital and labour into other channels. The magnitude of this change can be gauged to some extent from the individual indices of certain countries and by splitting certain of the indices given above into their component parts.

Not many countries supply current and complete information concerning even their leading industries, but the tendencies of trade in Great Britain, France, Sweden and Russia can be traced. Thus, in Great Britain in 1927 the iron and steel index averaged 91·5, the shipbuilding index 71, that for cotton 78·8, that for tobacco 130·8, for paper 145·8. In France the general industrial index in 1926, owing to the export premium which arose from exchange depreciation, stood as high as 125, while the metallurgical index, which was appreciably higher than in most other European countries, was well below the general average at 113, and textiles were as low as 94. In Sweden in the same year paper averaged 162, the chemical industry 144 and all industries 123. In Russia, in the commercial year 1926–1927 the heavy industries averaged 86 and the light 119.

Such data as exist for the whole of Europe give similar results. The recovery and development of the newer and smaller industries have been much more rapid than in the case of what were considered the major European industries at the end of the 19th century:—

Industrial Production in 1925; 1913=100

	Europe	North America	World
Coal and lignite (in terms of coal)	91	101	98
Petroleum†	110	310	284
Pig iron and ferroy alloys	80	117	98
Raw steel	96	143	118
Shipbuilding	66	48	66
Mechanical engineering	87	126	108
Electrical engineering	141	327	201
Sulphuric acid	99	200	126
Nitrogen	246	208	163
Cyanamide of calcium	510	167	469
Coal tar dyes*	79	1033	101
Cotton-mill consumption	84	112	108
Wool (consumption)	88	120	..
Natural silk	114	..	167
Artificial silk	402	3365	657
Copper†	73	149	147
Tin†	118	..	112
Aluminium†	292	348	315

*1924. †1926

In most cases the year 1925 has been chosen as more characteristic for Europe than 1926. Since that date there has been a very rapid development in certain countries, and by 1927 European production of coal and raw steel was over 100 per cent of that in 1913. But complete later figures are not available and those given bring out very clearly the character of the changes which have been taking place. All the heavy industries have suffered either from absolute weakening in demand or from over-capitalisation, an excess of plant laid down for war needs. The general service textiles, cotton and wool, owing to somewhat different causes, have suffered likewise. On the other hand new industries have grown up and industries which were previously of minor importance have greatly expanded. The tendency for lighter goods to replace the heavier, and for the more expensive the cheaper, is illustrated to some extent in the table. But, in fact, the movement is more radical and comprehensive than is suggested by the figures quoted. Thus, not only have artificial and natural silk replaced cotton and even wool to some extent, but within the cotton industry finer counts are being spun and in the woollen more merinos and crossbreds and less shoddy and coarse wool are employed. Similarly in the metallurgical and engineering industries, while the heavier branches have suffered, the manufacture of lighter machinery has developed and the motor-car industry has made vast strides. The internal combustion engine has for many purposes displaced the steam engine; aluminium has displaced cast iron for hollow ware; knitted goods have displaced woollen cloth, etc.

Of the recent technical changes perhaps the most revolutionary are concerned with the means of transport and the electrification of industry. Europe has directed large amounts of capital which might previously have been utilized for railways or other purposes necessitating the use of the products of the heavy metal industries to the construction of roads and is gradually substituting electric power for the direct employment of coal as fuel.

The Most Prosperous Industries.—But during the years immediately following the armistice, Europe was busily engaged in

repairing war damage, and much capital was sunk in the improvement of land, the reconstruction of towns and villages and the re-equipment of factories. There has thus been a greater expenditure on capital account than the bare statistics of basic industries portray. It remains nevertheless true that the industries which have prospered the most, apart from a few exceptions are rather those manufacturing goods for immediate consumption—the motor-car industry, hosiery, the manufacture of boots and shoes, of confectionery, of tobacco, of paper, etc. A number of factors have contributed to this result. During the years immediately succeeding the war, the national income of most European countries was reduced, and less was available for saving. The hazards of war and the storms of inflation weakened the will to save. The change in the distribution of wealth in favour of unskilled labour at the cost of the landlord and the middle classes hindered capital accumulation. Further, the international flow of capital was checked by currency instability. It is not necessary to deal here with all the complications to which inflation and deflation gave rise. From 1918 to 1925 unsound monetary conditions were without doubt the most important of all the hindrances to European industrial recovery. They had, however, one secondary effect which is likely to prove of longer endurance, for they contributed in a number of ways to the erection of those tariff walls which have helped to divide Europe up into a number of more or less water-tight compartments. The economic nationalism which has characterized post war commercial policy has further enforced the tendency in favour of the development of the smaller and newer industries. The endeavour of each State to make itself economically independent has led to the erection of new plant in a number of markets which were previously supplied from abroad. Thus has there been a double shift in the centre of gravity: first, away from the staple industries towards new activities, and secondly, away from the large existing agglomerations of plant and equipment towards new plant in less highly developed countries. Both tendencies have resulted in much existing plant being left inactive. Other influences beyond European control have worked in a like direction. Thus, the growth of industry in the countries in which the raw materials are found, stimulated by the war and fostered by tariffs, has weakened the extra-European demand for many and more especially for the coarser products of European factories. A particularly striking example of this phenomenon is afforded by cotton spinning; Japan and the United States consumed in the commercial year 1926–27 about 3½ million more bales of raw cotton than immediately before the war, and Europe about 1¼ million less. But while Japan, China, India and Brazil are able to meet their needs in coarser cotton products to a much greater extent than heretofore, the quality of European production has improved and its consumption of fine Egyptian cotton risen.

European industry has been affected, then, by lack of new capital and in certain directions excess of existing plant, by the vagaries of currencies and of taste, by the impetus which the war gave to the industrialisation of countries which for a time were unable to satisfy their needs in the markets on which they had previously relied, by tariffs, prohibitions, transport difficulties and all the other impediments to trade on the construction of which so much ingenuity has been spent. There has been a process of disintegration and new growth. But simultaneously there has been a tendency towards reintegration. The war promoted, and indeed rendered imperative, collective bargaining between the State and industries whose products were required for war needs, and thus stimulated the formation of industrial associations in all belligerent countries. The peace treaties in many cases divided the members of these associations from one another by new lines of frontier. The difficulties of the situation forced the leaders of industry to collaborate in seeking a solution of the problems which arose. Modern European industrial organisation is thus characterized by the concomitant growth of industries new in kind and in place and the association of industries, old and new, into powerful international combinations.

Nature and Volume of European Trade.—The attempts made by the great majority of European countries in post-war years to foster domestic industries have inevitably affected both the composition and the quantum of European trade. The proportion of the total goods produced which are exchanged internationally has diminished despite the fact that with the foundation of new States the number of trading units has increased. But the continent as a whole is necessarily dependent on outside sources of supply for many of her raw materials and is not self-sufficing in foodstuffs. The changes which have taken place in commercial policy therefore have not been sufficient seriously to modify the essential characteristics of her international trade. Europe remains necessarily a buyer of raw products and seller of manufactured goods. In some respects recent scientific progress has rendered her less dependent on foreign supplies; thus artificial silk is manufactured from indigenous timber, nitrogen is obtained from the air of Europe instead of the deserts of Chile, and the enormous capital expenditure on roads has necessitated the import of no raw materials from extra European lands. But on the other hand the demand for petroleum in which she is not self-supporting, of rubber, of vegetable oils and fats has greatly increased and with the growth of her population her purchases of bread-corn have likewise gone up.

The composition of the trade of the individual countries varies widely and roughly in accordance with the occupational division of the population illustrated above. A number of countries publish figures of their trade divided into five large groups of products, namely, (i.) live animals, (ii.) articles of food and drink, (iii.) materials raw or partly manufactured, (iv.) manufactured articles, (v.) gold and silver. These countries may with advantage be arranged in the order of the relative importance of their exports of manufactured goods.

Imports and Exports by Groups of Commodities

Country	Year	Imports					Exports				
		i.	ii.	iii.	iv.	v.	i.	ii.	iii	iv.	v.
Switzerland	1923	1·7	26·0	30·6	34·3	7·4	0·7	8·0	7·5	78·0	5·8
United Kingdom	1925	..	..	..	..	..	..	..	..	76·2	..
Austria	1926	9·4	27·5	27·2	33·1	2·8	1·3	1·9	21·3	73·2	2·3
Germany	1926	1·1	33·7	46·6	12·8	5·8	0·1	4·9	23·7	70·0	0·4
France	1923	0·8	22·7	61·5	14·8	0·2	0·7	10·2	21·8	67·0	0·3
Czechoslovakia	1926	4·0	22·4	47·2	26·4	..	0·3	18·7	19·4	60·9	0·7
Belgium	1926	0·2	25·6	52·2	21·8	0·2	0·8	9·7	33·8	55·4	0·3
Sweden	1923	0·1	23·7	36·1	39·7	0·4	0·8	4·9	57·1	36·8	0·4
Netherlands	1926	0·1	25·7	36·6	36·4	1·2	0·5	41·6	21·5	35·5	0·9
Spain	1926	1·9	16·0	36·3	44·7	0·2	0·1	55·5	18·5	25·8	0·1
Norway	1923	0·5	31·1	24·2	43·1	1·1	0·1	26·6	49·6	23·7	..
Hungary	1925	0·1	8·1	33·9	57·8	0·1	12·6	57·5	12·7	16·4	0·8
Poland	1926	0·1	14·1	48·9	36·8	0·1	5·0	26·4	54·8	13·8	..
Denmark	1923	0·1	22·6	40·0	37·1	0·2	6·0	80·5	5·1	8·4	..
Russia	1926	1·2	4·9	57·3	36·6	..	0·4	46·1	49·2	4·3	.
Bulgaria	1924	0·2	8·0	10·5	72·3	..	4·0	47·3	45·9	2·8	..

The selection of countries given is sufficiently characteristic of Europe as a whole to bring out the essential facts and to throw in relief the devotion to industry in the north and centre of Europe, and the importance of agriculture in the east and south-east. The imports of Europe are much more evenly spread amongst the second, third and fourth groups than are the exports. A third of the imports of Switzerland, one of the most highly industrialised countries in Europe, consists of manufactured articles, and over a third of those of the Netherlands and Sweden. This contrast between imports and exports is of course an almost universal phenomenon. Countries, like individuals, tend to earn their income by devoting their attention to a restricted number of activities and to spend it on a wide range of objects. But as a characteristic of European trade it is of vital importance. For as industries develop in other parts of the world, Europe's prosperity is necessarily dependent upon the demand by manufacturing States for manufactured goods. Her trade, as her industry, is accordingly tending to concentrate more on highly finished goods and articles of high value demanding an exceptional degree of skill in the process of their manufacture.

Exports of coal, of unbleached cotton piece goods, of railway material, have shrunk and British trade has been particularly

adversely affected. Both in the United Kingdom and elsewhere the products of the newer industries, of the most expensive goods, of luxury goods, have increased their importance. Thus manufactures of silk, paper, motor cars, scents and soap constitute an increasingly important share of French exports; electro-technical goods of German exports; silk piece goods, fine cotton tissues and motor cars of those of Italy; diamonds and plate glass of those of Belgium. The examples are selected almost at random. The tendency they illustrate is common to nearly all the more advanced industrial States of this continent. It has been intensified by the war, but is nevertheless a natural development. It was to be expected that the power of countries beginning on an industrial career to compete with Europe should have been greatest in respect of the coarser grades of goods. The advantage they derive from cheaper labour or cheaper raw materials could only be countered by methods of mass production—methods whose success is greatly dependent on a large home market. But European markets are fenced about with customs, tariffs and with a few important exceptions Europe produces relatively short lines of goods intended to meet the needs of a medley of consumers in all parts of the world and designed to penetrate through what gaps may be found in the tariff walls which have been erected. Further, as all continents in the world grow in wealth, the demand for superior European products mounts automatically.

Before the war Europe probably accounted for over 60 per cent of the total trade of the world. In 1926 her share had fallen to under one half. This diminution of her importance has been due in part to an absolute reduction of the quantum of her imports and exports and in part to the very rapid development of the far east and the United States of America. Within Europe the most serious factor has been the partial severance of Russia from the other trading nations of the world. But in the whole of central and eastern Europe the international interchange of goods is on a much smaller scale than it was for instance in 1913, although it is just in this part of the continent that the new states have been set up. In order to understand the changes which have taken place it is necessary therefore to divide the continent into large groups of countries and consider these groups separately.

Territory	Imports			Exports			Total		
	1913	1925	1926	1913	1925	1926	1913	1925	1926
A. Eastern and Central Europe:									
Excluding Russia (U.S.S.R.)	17·8	15·3	13·2	17·4	12·3	13·7	17·6	13·9	13·4
Including Russia (U.S.S.R.)	21·4	16·6	14·3	21·6	13·4	14·9	21·5	15·1	14·6
B. Rest of Europe*	40·2	37·9	37·4	33·6	30·7	29·0	37·0	34·4	33·3
C. Europe, excluding Russia (U.S.S.R.)*	58·0	53·2	50·6	51·0	43·0	42·7	54·6	48·3	46·7
D. Europe, including Russia (U.S.S.R.)*	61·6	54·5	51·7	55·2	44·1	43·9	58·5	49·5	47·9
World	100	100	100	100	100	100	100	100	100

*Excluding the Netherlands, owing to incomparability of pre- and post-war statistics. The inclusion of the Netherlands would raise the percentages for Europe, including Russia, in 1925 and 1926 to: imports 55·9 and 53·2; exports 45·3 and 45·2; totals 50·8 and 49·3.

While Europe's share in world trade has fallen off that of North America has risen from 14% in 1913 to 19% in 1926 and that of Asia from 12% to 17%.

Europe's Share of World Trade.—The change which has taken place is, however, more profound than might at first sight be believed. Europe's share in world exports has contracted more than her share in world imports. In 1913 the excess of imports over exports represented very largely goods obtained in payment for the interest owed by countries to which Europe had lent capital. During the war much of that capital abroad was lost or sold for goods required for immediate war-time consumption, so that Europe's claim on other parts of the globe was seriously diminished. By 1926 the position had been reversed and many European countries were borrowing from the United States of America and paying interest on previous loans. Their borrowings were however very much greater than their interest payments, exceeding them probably by some £100,000,000. The excess of imports over exports in that year therefore was composed largely of goods purchased out of the proceeds of capital borrowings. It may be expected that within a relatively short space of time Europe's borrowings will fall below her obligations on account of interest and amortisation of debt and that in consequence her exports will increase relatively to her imports, and both the direction of her trade and the average level of her prices profoundly modified.

Although there is no reason to believe that the net production of European industry is lower than it was before the war, the quantum of her trade, if that term may be employed to express volume in terms of stable values, would appear in 1926 to have been still about 10% less than in 1913. The following figures show the relative position of the same groups of countries as were employed above:

Percentage Changes in Quantum of Trade 1913=100

Territory	Imports		Exports		Total trade	
	1925	1926	1925	1926	1925	1926
A. Eastern and Central Europe:						
Excluding Russia	92·8	82·6	75·6	86·0	84·1	83·4
Including Russia	83·7	74·3	66·7	75·1	75·1	74·5
B. Rest of Europe	101·3	102·8	98·1	94·2	100·3	99·3
C. Europe excluding Russia	98·7	96·5	90·4	90·8	95·1	94·5
D. Europe including Russia	95·4	93·1	85·9	86·7	90·6	90·3
World	107·8	111·1	107·1	108·5	107·4	110·3

Russian trade is growing, but in 1926 was still less than half of what it had been in 1913. With the gradual restoration of settled conditions in the other countries of central and eastern Europe trade throughout the whole of this area steadily develops—impeded though it is by high tariffs and frequent changes in rates of duties. The rest of Europe by 1926 had just about got back to the pre-war level, a proof, since foreign trade has become less important than domestic, that the total production of goods had risen above that level. The neutral maritime countries, Denmark, Norway, Sweden, Spain, etc., have achieved the greatest progress; and the first three countries, with Holland, have pursued the most liberal commercial policy. (A. Lov.)

MINERALS AND INDUSTRIES

The modern period was inaugurated by the exploitation of coal and iron for steam-driven industry, England for long leading in this development. In the last quarter of the 19th century the predominance of British industry was strongly challenged by Belgium, Germany and the United States of America, and with the coming of the 20th century, electrical power, whether from waterfalls or from coal and the use of gas and oil engines diminished England's initial advantages seriously. The mid-Victorian form of the doctrine of Free Trade, with its consequences of high-specialization on the part of different countries in different activities, was not attractive to Continental States anxious lest economic dependence upon neighbours or possible enemies might interfere with political freedom. The idea grew up of States producing within their borders as much as possible of the manufactured goods they need, and developing an export trade in certain industries in which they might have special advantages. The repercussion of this movement upon Britain has been a marked feature of British life in the last ten years, during which efforts have been made in many industries to safeguard the British markets for British products. The conflict between the idea of a British market preserved for British goods and the idea of Britain as a centre of large scale industry for export purposes is one of the standing problems of British life; and solutions are sought by compromise rather than by planning on one or other line.

The coal and iron industries of Europe have developed a zone of dense population along the northern bases of the central hills of Europe, from Flanders to Poland, and in that zone many great industrial centres have grown in what had already long been

famous cities, often at the exit of valleys from the broken lands of central Europe. The greatest coal producers, in sheer quantity, are Britain and Germany, half the German production being lignite, formerly considered inferior but now recognized as of value for special purposes. France, Belgium, Czechoslovakia, Poland and Russia also produce large amounts of coal, and Spain, south-east, Holland, Austria, Hungary and Yugoslavia a certain amount. Quantities of less than three million tons per annum are produced in a number of States. The development of coal mines in the Belgian Campine and in Dutch Limburg, the opening of the Kent coalfield and the development of the Doncaster area in England, and the rehabilitation of the French coal mines after 1914–18, are outstanding recent features.

The production of iron was at first predominant in England, but the situation changed, especially with the invention of methods for extracting the iron from the *minette* of Lorraine, which has now become the chief source of the metal on the Continent, Europe, as a whole, being behind the United States of America in iron production. With the re-entry of Lorraine into France that country has become the leading producer of iron in Europe, with Luxembourg and England a long way behind. The change of political frontiers has reduced Germany to a minor position in iron production, though she has the coal and the skill for the industry. Iron production in Sweden remains important, thanks to the superior ores found there. Spain, Austria and Czechoslovakia produce a certain amount of iron, and so does Russia. The large iron industry in Belgium depends mostly on Luxembourg for its raw material, and international co-operation between Germany and France is of the utmost importance to the German ironworks. Vein-minerals, especially copper, are produced chiefly in the Iberian peninsula and Germany, as also are lead, manganese and zinc. Austria is also of some importance here. Some gold and platinum are produced in Russia, and silver in Germany, but the Continent is not rich in the precious metals.

Salt has long been of economic importance, indeed many a prehistoric site of the Late Bronze or Early Iron age is near salt and seems related to salt supplies. The regulation and taxation of salt supplies have exercised Governments throughout the historic period, and this attention on the part of rulers demonstrates its special value to mankind. Europe is specially fortunate in having large salt supplies, which are specially important in England, Germany and Poland. Potash compounds are obtained in large quantities in central Germany, and also in France now that the potash deposits of Alsace are within that country once more.

The old predominance of Britain in the textile industries has gone. Customs boundaries in Europe have multiplied, and many States are trying to develop these industries for themselves. Moreover, the introduction of wood pulp industries, both for artificial silk and for paper, has given advantages to countries with forests for pulp and waterfalls for power, features which often go together. Further, Holland, as a neutral in the war of 1914–18, has gained very greatly in industrial importance, especially in the making of textiles (both cotton and artificial silk). Italy, with long experience of natural silk, leads, in Europe, in the production of artificial silk, though its total is far below that of U.S.A. Germany and England follow, and France, Belgium and Holland also produce the material largely, the production of the two latter being remarkable for the size of the countries.

Motor-cars, oil- and gas-engines, and the use of electrical power, have altered the distribution of the manufacture of fine machinery, and south Germany, Switzerland and north Italy have profited specially in this sphere. The spread of rubber industries is another recent phenomenon. The term chemical industries has come into use to cover a large range of works based upon applications of chemical science working upon mineral salts, vegetable oils, and a variety of other materials. The high development of scientific education in Germany has given that country a leading place in chemical industries, but Britain has organized herself in this matter and in that of the production of dye-stuffs in the last few years, and many countries are taking part, in varying measure. The growth of industries in ports to which are brought copra, palm oil, earth-nuts, rubber, etc., from the equatorial regions is a notable feature of this century, while the supply of electric power has promoted the distribution of industries along railway lines, as west of London, not necessarily near coalfields.

POST-WAR REORGANIZATION

The adaptation of former armament works in Germany to industrial production after 1918, and the reconstitution of the German mercantile fleet, and the re-growth of Germany's shipbuilding industry, by a great effort of all concerned, has been a marked feature of European life since 1918. Parallel with this has been the reconstruction of the ruined regions of northern France and their equipment for modern industry on a large scale; this region needs supplies of fuel from Belgium and Germany. The renovation of Belgian industry has been very marked, and Antwerp has recovered and expanded, while there has been great expansion of Dutch textile and other industries. The northwestern lands have felt the crisis of 1914–18 in other ways. Sweden, with her own supplies of high grade iron and timber, was able to maintain her position throughout the crisis, and in the subsequent period of financial upheavals. Norway lost a proportion of her mercantile fleet through submarines and mines, and both her carrying trade and her exports and imports were seriously interfered with. The reorganization of trade and finance after the war has been difficult, and the Norwegian mercantile marine, formerly among the largest in Europe (after Britain and Germany) has been outstripped in size by those of several other nations; it was naturally of importance when wooden ships were in general use. Denmark lost a proportion of her cattle in 1914–18, partly through difficulties about fertilizers and feeding stuffs, and her entrepôt trade at Copenhagen is not what it was under pre-war conditions. Also, industrial depression in Britain, and the competition of New Zealand in the supply of dairy produce have limited Denmark's chief market. On the whole, therefore, the north-west is somewhat less prosperous than formerly, while the low countries seem to have gone ahead markedly. Switzerland has been in a strong position throughout, but had to face special difficulties when the currencies of all surrounding countries were heavily depreciated and subject to daily fluctuations. The progress of the electrical industry and of the utilization of electrical power is a leading feature. The struggle of Austria, left with a historic city of nearly two million people in a small and rather poor State, has been and still is a severe one; it is increasingly recognized that Vienna is needed by Europe as a whole, and if the Main-Danube, Elbe-Danube and Oder-Danube ship canal schemes should mature, the great city would have to play a very important part once more; every re-growth of international links is likely to profit Vienna, but the new and strong Czechoslovakian State is naturally inclined to use its own Bratislava (formerly Pressburg) as outlet towards the Danube. Czechoslovakia, in the fortunate position of combining strong agricultural, industrial and cultural traditions under able leaders, has advanced remarkably since its birth in 1918; the other new States have nearly all found serious political difficulties and, in several of these, the loss of the old aristocracy and the parcelling of the land among peasant proprietors has thus far brought a diminution of harvests. Finland, with its timber, has prospered considerably.

Communications.—Communications in an area of such varied and broken topography are very largely determined by physical features and, in Europe, the lines or zones of the loess (*see* above), the Elbe-Oder lines to the boundaries of the mid-Danube basin, and thence to the Adriatic, to the Vardar, to Nish, Sofia and Constantinople, and to the Black sea, have remained important since prehistoric times, while the Alpine passes and the Rhône-Rhine ways have played great parts in Roman and later periods and, among the former, the Brenner was important still earlier and had very special importance in the middle ages. This importance is illustrated by the historical development of Venice and of Innsbruck, Ulm, Augsburg, München, Ratisbon, Passau, Nürnberg and Frankfurt-on-Main north of the Alps. Many of these towns are of great industrial importance at the present time, having re-developed, especially with the re-distribution of industry and the spread of the use of electrical power in the 20th

century. But the historic route is no longer of special commercial importance, and as a way across the Alps it is now supplemented by lines of railway in other passes. The Semmering had a railway built in 1848–54, and this was continued by other passes via Caibach to Trieste in 1857; this was built before the Brenner railway. The Mont Cenis railway (altitude 4,380 ft.) was built in 1871, and is being supplemented (1928) by a line from the French side down to the Riviera. The St. Gotthard tunnel (altitude 3,785 ft.) was made in 1882, and the Simplon tunnel (altitude 2,300 ft.) in 1906. Each of these three railways has been built at a lower level than its predecessors, thanks to the growth of engineering enterprise in planning longer and longer tunnels, and the introduction of electric power for locomotives, lighting, ventilation and pumping has greatly reduced the difficulties of long tunnels. The importance of the Simplon route has been greatly increased by the cutting of the Lötschberg tunnel through the Berner Oberland, giving direct communication from the Simplon to the north via Berne and Basle. There are many other tunnels within the Alpine system, and the development of mountain railways, notably to Davos and the Engadine, has been an important feature of the growth of communications. The railway network of Europe has been made a good deal closer, the mileage of track laid having increased considerably since the beginning of the century. Electrification of railways is proceeding apace in Switzerland, France, Italy, Holland, Germany, etc. The railway systems which can be termed continental in the fullest sense include the following:

(*a*) That from Calais or Paris via Strasbourg, Stuttgart, München, Linz, Vienna, Budapest, Belgrade, Nish, Sofia and Philippopolis to Constantinople, with a prospect of organization of a train ferry across the Bosphorus to link this system with the railways of Arabia, Syria and Palestine and, ultimately, Egypt and beyond.

(*b*) That from Ostend or the Hook of Holland via Cologne, Frankfurt-on-Main and Nürnberg to join (*a*).

(*c*) That from Calais or Paris via Mont Cenis to Milan, Zagreb (Agram) and Belgrade to join (*a*).

(*d*) That from Ostend or Paris or, ultimately Lisbon or south Spain, via Brussels to Cologne, or from the Hook of Holland to Cologne, Magdeburg, Berlin and onwards, either via Vilna to Leningrad or to Warsaw and Moscow, linking with the trans-Siberian system.

(*e*) That from Calais or Ostend via Paris or Basle, or from north Germany, etc., via Basle to the Lötschberg and Simplon or the St. Gotthard, and so into Italy, or via München and Innsbruck and the Brenner, also into Italy.

(*f*) That from north Germany via Vienna and the Semmering pass to Trieste.

(*g*) That from Berlin and Vienna through Klagenfurt and the Karawanken, and the Julian Alps to Trieste, etc.

(*h*) That from Berlin via Lwow to Odessa.

(*j*) That from Oslo and Stockholm to Helsingborg and Malmö, across the Sound to Helsingfors or Copenhagen by train ferry. From Copenhagen one route via Gedser, with its train ferry to the German port of Warnemünde, giving connections with the German and general Continental systems. Another route goes across Zealand and Fünen to Jutland, traversing the Great and Little Belts by train ferry, and reaches Esbjerg, whence steamship communications give links with England, France, the Low Countries, etc.

Water transport on rivers and canals developed greatly prior to the invention of the railway locomotive, and in England it has, on the whole, lagged behind since the railway gave such added speed to movement. Canals in Britain involved much engineering and many locks, which greatly delayed transport. On the European plain, however, there were large navigable rivers, and, linking them in Prussia, natural channels between morainic hills (*see* BERLIN). The canal systems of the Rhine and north Germany are of great economic importance, but they are, as yet, not adequately united to the Danube system of navigation, for the old Ludwigs Kanal via the Altmühl linking Nürnberg and Regensburg (Ratisbon) is small and may freeze in very cold weather. A new canal, from Main to Danube, for large boats, has been planned and would make a great difference to European communications, as also would the projected canal from the Oder to the Danube via the March. The added importance of Vienna, if these schemes develop, is easily appreciated. The canal from Marseilles to the Rhône and the opening up of the Étang de Berre which is the consequence, the improvement of the Seine, making Paris an important port, the similar development at Manchester, due to the Manchester Ship canal, the Kiel canal, and the improvement of the Hamburg-Lübeck system, are important local changes of water communication in the last generation which deeply affect European commerce. Ocean-going boats of moderate size can go up the Rhine to Cologne, and very large river boats and barges get up to Mannheim; 1,000 ton barges go right to Strasbourg and Kehl, Kehl being the port on the German side of the Rhine opposite Strasbourg; at times they can even go as far as Basle. Barges of 1,000 tons can go up the Meuse to Liége; Brussels is becoming a port of some importance. The treaties of 1919 enforced international control in the case of several navigable rivers, previously belonging to the Central Powers, and, for example, gave Czechoslovakia special privileges at Hamburg and Stettin.

The revival of road-transport, thanks to motor cars and lorries, is leading to improved road systems and alterations of communications, the end of which it is not easy to foresee, but it is said that this has not yet deeply affected international commercial transport, much as it has changed tourist traffic. Air communications are still in their infancy (1928), but promise to enhance the importance of the capitals as termini at the expense of junctions near frontiers. The many, and in some cases unexpected, results of the development of telephones, wireless telegraphy and films as means of international communication are matters of common talk, and the spread of certain English or American phrases and notions through the films is very noticeable in some countries in Europe.

DISTRIBUTION OF THE POPULATION

Population—States and Towns.—The populations of the countries of Europe, according to censuses or estimates subsequent to the last census, are given in the table opposite.

Population is increasing everywhere as a result of the development of economic resources and the advance of medical science, but the rate of increase is lessening very markedly in several regions, and this is shown most typically in the decline of the birth rate, which, in England and Wales, was 16·6 per thousand in 1927, the lowest figure ever touched. The contrast between this and figures over 35 reached about 60 years ago is very striking. In Italy the diminution of death rate, though well marked, is not as striking as in Britain, and the fall of the birth rate has been much slower, the increase of population since the beginning of the century has thus been nearly 25%, and this followed an increase of some 14% in the previous 20 years. The stability of the French population, with somewhat higher birth and death rates than the British, is proverbial. The fact that the German republic, shorn of so much territory through the war of 1914–18, nevertheless has a much larger total population than at the beginning of the century is a clear indication of the immense industrial development that has occurred. Density of population in Belgium and the Netherlands has increased markedly in the 20th century, in large measure owing to development of manufactures, as discussed in the articles on those countries, but, at the moment, England and Wales together have a slightly greater density of population even than Belgium. If the above figures be added together it should be noted that they would give the population, not of Europe, but of Europe with a large area in Asiatic Russia.

The population and area of the British Isles and Italy are not now very different from one another, but the distribution of population in the two cases is very different. In the British Isles, London and Glasgow overtop the million, and at least three towns approach that mark, while seven more have over 300,000 people each, ten others over 200,000 and 25 others over 100,000. In Italy, on the other hand, the three chief cities are nearly on a level, at over 800,000 people, there are three others with over 300,000

	Year	Population	Per square mile
British Isles:			
1. England and Wales	1927	39,290,000	673
2. Scotland	1927	4,892,000	164
3. Northern Ireland	1927	1,253,000	239
4. Irish Free State	1927	2,958,000	111
also:			
Isle of Man	1921	66,284	273
Channel Islands	1921	90,230	1,203
Gibraltar	1921	20,638	..
Malta, etc.	1926	227,440	1,864
Albania	1925	831,877	48
Austria	1923	6,534,481	202
Belgium	1926	7,874,601	670
Bulgaria	1926	5,483,125	138
Czechoslovakia	1926	14,356,600	265
Danzig	1924	384,000	..
Denmark	1925	3,434,555	207
Iceland	1926	101,764	2·5
Estonia	1926	1,117,270	61
Finland	1926	3,558,059	27*
France	1926	40,743,851	192
Germany (with the Saar)	1925	63,180,619	347
Greece	1926 estimate	6,600,000	261
Hungary	1920 adjusted	7,987,143	222
Italy	1927	40,548,683	339
Latvia	1925	1,844,805	76
Lithuania	1927	2,254,668	100
Lichtenstein	..	10,716	165
Luxembourg	1922	260,777	261
Monaco	..	22,153	..
Netherlands	1926	7,526,606	598
Norway	1927	2,788,803	22
Poland	1927	29,589,000	197
Portugal	1920	6,032,991	170
Rumania	(var.)	17,393,149	142
Soviet Russia (including Asiatic portions of the Soviet Union)	1926	147,013,609	18
Serb, Croat, Slovene State	1921	12,017,323	125
Spain	1920	21,338,381	112
Sweden	1926	6,074,368	38
Switzerland	1926	3,959,000	243
Turkey in Europe	1927	1,203,151	145

*Land area

people, five others with over 200,000 and seven others with over 100,000. The contrast between the British Isles and France is equally marked, for, apart from Paris, France has one city with over 600,000, one other with over 500,000, two others with over 200,000, and 12 others with over 100,000. France has been far more successful than England in holding her rural and small town population in several regions, though rural decreases are widespread and serious. France and Italy again contrast, for Paris has as many people as Rome, Milan and Naples together, an illustration of French centralization. Germany, with Berlin and Hamburg over the million mark, and 13 others over 300,000, nine more over 200,000, and 22 others over 100,000, shows a condition of much more intense urban development than is found in France, and a larger number of towns over the 300,000 mark than have the British Isles, a reflection of the fact that in Germany there are many historic capitals of constituent States, as well as a number of great industrial centres. The number of large towns in Soviet Russia is a conspicuous feature at the present time.

Cities of Europe having over 1,000,000 people each are:—

London (Greater London)	7,791,310
Paris (Greater Paris, Dept. of Seine)	4,628,637
Berlin (Greater Berlin)	4,024,165
Moscow	2,019,453
Vienna	1,865,780
Leningrad	1,616,118
Hamburg	1,079,126
Glasgow (estimate)	1,049,000

The effective population of Liverpool, of Manchester and of Birmingham is much larger than is given in the official figures for specified areas, and they are all practically agglomerates reaching or passing the million. The same reserve should be borne in mind concerning a number of Continental cities. There is a widespread tendency towards ribbon growth of cities beyond their old limits and to a decline of population at the centre, and many diverse attempts are being made to cope with the serious disadvantages of ribbon growth along the roads by planning schemes, in which Germany has shown great foresight and understanding. It seems to be widely true of cities of over 300,000 people in western Europe that they tend towards a metropolitan character, save in certain special cases, whether they are official capitals or no.

It has been said in an earlier section that the idea of the city is far older in the Mediterranean region than in Europe farther north, indeed many a "village" in Italy has a more or less urban appearance, the tendency being to close agglomeration, often on hills, near a spring, and, in olden times, behind a circuit of walls. A dispersed population has become more and more characteristic of north-west Europe in recent centuries as dangers of local anarchy have diminished and agricultural improvements have broken down communal tradition.

In France the idea of the town is older than it is farther north and north-east, and quite a number of towns usually in charge of a bishop in the post-Roman centuries, survived the difficult prelude to the middle ages and grew again as trade and intercourse developed, from the second half of the 11th century onwards. The towns on the left bank of the Rhine, and some on the Danube, also retain a measure of continuity from Roman times, but the towns farther east are, for the most part, appreciably younger. From this cause there has arisen a difference fraught with great consequences for modern political organization. As the towns of east-central Europe grew, in many cases, long after those of the west, and grew in the midst of a rurally-minded population, they often attracted to themselves people from the west, German-speaking or Jewish people, who settled among Slavonic and other peoples of east-central Europe, sometimes in this way making a middle class that neither the aristocracy nor the peasantry has been able fully to assimilate to itself.

Attention may be drawn to a tendency to change in the town-plan from west to east. In a French town of Roman tradition, typically ruled by a bishop in the centuries following Roman decline, the cathedral is often the centre around which the market town is set, and often enough within the Paris basin there may not be any old town hall or other obvious mark of the burghers' power. On the borders of that basin, however, the historic town hall and the watch-tower are frequent features. Beyond the Rhine the old town is more often in the shelter of a castle, though the cathedral may be important here too. Going east one notes the frequent coupling of cathedral and palace within a stronghold, as at Prague and Cracow, and this idea is expressed most forcibly in the kremlins of the Russian cities. To understand the historic evolution of European town plans, however, one needs to have in mind many other evolutionary lines, notably the growth of maritime cities, with their groups of traders, as at Ypres, Bruges, Lübeck, etc. This has given a richness of public buildings and residences and a burgher pride which spread from the early trading cities of the coasts far inland.

POLITICAL REORIENTATION

Political Geography.—The city-state of the Mediterranean area has been the subject of many discussions, and here it is necessary to say only that its existence in antiquity and its revival in the middle ages were hindrances to any tendencies towards the growth of the idea of nationality in that region. On the other hand, in the Paris basin and on the English plain, with their towns growing or reviving, from the 11th century onwards especially as foci of rural areas around them, ease of communication led to a growth of a common vernacular tradition which, with military considerations to spur it, gave rise to the idea of a nation. This was, in the case of the Paris basin and the English plain, a group of people speaking one language, following one law and at first one form of religion, and inhabiting one continuous territory under one unified Government which controlled defence at least. The old unity under the Church was to some extent in opposition to the growth of national units and, in Germany, division as regards law and religion in the 16th century delayed the possibilities of growth of

unity around the common language which the introduction of printing, and especially the printing of the Bible, was tending to standardize. The cheapening of printing, and the spread of book-education to the middle classes in the early 19th century, was a contributory factor, alongside of a natural resistance of peoples to the enforcement of unity by Napoleon, of the phenomenal rise of nationalism in modern Europe, which has found its expression in such marked fashion in the treaties concluded after the war of 1914–18. The basic factor of nationality is more and more group consciousness, and we have the attractive example of Switzerland to show that this can be strongly developed where there is neither unity of language nor unity of religion and where even unity of law is not of very ancient growth.

Hardly any nation except Sweden, Norway, Denmark, Holland and England (without Wales) had a complete unity of language before the war of 1914–18, and Wales is included with England for many political purposes, so that the claim to unity of language is not really effective, though all save a very few can understand English. France has a Breton, a Basque, a Flemish and an Allemanic-speaking region, Germany has Slavonic elements, much reduced since the war; and most of the east-central European States created after 1918 have minorities differing in language, and sometimes in religion, from the governing group. The problems of national organization are much increased as a consequence of this, for in most cases there is a lack of that feeling of security, military and economic, which so greatly helps to keep Switzerland a group-conscious unit. The Russian plain with its multiplicity of languages and customs, and the isolation of its communities in those immense areas, is difficult ground for the growth of a valid group-consciousness. It is important to note that the 19th century nationalist movement achieved the unity of Italy, and the growth of its group-consciousness of recent years has been a very marked feature of European life. The ferment of nationalism in the Balkans in the late 19th and early 20th century, and the relations of the movements concerned to political powers outside, are well known to have been among the most important factors of the war of 1914–18. While the passion of nationalism has remodelled the map of Europe, has immensely increased the difficulties of tariff frontiers in Europe, and has caused currency troubles which have shaken credit very seriously, there are abundant signs of developments in a very different direction.

There have long been international congresses of specialists in branches of learning or of education, or of public health and welfare, or of technology. In spite of post-war difficulties these are now reviving, and some nationalist enthusiasm is turning to rivalries in these activities. Of the importance of many of these congresses, both for public welfare and for international effort, too much cannot be said. The network of banking is spreading across national frontiers, and this has greatly helped in the gradual re-establishment of currencies ruined by the crisis of 1914–18. Many large industrial enterprises are increasingly spreading to most of the industrialized lands, and in some cases even to others, so as to have production behind the tariff wall. There are attempts at international arrangement in railway, canal and river transport, not always happy or successful when dictated in treaties. There are important international labour movements and movements among university students. Most of all, there are the foundations of the Permanent Court of International Justice at The Hague and of the League of Nations at Geneva, with its related International Labour organization and the many committees of the League Assembly for health and humanitarian purposes, and finally, the International Institute of Intellectual Co-operation.

These are organizations, but in addition to such deliberate efforts there is a change in mind making itself felt, a growing consciousness of the difficulties of self-sufficiency of the nation as an economic unit, of the waste due to the multiplicity of organizations in many small States for doing or making the same things. The contrast between the small production in an average European country and the large scale production possible in the immense free trade area of the United States, is one that is causing much anxious thought.

The present (1928) difficulties of international co-operation between peninsular Europe, Europe and the Russian plain, largely political, cannot be discussed here, but these difficulties are in everyone's mind, both in the nation-States of peninsular Europe and in the Soviet Union, as hindrances to the welfare of the peoples of the whole of Europe.

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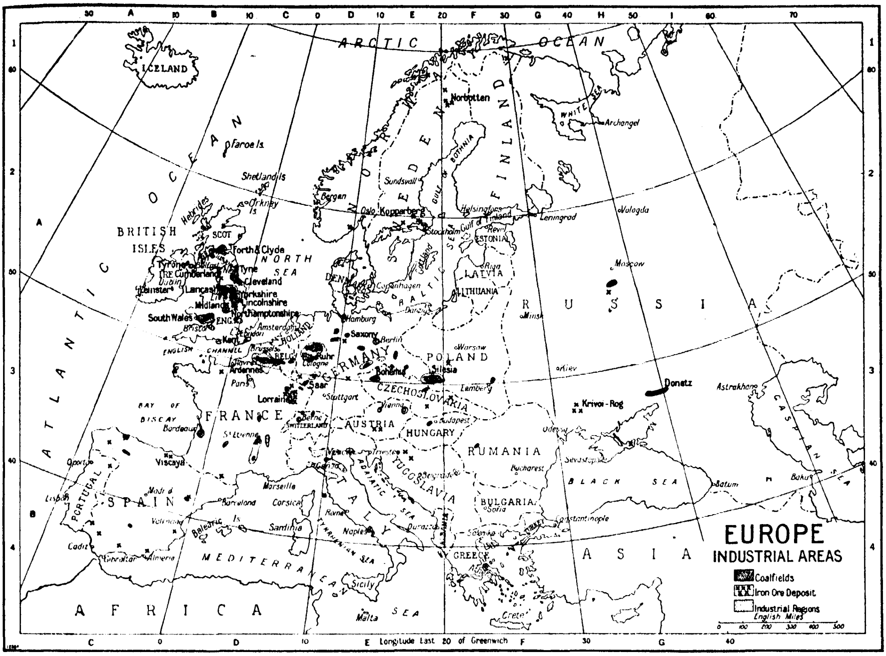
See also bibliographies of the separate countries.

EUROPE AS AN ECONOMIC UNIT. The line of division between Europe and Asia has been obliterated by the Soviet Government. Border provinces have been amalgamated into new administrative areas which straddle the ancient frontier in complete disrespect for geographical dogmas. The exact population of Europe in 1928 is thus unknown, and the European area can only be stated on the hypothesis that reference is made to an historic and not to an actual fact. But the convention of the existence of Europe is worth preserving; the medley of races which dwell between the Ural River and Ural Mountains on the east and the coasts which face the Atlantic on the west do constitute, despite all political fissures and commercial barriers, an economic unity with a being, personality and character essentially its own.

The climate of the extreme north may be sub-arctic and of the southern peninsulas sub-tropic, but that of the great bulk of the continent is temperate; rainfall is almost everywhere adequate for the cultivation of the soil, and by far the larger portion of the ten million odd square kilometres of area is nourished by a single vascular system of rivers which flow without exception into the seas embracing the mainland, none twisting round the eastern watershed into Asia. Of the 470 million inhabitants (estimated 1928) the great majority are of Indo-European stock and of one religion. Almost all are settled tillers of the soil or fixed residents of towns. Stretching as Europe does from north of the 70th to the 36th degree of latitude, exceptions to this rule of essential unity are inevitable. Thus, the Tartars pursue a nomadic life over the arid steppes of south-eastern Russia, the Vlakhs wander unimpeded, as the seasons change, through half a dozen states; the Magyars in the heart of Europe, the Finns and Lapps in the north are of another racial stock; there is little in common between the reindeer pastures of the Russian tundra and the volcanic gardens of Naples. But these exceptions serve to emphasize the characteristic homogeneity of the whole.

Europe's Livelihood.—How, then, do these 470 million people earn their living? Europe, for all her manufacturing and mining industries, is predominantly agricultural. In only five countries do the industrial exceed in number the landworkers. The most important factors, therefore, determining the daily occupations of her population are the fertility of the soil and the character of the climate. North of a line which may be traced roughly along the river Dal in Sweden across the Baltic sea to Leningrad and the southern shore of Lake Onega and thence south-east



DRAWN BY JOHN BARTHOLOMEW & SONS, LTD.

MAP OF EUROPE SHOWING THE CHIEF INDUSTRIAL AREAS AND THEIR PRODUCTS

towards Orenburg, the predominant vegetation consists of forests. Between this line on the north and east and the grasslands of central Russia on the south, spreads out westwards the great tract of territory broken by the Carpathians and bordered by the Rhodopes, the Alps and the Pyrenees, where arable and mixed farming alternate. In the southern peninsulas, in the lower valley of the Rhone and along the Adriatic coast this mixed farming is largely replaced by the cultivation of southern fruit, by olive groves and vineyards. But vineyards spread as far north as the 52nd degree in Posen, and rye, the most important cereal in Germany and Russia, is sown in the high-lying districts even of Greece and Portugal. All the peninsulas save Denmark are mountainous, and the vast plain which is Russia and its extension over northern Germany, is divided by the folds of the Carpathians from the wheatfields of Hungary and by the folds of the Alps from the fertile valley of Lombardy. These mountain ranges of the south increase the rainfall where rain is needed, and the Carpathians protect to some extent the centre of Europe from the rigours of the Russian winter.

If the local distribution of the population of Europe be studied it will be found that its lower densities tend to vary with the fertility of the soil and the clemency of the climate, its intenser densities with the richness of the subsoil and the natural means of communication.

Thinly Populated East.—The whole forest and steppe area of the north and east, the mountain massifs and the arid plateaux of Spain contain but a minute fraction of the total population. Into the black land of central Russia and round the central coalfield projects a wedge of greater density. But even with all the industrial areas of the Donetz basin, of Moscow, of Lodz, Upper Silesia, etc., the total population of the nine countries in Europe which lie east of the 20th degree of longitude, and together account for 60% of the whole area of Europe, only comprise a little over one-third of its inhabitants. Of that third, the great majority to-day are peasants farming, since the agricultural revolution which the war ignited, their own land and producing mainly for their own needs. In the north, below the forest belt, the typical crop is rye, in the south wheat and maize. But in Estonia the main occupation is dairy farming; Northern Russia supplies two-thirds of the world's requirements of flax, and flax is the staple article of Latvian export. South of the Rhodope mountains cereals give way to vines, olives and tobacco; but in recent years the cultivation of tobacco has spread widely.

This greater eastern half of Europe produces mainly for its own needs. It exports not more than 5% of its average cereal harvest. But it forms, nevertheless, the main granary of Europe, produces a half of Europe's wheat and maize crop, nearly two-thirds of her rye and about one-half of her oats. For the industrial population of the west the surplus is too small, and over 10% of the total bread corn is imported from other continents.

Densely Populated West.—West of the 20th degree of longitude the populations are congregated in much closer masses, the greatest density being found in the valleys of the Rhine and the Scheldt, on the lower reaches of the Thames and between Birmingham and Bradford. Though in the whole of this area there are no tracts of land comparable at once in fertility and size with the black soil of Southern Russia, the tillage is more scientific, the production per hectare, save in the Iberian peninsula, is higher and the organization of agriculture more nearly approaches that of industry. The wine of France, the sugar of Germany or Czechoslovakia, the butter and bacon of Denmark, the cheese of Holland, are all produced with the aid of an elaborate

economic organization which more closely resembles the business mechanism of industry than the primitive labour of the eastern peasant. The higher output per hectare and the higher average value of the crops produced enable the land to carry a heavier population than elsewhere. But in these countries the proportion of land to total workers is with but few exceptions relatively low. In agriculture, unlike industry, machinery directly and continuously competes with labour after a certain stage of efficiency has been reached, and while the growth of industry has attracted labour to the towns the increased use of mechanical appliances on the land has tended to reduce the demand for labour. To some extent this tendency has been counteracted by other forces. The demand by towns for vegetables and fruit, as in Belgium and round almost all the great industrial centres, has gradually converted agriculture into horticulture, while the laws of inheritance in France and elsewhere have led to the incessant sub-division of properties and impeded the use of mechanical processes. But throughout western Europe, with the possible exception of France, the march from village to city has been uninterrupted. In Europe, indeed, the towns have grown up from the country-side, while in more recently colonised lands, after the first few years of struggle, the circle of cultivated land has slowly expanded as demanded by the increasing population of the towns.

Across the whole of the alluvium deposits of the North German plain rye and oats predominate, intercepted in the richer river valleys by wheat and alternated with potatoes and sugar beet. Czechoslovakia is a transition land where rye and wheat and potatoes compete on almost equal terms; in the Valley of the Danube rye gives way to wheat and after its junction with the Drave wheat in its turn is alternated with maize. West of the Rhine, the hardier cereals almost disappear to be replaced by wheatfields and vineyards, by mulberry groves in the south of France and the Lombardy plain, by olives and rice in Italy and Spain, and by oranges and lemons along the Mediterranean littoral.

The southern littoral is devoted to fruit trees, much of the northern to pasture land and dairy farming. Denmark, Holland and Estonia are essentially dairy countries, Great Britain is the greatest breeder of cattle for stock and beef, and after Russia the owner of the largest flocks. But elsewhere sheep are to be found in the largest quantities, not on the fat pastures of the valleys, but on the mountain slopes moving with the seasons, on the high uplands of Spain, on the Carpathians and the Apennines.

Europe Does Not Feed or Clothe Herself.—Europe produces a quarter of the world's supply of wool, a half of its crop of wheat and oats, over nine-tenths of its rye, two-thirds of its barley (excluding China's production). But she does not feed herself or clothe herself. The denser agglomerations of her population live not by the interchange of products with the agricultural area, though those areas meet the great bulk of their requirements within the continent, but by the sale of manufactured goods to all parts of the world. The raw materials exported are few—coal, wood-pulp from the north, some silk and wool, some platinum from Russia. The raw materials derived from the soil or subsoil are far from adequate for her industrial needs. But though Europe looks to other continents for her raw textiles, and rarer metals, for her vegetable oils and rubber, even for a large proportion of her hides and tanning materials, the seat of her great industries has been determined mainly by the deposits of coal and the proximity of raw products.

Of all factors determining the distribution of population, the most powerful have been the depth and availability of the coal seams and the natural means of communication. Coal is found in the great majority of European States, but Great Britain and Germany together are responsible for over two-thirds of the total supply and these two countries, Belgium, France and Poland, for nearly nine-tenths. Round the coalfields in these countries, in Lancashire and Yorkshire, in the valleys of the Sambre and the Meuse, in the Ruhr and the Saar districts, round Creusot, in Saxony and Silesia and in Bohemia, lie the great industrial centres. On the continent of Europe they are thus largely concentrated in the territories drained by the Rhine, the Meuse, the Elbe, the Oder, and their tributaries, and it is in these valleys that the density of population is thickest. Indeed, their only serious rivals are the rich Lombardy plain with its centre at Milan, and the scattered points constituted by the great capitals Paris, Berlin, Stamboul, and the volcanic oases in Southern Italy and Sicily. But none of these points can rival the Rhine valley and more especially the wealthy zone which lies between Dortmund and Lille.

Coal as a European Industrial Factor.—Coal has been and is the greatest natural factor determining the industrialization of Europe, and her greatest natural source of wealth. It accounts still for some 6½% of British exports, and of the total amount entering into international trade, Great Britain and Germany are together responsible for almost two-thirds. But only from these two countries and from Poland is there a net surplus for export. It is the magnet which has drawn the country population and all types of industry to itself. It is often cheaper to transport even iron ore to coal than coal or coke to the iron mines, and the economy in the case of other raw materials is determined jointly by their requirements of power for treatment and by their weight and bulk.

On coal and iron the European industry of the nineteenth century was based. Europe still produces about 45% of the world's supply both of pig-iron and steel, and of Europe's output over five-sixths of the pig-iron and over three-quarters of the steel are manufactured in Great Britain, France, Germany and the Belgo-Luxemburg Union. Coal and iron in these four countries lie for the main part not only in juxtaposition to one another, but near either to the sea coast or to rivers which could be and have been connected by a network of canals. Thus, to the north of the Tyne lies the Durham and Northumberland coal, to the south the Cleveland ore; in Ayrshire and the Clyde basin the black band ironstone extends to the coalfields; the iron works on the coast of South Wales were based originally on local ore and worked with local coal. In Belgium and Luxemburg, France and Germany, the main deposits lie in the basins of the Meuse and Moselle, or between the Moselle and the Rhine in Lorraine, and north to Luxemburg, in the provinces of Namur and Liège, round Saarbrücken; in the neighbourhood therefore of their greatest coalfields, and in easy access to the sea. The great inland iron works of Europe, at Creusot, in Silesia, in the Erzgebirge, west of the Ural Mountains, and south of Moscow likewise are all situated in the vicinity of coal. The works on the Donetz basin are at once near coal and near the Black sea at Rostov.

Here, too, in these valleys, where coal is mined and access to the sea is ready, many of the other major industries of Europe have concentrated, as cotton in Lancashire, round Chemnitz and the Saxon coalfield, in the Rhine valley at Mulhouse, Colmar, etc., in Bohemia; wool in Yorkshire, at Roubaix, Amiens, Tourcoing, etc., at Barmen and Elberfeld; machinery again largely round the central British coalfield, at Creusot, Essen, Krefeld, Barmen, Chemnitz, etc. Indeed an almost unlimited range of examples might be quoted.

But although coal has been the prime factor in determining the localization of European industry, it would be easy to exaggerate its importance. On the continent of Europe as a whole, industrial energy is both less specialized and less topographically centralized than in Great Britain. In France this is due in part to the fact that she has many coal mines scattered throughout the central region at Creusot, St. Étienne, Alais, Carmaux, etc. But other forces, some natural, some historical, have competed. Her woollen industry has grown up near the downs of Champagne where her flocks were fed, at Rouen within the pastures of Normandy and close to Le Havre where foreign fleeces are transshipped. Rouen, too, for its closeness to the sea, is one of the centres of cotton spinning. The mills in the Vosges, at Epinal, St. Dié and Sénones, date from the transference of the Alsatian industry to Germany after the wars of 1870. The textile industry of Lodz is an artificial creation; the silk industry of Krefeld and the cutlery of Sheffield owe their prosperity to the properties of the local water. Lyons, where also the water meets to a peculiar degree the requirements of the silk industry, is in the centre of the mulberry area; the chemical industry at Stras-

bourg has been built up on the deposits of natural potash salts. But quite apart from natural causes the whole history of Germany with its multiplicity of states and far-flung seats of learning has naturally conduced to the decentralization of industry. European industry has been built on the natural resources of the soil and the sub-soil. But it has been preserved and extended by acquired skill and technical education. The cork and wine of the Iberian peninsula, the steel or pulp of Sweden, the zinc of Upper Silesia, the attar of roses of Bulgaria, the linen of Ulster or Cambrai, even the tulips of Haarlem and the carnations of San Remo are the natural outcome of favourable local conditions. But the chemical industry of Germany has its roots in her thorough system of technical education, the scents and dressmaking of Paris spring from a national talent, as do the luxury goods and wares of Vienna. Again, the European countries which have been most successful in the manufacture of artificial silk—Italy, Great Britain, Germany and France—are not those in which the raw materials are most plentiful. The motor-car industry of Italy has been based on the skill of her mechanics, the watches and chocolates of Switzerland on native ingenuity and the absence of reasons for other occupations, and the rubber sponges of Moscow on the invention of a single individual.

Thus, the forces which have determined the character and the place of European industry have been manifold. Her industries were highly developed when the newer industrial countries were still in the process of early colonization and settlement. As these countries have gradually discovered and exploited their natural resources, a change has taken place in the economy of Europe, caused in part by their increasing competitive power and in part by the normal progress of science. Both causes have tended towards the decentralization of industry. The first because the increased competitive power of these younger countries has attacked particularly the basic industries of Europe, coal and cotton, wool and pig iron; the second because it has affected above all the means of transport and the source of power.

White Coal.—Coal is being supplanted in many countries by hydro-electric power, or itself transformed into electric energy and distributed in that form by long radii of transmission cables over an ever widening circle from the central mine heads. In Sweden and Norway, in Italy, north and south, in Switzerland, the Tyrol, in the mountains which lap round the east and south of France, in the Iberian peninsula and indeed wherever water can be harnessed, it is being employed as energy for driving the wheels of industry. Its use is bringing about a decentralization of industry dual in form, first, from the former centres dependent on the riches of the sub-soil, and secondly within the regions of hydraulic power themselves. For that power is caught here and there in scattered valleys, not concentrated as is coal.

Dispersion of Industry.—But there are other human forces at work which aid in the dispersion of industry. The desire of each country to be independent of its neighbours and the neglect of the value of agriculture by town dwellers into whose hands political power has passed have led to the obstruction of the free interchange of goods within Europe by the imposition of customs duties and the creation of industries in countries, more especially in the centre and east of the Continent, which before relied on Germany and the industrial States of the West for the manufactured articles which they required. The causes of this policy of national and rationalistic protection are many and need not here be enumerated. But amongst them there is one which is profoundly affecting both the relationship of Europe as a whole with the rest of the world and her own internal unity.

American Capital and European Labour.—Before the war the surplus population migrated to America, attracted by the natural resources of a half-developed continent, and thus maintained a certain equilibrium between the growth there of capital and the increase of population, an equilibrium at which the attraction to European labour and to national capital was maintained. Now the gates to the greatest field for emigration have been nearly closed, and the accumulations of American capital have vastly increased. The old equilibrium has been upset and American capital seeks European labour instead of European labour migrating to American capital. This change must have impeded the growth of wealth in the world, for the resources of nature on which that capital and labour may combine are more readily available and more plentiful west than east of the Atlantic. But in Europe, in the first place, it has affected the centre of gravity and in the second, brought about a radical modification of the relations of that continent to the rest of the world. The western and northern countries of the Continent were, and are again gradually becoming, capital exporting countries and it is to the south and east that American capital is tending, and must tend, to flow—to those countries in fact in which the old streams of emigration had their source. The rate of development of these countries will thus be, and is being, accelerated and the balance of the whole Continent altered.

That form of economic organization which is vaguely defined as modern industrialism has been slowly spreading from the midlands of England, where it had its birth in the eighteenth century, east to the great centres of economic activity which have been considered, and from these centres, through a multiplicity of trickling, often scarcely perceptible, streams to new basins. But it still remains true that if a line be drawn from Reval to Minsk and through Lemburg down the river Theiss to Belgrade and then west along the line of the river Save to Fiume, and across the north of Italy from Ravenna to Leghorn, south and east of that line the characteristic industry is handicraft. In Russia, Rumania and the Balkan peninsula, for all the big towns which exist, the typical centre of economic activity is the market village. The peasants clothe and feed themselves and the division of labour is between individuals, not between armies of specialized trade unions. In Italy the industrialized north has naturally affected the habit of life throughout the peninsula. Owing to the peculiar adaptability of the Italian workman to highly skilled individual effort, however, the workshop has continued to compete on equal terms with the factory. But the pressure of increasing population and the infiltration of capital from abroad are, except in Russia where other forces are at work, furthering the movement towards industrialization. The oil deposits in Galicia and Rumania likewise tend to this development. Indeed, all the petroleum fields of importance in Europe lie east of the line from Reval to Leghorn traced above. They lie in fact along the line of the Caucasian and Carpathian mountains, from Baku on the Caspian sea across the Crimean peninsula, a line which is broken by the Black sea and the Danube plain to be renewed at the Buzau-Dambovița fields in Rumania. But of all forms of energy petroleum is the most easily transported and industries, though aided by its proximity, are not tethered to it as they were to coal mines. Indeed, the influence of petroleum and its use in road transport has been rather to knit Europe more closely together as a whole than to intensify the development of isolated spots. For it has added a new means of international communication to the old network of waterways and railways, which crosses national frontiers with infinitely greater frequency than either of these. Moreover, rivers, though some of them, the Danube, the Rhine and the Elbe, may be the greatest of Europe's international highways, frequently divide while they join, and the obstruction caused by political boundaries is appreciably less for traffic by road than by rail. Petroleum again has rendered possible transport by air, which is, of all forms, the freest from artificial hindrances.

But the essential unity of any living organism is more easily apprehended by regarding it in its relations to other organisms than by studying with close inspection the cells of which it is itself composed. Europe, at the close of the nineteenth century, represented to the rest of the world a form of economic structure, which, though not unique, was uniquely perfected, instrumental in the provision of certain services upon which the other continents were largely dependent. She purchased their raw materials and foodstuffs, gave in exchange manufactured articles destined either for immediate consumption or for the further exploitation of undeveloped regions. She also provided goods largely in the form of loans, thus supplying at once the capital needed and through her streams of emigrants, the labour to manipulate that

capital. The raw products she bought, the manufactured goods she sold and lent, the labour she released were all alike carried on her vessels. Europe was thus to those outside her essentially the centre of commerce and the source of labour and capital. By the beginning of the second quarter of the 20th century these characteristics had become less striking; her services were less urgently required, partly on account of the growth of rivals to her position, partly because, as has been seen, the traits of her character had changed. Raw materials are increasingly manufactured elsewhere, North America can export capital in large quantities, the stock which Europe has planted throughout the American continent, in Australasia and Africa has multiplied, and Europe is herself borrowing abroad. But she remains the greatest centre of world trade; nearly two-thirds of the world's mercantile marine belongs to her; her foreign investments still greatly exceed those of any other continent.

Europe as Trader.—Where the great industries lie, there naturally does trade demand the most of the people's energies—in Great Britain, France, Germany, Belgium and Switzerland. But the distribution of trade and industry is not identical. The size of the seats of commerce depends on the wealth of their hinterland, but the overseas carrying trade is conducted largely by nations such as Norway and Greece, Holland and Denmark, naturally thrust upon the sea. In these countries and in those such as Austria and Switzerland which lie across the inland routes east and west or north and south, the largest proportion of the active population, after Great Britain, is engaged in trade and transport. But the services rendered vary. In London and Liverpool, Hamburg and Bremen, Rotterdam and Antwerp, Le Havre and Marseilles, the goods produced in the neighbouring factories and the raw materials required are congregated, bought and sold, unloaded and shipped. But Norwegians send their ships to collect goods in foreign ports, the Greeks both collect and trade widely themselves, Switzerland, though a centre of commerce, is essentially a transit country, Austria, though a country of transit, is essentially a centre of commerce with a network of banks and merchant houses spread over all the neighbouring States.

The mercantile marine of all the Mediterranean peninsulas is considerable, but the distribution of the products not only of Western and Central but also of Eastern Europe is largely conducted by the countries giving on the Atlantic and the North Sea, and it is in the North Sea ports that the markets both for raw products of warmer climates and the cereals of Eastern Europe centre. Thus Liverpool, Antwerp and Bremen are the central points for the distribution of raw cotton, London and Hamburg for wool, Bermondsey and Hamburg for hides; the wheat and maize of the Danube valley is graded for further distribution at Antwerp and Rotterdam. The largest international European markets for petroleum are at Liverpool, Glasgow and Swansea, the largest market for rubber at Liverpool. Of the distributing centres in the south of Europe which can claim international importance, the greatest are Lyons and Milan—the two main arteries of the silk trade.

But both in the distribution and in the overseas transport of goods, Great Britain plays a preponderant part. She stands at the Atlantic gate of Europe, unhampered by contiguous frontiers and unimpeded by artificial barriers. She stands, indeed, without the unity of Europe, attached by trade more to her Empire than to the continent—a focus of that trade, and a distributing centre not only for Europe but for the whole Atlantic. Despite her partial isolation, she represents in large measure the prototype of the economic organization to which continental Europe has tended to conform—a model it is true never exactly copied. With her extraordinary specialization in industry and commerce, and, at least before the World War, in output of a few major products; with her deliberate sacrifice of agriculture, and the urban massing of population, she has exaggerated the features which are largely characteristic of the economy of Western Europe to a point far beyond that which other countries have reached or attempted to reach. From the specialization on a few industries there is, as has been observed, a reaction in most European countries, and in eastern and central Europe an attempt has been made to check the drift towards the towns by dividing the large landed estates into smaller holdings. But this revolution in agriculture has been accompanied by a deliberate policy of industrialization. The east, up to the Russian frontier, looks to and imitates the west, and in doing so breaks the unity and spreads the uniformity of Europe. It breaks the unity because with the industrialization of the agricultural countries the surplus of bread corn available for the rest of the continent is likely to be diminished and the demand for the manufactures of the north and west weakened. New or higher barriers obstructing the free flow of goods are constructed, the markets within Europe are restricted and the opportunities for large scale production reduced. But Europe is necessarily dependent on other continents and on warmer climates for many of her raw materials, and these she can only buy with what she herself produces. To buy cheaply she must produce cheaply, to produce cheaply she must be permitted to devote her energies free from artificial impediments to the manufacture or the cultivation of those goods for which the natural conditions or the quality of her workers best fit her.

The New, Post-war Barriers.—The war and its settlement increased the impediments to the exchange of goods and inevitably upset the balance and distribution of productive forces within Europe. Almost 11,000 kilometres of new frontiers were traced and along every kilometre was built a new tariff wall, here high, there low, behind which national economic lakes stagnate. The political frontiers themselves, even when as in Holland surmounted only by the tiniest parapet, must to some extent check the free flow of the forces of production. Goods move more readily than capital, and capital incomparably more willingly than labour. Even had there been no new tariffs the new political demarcations scored across the face of Europe would inevitably have affected the existing economic equilibrium.

Industrial Europe has never known free trade and the equilibrium which existed in 1913 was determined largely by the political boundaries which then existed. The new frontiers determined at Versailles sometimes cut and sometimes joined the natural fields of wealth. Thus the Lorraine iron field, previously divided between France and Germany, was reunited, but the whole was separated from the Ruhr coke with which the eastern half had previously been supplied without hindrance, and many of the German blast furnaces were cut off from their supplies of ore. Upon the iron and steel of the Lorraine, Luxemburg and the Saar, the iron works of Westphalia, and the engineering and shipbuilding industries throughout Germany had largely relied. Similarly, the division of Upper Silesia separated the blast furnaces of the Polish half from the hard coke for which they had been constructed, and many of the industries of eastern Germany from their supplies of coal, and severed or half severed, innumerable meshes of the net-work of lead, zinc and coal mines, furnaces and factories which had been gradually perfected during the last fifty years.

The new frontier cut through both the existing economic organism and the natural supplies of wealth which lay in the subsoil; but by the Treaty of 1922 between Germany and Poland time was allowed for the regrowth and training of that organism before the separation of the two parts was made complete.

The cotton mills of Lodz and Narva lost their Russian market; the engineering shops of Riga and Tallin and the dairy farms of the surrounding country were cut off from Petrograd.

Industrial Czechoslovakia could no longer readily dispose of her goods in her old markets in Austria, Hungary, Galicia, Transylvania and the southern littoral of the old Austro-Hungarian Empire: the spinning mills of Austria were divorced from the looms of Bohemia, the Styrian iron ore from the Moravian coke, the flour mills of Budapest from the corn lands of Transylvania and Croatia. The road between Central Europe and the Mediterranean at Fiume and Trieste has been obstructed; Bulgaria has been cut off from contact with the Aegean at Dedeagatch.

European Trade Frustration.—All these modifications of national boundaries have checked the growth of old economic organisms and caused a loss to vested interests. All large modifications of frontier must have this result. The frontiers which existed in 1913 could claim no very special economic virtue.

Transylvania is the natural complement to the old kingdom of Rumania; Posen, Congress Poland and Galicia were disintegrated by the treaties of the eighteenth and the legislation of the nineteenth century, not by natural forces. Of permanent significance as affecting the circulation of goods in Europe, the distribution of industry, and the growth of wealth is not the fact that frontiers have been changed, but that they have been increased in length, that they embrace more and smaller states, and that along their length higher protective tariffs have been constructed. Each new state has endeavoured to fabricate with the help of such tariffs those parts of the general mechanism of production of which it found itself deprived when its new frontiers were constituted, or to build up new industries for the employment of those who were temporarily thrown out of work. Thus have been forced into existence a new textile industry in Hungary, new engineering shops in Rumania, new motor-car factories in Czechoslovakia. Behind the quickset hedges planted at Versailles have been built formidable walls from which now a coping stone, now a whole line of bricks may occasionally be removed by way of reciprocal concession. The centre and south-east of Europe has thus been divided into allotments, and the agricultural produce of Russia is crushed painfully through a few state-guarded gates on a closed frontier stretching from north to south across the whole breadth of Europe. So the natural interchange of goods between east and west, or between the industrial and agricultural areas of the centre of Europe is impeded. But the new obstructions are not confined to the new frontiers. The highest tariffs in Europe are those of Spain; Britain has ceased to be a free-trade country.

Europe must export manufactured products to feed herself. Supplies of grain from Russia are reduced and controlled and from the rest of eastern Europe greatly curtailed. But it is on industrial products that her new and higher duties are imposed. The cost of production to the European agriculturist is thus raised and the possibility of cultivating poorer land reduced. The cost of living, the costs of production and the price at which manufactured articles can be sold in exchange for the raw materials and foodstuffs of other regions of the world are all enhanced. The power of Europe to compete is weakened by every denial of her essential unity and by every obstruction to her liberty of internal intercourse.

From century to century the political scene has changed; now this nation, now that, has occupied the forefront of the stage. But what Europe as a whole has had to offer has changed but little. Some of her minor gifts have been exhausted, part of her major legacies expended; one generation has chosen this source of wealth, another that, tin or copper or iron or coal. With the growth of science, unknown wealth has been discovered and old forms put to new uses. Timber to-day is converted more into pulp for paper than into charcoal for crucible steel; the platinum of the Urals, the uranium ore of Czechoslovakia, the bauxite deposits of Jugoslavia have lain awaiting the knowledge to employ them. Some other mines may have been worked out, but to the natural gifts has been added a vast accumulation of capital built up through centuries, and the essential heritage of Europe, her soil, her climate, her central position and great mineral wealth, still remain. (A. Lov.)

EUROPEAN CORN BORER (*Pyrausta nubilalis*), a pyralid moth of the subfamily Pyraustinae accidentally introduced into the United States from Europe and now considered to be a great potential pest to the principal agricultural crop of the States, namely Indian corn (*Zea Mays*). The species has a wide geographic range in the northern hemisphere, occurs all over Europe as far north as 58°. It occurs also in many parts of Asia, and in Pacific islands as far south as Guam and the Philippines. Its climatic range shows a variation from the dry steppes of south-eastern Russia to the moist tropical conditions of Guam. It is known in Europe as an enemy of maize, hops, millet and hemp, and has many other food plants. It was probably introduced into the United States in broom corn coming from Hungary, having been discovered in 1917 near Boston, Mass., in 1919 near Schenectady, N.Y., and in the same year near Buffalo, N.Y. There seems to have been an independent introduction in Ontario. The insect spread rapidly, and is now found in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, Indiana and Michigan. In Massachusetts it has many food plants, known under the popular names pigweed, smartweed, cocklebur, barnyard-grass, lambsquarters, ox-tail, and panic-grass. West of Pennsylvania it is largely confined to the maize plant. There are two generations each year in New England, but only one in its western range.

The female moth measures about an inch from tip to tip of the spread wings. The colour is variable, and ranges from pale yellow to light brown, the wings being marked by zigzag lines. The insect hibernates as a full grown larva in its burrow in the corn plant. In May or early June it transforms to a pupa within the stalk, remaining in this stage from ten days to two weeks. The moths issue, through holes previously cut by the larvae, in late June. They are active fliers, and lay their eggs in flat, irregular masses on the underside of the corn leaves, sometimes, however, on the upper sides, sometimes on the stalk or on the husk of the ears. Each moth lays an average of 400 eggs. The eggs hatch in four to nine days. The larvae feed for a few days on the surface of the leaf, but soon enter the stem of the plant. In the midwestern States they become nearly full-grown by the middle of August, but remain within their tunnels throughout the winter. In New England the moths issue in June; their larvae become fully grown toward the end of July, and the moths from the second brood issue during August and early September. Their eggs hatch, and the larvae enter the stalks, becoming full-grown before the appearance of cold weather.

Efforts at Control.—Extraordinary efforts have been made by the Federal Government and by the States to retard the spread of this injurious insect, at first by quarantines enforced by the inspection and seizure of all products likely to carry the borers, but it has been impossible to prevent the spread by the flight of the moths; and by the winter of 1926–27 midwestern farmers and stock-growers became so alarmed at the prospective damage that Congress was induced to pass an appropriation of $10,000,000 to be spent in an effort to stop further spread in a radical manner; in other words, to enforce along the border of spread the destruction during the winter months of all portions of the plant remaining in the fields. This effort was carried on with the co-operation of the States concerned during the late spring of 1927, and there can be no doubt that the result has been to retard the spread of the pest to a certain extent and to educate the corn planters of that part of the United States concerning the best methods of control. The corn borer becomes a serious pest only where cornstalks are allowed to stand in the field through the winter. During seven months of the year the full-grown larva remains in the lower part of the stalk. The mere pulling of the stalks and placing them in piles, as is done in certain parts of southeastern Europe, does not prevent the issuing of many moths in the spring; the absolute destruction of the stalks and their contents is necessary. A method of corn culture has grown up in the larger part of the United States which is peculiarly favourable to the increase and spread of this pest, and a reform in this method, which seems simple, will prevent the enormous damage that has been feared. The experts of the Federal Government, aided by especial funds appropriated by Congress, have made extensive investigations of this insect since its discovery in Massachusetts and New York, in the effort to find control measures. Some of these investigators have been stationed in Europe and have made careful studies of European methods and conditions. These experts have especially investigated the question of natural control and have sent to the United States many thousands of specimens of European parasites of the borer which have been multiplied in the United States and liberated in the fields.

See the publications of the U.S. Department of Agriculture, particularly *Farmers' Bulletin No. 1535*, and the publications of the State agricultural colleges and experiment stations. (L. O. H.)

EUROPEAN WAR, 1914–18: *see* WORLD WAR.

EUROPIUM is a very rare metallic element (symbol Eu, atomic number 63, atomic weight 152·0) belonging to the rare-earth group, discovered in 1896 by Demarçay. Previously, in

1889, Crookes noticed a band in the spectrum of some earths from samarskite and to the substance giving this spectrum he provisionally gave the name S. This was found, later, to be identical with europium. It was first obtained in a pure state by G. Urbain and H. Lacomb in 1904 by the employment of a very ingenious method which involved the crystallization of the double magnesium nitrates of the rare earths along with the isomorphous bismuth magnesium nitrate. The latter possessed a solubility similar to that of the europium salt and thus, by increasing the bulk of material, made the process easier to carry out. Owing to the great rarity of this metal, it is best obtained from the crude mixture of samarium and gadolinium oxides derived from monazite. The salts possess a pale pink colour and show a faint absorption spectrum. The spark spectrum of this element is very brilliant. (*See* RARE EARTHS.) (C. J.)

EURYDICE, in Greek mythology, the wife of Orpheus (q.v.).

EURYMEDON, one of the Athenian generals during the Peloponnesian War. In 428 B.C. he was sent by the Athenians to intercept the Peloponnesian fleet which was on the way to attack Corcyra, but was anticipated by Nicostratus with a squadron from Naupactus. In the following summer, in joint command of the land forces, he ravaged the district of Tanagra; and in 425 he was appointed, with Sophocles, the son of Sostratides, to the command of an expedition destined for Sicily. Having touched at Corcyra on the way, in order to assist the democratic party against the oligarchical exiles, Eurymedon proceeded to Sicily. He agreed to terms of peace proposed by Hermocrates, but the Athenians repudiated the agreement and fined him. In 414 Eurymedon, who had been sent with Demosthenes to reinforce the Athenians at the siege of Syracuse, was defeated and slain before reaching land (Thucydides iii., iv., vii.; Diod. Sic. xiii. 8, 11, 13).

EUSDEN, LAURENCE (1688–1730), English poet, son of the Rev. Laurence Eusden, rector of Spofforth, Yorkshire, was baptized on Sept. 6, 1688. He was educated at St. Peter's, York, and at Trinity college, Cambridge, of which he became a fellow. He was made poet laureate in 1718, and became rector of Coningsby, Lincolnshire, where he died on Sept. 27, 1730. His name is remembered by the numerous satirical allusions of Pope, *e.g.*,

> "Know, Eusden thirsts no more for sack or praise;
> He sleeps among the dull of ancient days."
> *Dunciad*, bk. i. 11. 293–294.

EUSEBIUS, a name borne by many bishops and others in the early Church. The most important are:

EUSEBIUS, bishop of Vercelli (d. 371), a strong opponent of Arianism, was with St. Augustine, the first Western bishop to unite with his clergy in adopting a strict monastic life after the Eastern model (*see* Ambrose, *Ep. 63 ad Vercellenses*, s. 66). The legend that he was stoned to death by the Arians was probably invented. His three extant letters are in Migne *Patrol. Lat.* vol. 12.

EUSEBIUS, bishop of Samosata (d. 380), is first mentioned among the Homoean and Homoeusian bishops who in 363 accepted the Homousian formula at the synod of Antioch presided over by Meletius, whose views he seems to have adopted (*see* MELETIUS OF ANTIOCH). According to Theodoret (5, 4, 8) he was killed at Doliche in Syria, by a stone cast by an Arian woman. He thus became a martyr, and found a place in the Catholic calendar (*see* the article by Loofs in Herzog-Hauck, *Realencykl.*, ed. 1898, v., p. 620).

EUSEBIUS OF LAODICEA, was an Alexandrian by birth, and gained so great a reputation for his self-denial and charity that when in 262 the city was besieged by the emperor Gallienus he obtained permission to lead out the non-combatants. In Syria, he took part in the controversy against Paul of Samosata, bishop of Antioch. He became bishop of Laodicea, probably in 263, and died before 268. (*See* the article by E. Hennecke in Herzog-Hauck, v. 619.)

EUSEBIUS, bishop of Rome for four months under the emperor Maxentius, in 309 or 310. The Christians in Rome, divided on the question of the reconciliation of apostates, on which Eusebius held the milder view, brought forward a competitor, Heraclius. Both competitors were expelled by the emperor. Eusebius was buried in St. Calixtus, at Rome. The epitaph, in eight hexameter lines, set up by his successor Damascus, contains all the available information.

EUSEBIUS (OF NICOMEDIA) (d. 341?), Greek bishop and theologian, was the defender of Arius more avowedly than his namesake of Caesarea, and from him the Eusebian or middle party specially derived its name, giving him in return the epithet of Great. His first bishopric was Berytus (Beirut) in Phoenicia, but his name is especially identified with the see of Nicomedia. He wrote a letter in defence of Arius to Paulinus, bishop of Tyre, which is preserved in the *Church History* of Theodoret. He appears to have been agreed with Eusebius of Caesarea in placing Christ above all created beings, the only begotten of the Father, but in refusing to recognize him to be "of the same substance" with the Father, who is alone in essence and absolute being.

At the council of Nicaea Eusebius of Nicomedia earnestly opposed the insertion of the Homousian clause and refused to sign the anathema directed against the Arians, "because he doubted whether Arius really held what the anathema imputed to him" (Sozom. ii. 15). After the council his zeal against the Athanasians led to his temporary banishment from his see but through the influence of the emperor's sister Constantia he was promoted to the see of Nicomedia, and by her favour he was later restored to his position. He was promoted in 339 to the see of Constantinople and became the leader of the anti-Nicene party till his death (*c.* 341). (*See* ARIUS.)

EUSEBIUS OF CAESAREA (Eusebius Pamphili) (*c.* 260–*c.* 340) (bishop of Caesarea in Palestine), ecclesiastical historian, was born probably in Palestine and died as bishop of Caesarea. In early youth he became acquainted with Pamphilus, presbyter of the Church of Caesarea, and founder of a theological school there (see *Hist. Eccl.* vii. 32). He assisted him in the preparation of an apology for Origen's teaching (*Hist. Eccl.* vi. 33), the first book of which survives in the Latin of Rufinus (printed in Routh's *Reliquiae sacrae*, iv. 339 *sq.*, and in Lommatzsch's edition of Origen's Works, xxiv. p. 293 *sq.*). After the death of his friend Eusebius withdrew to Tyre, and later, while the Diocletian persecution was still raging, to Egypt, where he seems to have been imprisoned, but soon released. He became bishop of Caesarea between 313 and 315, and in 331 declined the patriarchate of Antioch. Eusebius was one of the most learned men of his age, and stood high in favour with the emperor Constantine. At the council of Nicaea (325) he led the large middle party of Moderates, and submitted the first draft of the creed afterwards adopted with important changes. Later, he yielded to the Alexandrian party, and voted for a creed which repudiated the Arian position, with which he had previously sympathized. He seems to have discovered during the council that the Alexandrians were right in claiming that Arius was carrying his subordinationism so far as to deny all real divinity to Christ. His explanation of his conduct in a letter to the Caesarean church is exceedingly interesting (*see* Socrates, *Hist. Eccl.* 1, 8). With the extreme views of the Athanasian party, however, he was never in complete sympathy for they seemed to savour of Sabellianism, which always remained his chief dread.

Eusebius's greatness rests upon his vast erudition and his sound judgment. He is best known by his *History of the Christian Church* completed in 324 or early in 325. It is the most important ecclesiastical history of ancient times, and is written in the belief that the old order of things was passing away and with the apologetic purpose of exhibiting the history of Christianity as a proof of its divine origin and efficacy.

The value of the work does not lie in its literary merit, but in the wealth of the materials which it furnishes for a knowledge of the early church. Many prominent figures of the first three centuries are known to us only from its pages. Many fragments, priceless on account of the light which they shed upon movements of far-reaching consequence, have been preserved in it alone. Eusebius sometimes misinterprets his documents and misunderstands men and movements; but usually he presents us with the material upon which to form our own judgment. His *Chronicle* (*c.* 303; later continued down to 325), contains an epitome of universal history, and chronological tables exhibiting in parallel columns the royal succession in different nations, and accom-

panied by notes marking the dates of historical events. A revised edition of the second half with a continuation down to his own day was published in Latin by St. Jerome. His *Martyrs of Palestine* is an account of martyrdoms occurring in Palestine during the years 303 to 310, of most of which Eusebius himself was an eyewitness. The *Life of Constantine* is a panegyric rather than a sober history, but contains much valuable material. Eusebius's apologetic works include the *Contra Hieroclem, Praeparatio evangelica, Demonstratio evangelica* and *Theophania*. The first is a reply to a lost work against the Christians written by Hierocles, a Roman governor and contemporary of Eusebius. The second and third are important apologetic works of the early church. The former, in fifteen books, valuable for its numerous quotations from classical literature, contends that the Christians are justified in accepting the sacred writings of the Hebrews, and in rejecting the religion and philosophy of the Greeks. The latter, in twenty books, of which only the first ten and fragments of the fifteenth are extant, endeavours to prove from the Hebrew Scriptures that the Christians are right in going beyond the Jews and adopting new principles and practices. The *Theophania,* whose subject is the manifestation of God in the incarnation of the Word, aims to give with an apologetic purpose a brief exposition of the Divine authority and influence of Christianity. Of Eusebius' dogmatic and polemic writings, we have the *Contra Marcellum* and the *De theologia ecclesiastica*. The former exposes the errors of Marcellus (bishop of Ancyra), whom Eusebius accuses of Sabellianism, the latter refutes them. We also have parts of a General Introduction (Ἡ καθόλου στοιχειώδης εἰσαγωγή), which consisted of ten books (the sixth to the ninth books and a few other fragments still extant), under the title of *Prophetical Extracts*. It contains prophetical passages from the Old Testament relating to the person and work of Christ, accompanied by explanatory notes. Of Biblical and exegetical works we have a considerable part of Eusebius' Commentaries on the Psalms and on Isaiah, which are monuments of learning, and critical acumen, though marred by the use of the allegorical method characteristic of the school of Origen; also the *Onomasticon*, a work on the place names of Scripture; and an epitome and some fragments of a work in two parts on Gospel Questions and Solutions, the first part dealing with the genealogies of Christ given in Matthew and Luke, the second with the apparent discrepancies between the various gospel accounts of the resurrection. For other important works *see* Harnack, *Alt-christliche Literaturgeschichte*.

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EUSEBIUS (OF MYNDUS), Greek Neoplatonist and pupil of Aedesius, who lived in the time of Julian. Criticizing the magical and theurgic side of Neoplatonism, he devoted himself principally to logic. Stobaeus in the *Sermones* collected a number of ethical dicta of one Eusebius, who may be identical with the Neoplatonist.

The fragments exist in Mullach's *Fragmenta Phil. Graec.*, and in Orelli's *Opuscula veter. graec. sentent. et mor.*

EUSEBIUS (OF EMESA) (d. *c.* 360), a learned ecclesiastic of the Greek church, was born at Edessa. After studying at Caesarea, Antioch and Alexandria he was offered in 339 the see of Alexandria in succession to the deposed Athanasius, but he declined. He accepted the small bishopric of Emesa (the modern Homs) in Phoenicia, but his scientific bent led his flock to accuse him of sorcery, and he had to flee to Laodicea. A reconciliation was effected, but Eusebius finally resigned his charge and lived a studious life in Antioch. His life was written by his friend George of Laodicea. The fragments of his numerous writings are in Migne, *Patrol. Graec.* vol. lxxxvi.

EUSKIRCHEN, a town of Germany, in the Prussian Rhine province, on a plateau lying to the east of the Eifel range, at the junction of railways from Cologne and Bonn and 10 m. W. of the latter. Pop. (1925) 14,549. Its industries include cloth, sugar and stocking manufactures, besides breweries, metal-ware factories and iron foundries.

EUSTACE, the name of four counts of Boulogne.

EUSTACE I., a son of Count Baldwin II., held the county from 1046 until his death in 1049.

His son, EUSTACE II. (d. 1093), count of Boulogne, was the husband of Goda, daughter of the English king Aethelred the Unready, and aunt of Edward the Confessor. Eustace paid a visit to England in 1051, and was honourably received at the Confessor's court. A brawl in which he and his servants became involved with the citizens of Dover led to a serious quarrel between the king and Earl Godwin. The latter, to whose jurisdiction the men of Dover were subject, refused to punish them. His contumacy was made the excuse for the outlawry of himself and his family. In 1066 Eustace came to England with Duke William, and fought at the battle of Hastings. In the following year, probably because he was dissatisfied with his share of the spoil, he assisted the Kentishmen in an attempt to seize Dover Castle. The conspiracy failed, and Eustace was sentenced to forfeit his English fiefs. Subsequently he was reconciled to the Conqueror, who restored a part of the confiscated lands.

Eustace died in 1093, and was succeeded by his son, EUSTACE III., who went on crusade in 1096, and died about 1125. On his death the county of Boulogne came to his daughter, Matilda, and her husband Stephen, count of Blois, afterwards king of England, and in 1150 it was given to their son, Eustace IV.

EUSTACE IV. (d. 1153) became the heir-apparent to his father's possessions by the death of an elder brother before 1135. In 1137 he did homage for Normandy to Louis VII. of France, whose sister, Constance, he subsequently married. Eustace was knighted in 1147, and in 1151 joined Louis in an abortive raid upon Normandy, which had accepted the title of the empress Matilda, and was now defended by her husband, Geoffrey of Anjou. At a council held in London on April 6, 1152 Stephen induced a small number of barons to do homage to Eustace as their future king; but the primate, Theobald, and the other bishops declined to perform the coronation ceremony on the ground that the Roman curia had declared against the claim of Eustace, whose death in 1153 opened up the possibility of a peaceful settlement between Stephen and his rival, the young Henry of Anjou.

See Sir James Ramsay, *Foundations of England,* vol. ii. (1898); J. M. Lappenberg, *History of England under the Norman Kings* (trans. B. Thorpe, 1857); and Freeman's *Hist. of the Norman Conquest* (1867–79).

EUSTATHIUS (d. *c.* 1193), archbishop of Thessalonica, Byzantine scholar and author (probably a native of Constantinople), was bishop of Myra in Lycia, before being transferred to Thessalonica in 1175. He opposed the emperor Manuel, when the latter desired an alteration in the formula of abjuration necessary for converts from Mohammedanism, and in 1185, when Thessalonica was captured by William II. of Sicily, secured

religious toleration for the conquered. His best known work is his *Commentary on the Iliad and Odyssey of Homer*, which contains valuable extracts from the scholia of other critics, whose works are lost. The commentary on the geographical epic of Dionysius Periegetes also preserves much of Stephanus of Byzantium and the lost writings of Arrian. Of his commentary on Pindar only the preface, which contains an essay on lyric poetry, a life of Pindar and an account of the Olympic games, remains. Eustathius also wrote a history of the conquest of Thessalonica by the Normans, and *The Reform of Monastic Life*.

Editions: Homer Commentary, by G. Stallbaum (1825–30); preface to Pindar Commentary, by F. W. Schneidewin (1837); Dionysius Commentary in C. W. Müller, *Geographici Graeci minores*, ii.; pentecostal hymn, in A. Mai, *Spicilegium Romanum*, v. 2 (1841). The smaller works and the *De Thessalonica* were edited (1832 and 1839) by L. F. Tafel; many will be found in Migne, *Patrol. Graeca*, cxxxv., cxxxvi. Five new speeches have been edited by W. Regel, *Fontes rerum Byzantinarum*, i. (1892). *See* J. E. Kalitsunakis, *Mittel- und Neugriechische Erklärungen bei Eustathius* (1919).

EUSTATHIUS, of Antioch, sometimes styled "the Great" (*fl.* 325), was a native of Side in Pamphylia. He was bishop of Beroea (*c.* 320), and patriarch of Antioch before the Council of Nicaea (325). In that assembly he ably opposed the Arians, though the *Allocutio ad Imperatorem* with which he has been credited is hardly genuine. His anti-Arian polemic against Eusebius of Caesarea made him unpopular among his fellow-bishops in the East, and a synod convened at Antioch in 330 passed a sentence of deposition, which was confirmed by the emperor. He was banished to Trajanopolis in Thrace, where he died, probably *c.* 337, though possibly not till 360.

Eustathius's works are in Migne's *Patrol. Graec.* vol. 18. His *Engastrimytho contra Origenem* was edited by A. Jahn in *Texte und Untersuchungen*, ii. 4. *See* H. E. Burn, *S. Eustathius of Antioch* (1926), R. V. Sellers, *Eustathius of Antioch* (Cambridge, 1928), and Loofs's article in Herzog-Hauck's *Realencyklopädie*.

EUSTATHIUS or **EUMATHIUS,** surnamed Macrembolites ("living near the long bazaar"), the last of the Greek romance writers, flourished in the second half of the 12th century A.D. His title *Protonobilissimus* shows him to have been a person of distinction, and if he is also correctly described in the mss. as chief keeper of the ecclesiastical archives, he must have been a Christian. He was the author of *The Story of Hysmine and Hysminias*, in 11 books, a tedious and inferior imitation of the *Cleitophon and Leucippe* of Achilles Tatius. There is nothing original in the plot, and the work is tasteless and often coarse. The digressions on works of art, apparently the result of personal observation, are the best part of the work. A collection of 11 *Riddles*, of which solutions were written by the grammarian Manuel Holobolos, is also attributed to Eustathius.

The best edition of both romance and riddles is by I. Hilberg (1876, who fixes the date of Eustathius between 850 and 988), with critical apparatus and prolegomena, including the solutions; of the *Riddles* alone by M. Treu (1893). On Eustathius generally, *see* J. C. Dunlop, *History of Fiction* (1888, new ed. in Bohn's *Standard Library*); K. Krumbacher, *Geschichte der byzantinischen Litteratur* (1897); E. Rohde, *Der griechische Roman* (1900). There are many translations in modern languages, of which that by P. le Bas (1825) may be recommended; there is an English version from the French by L. H. le Moine (London and Paris, 1788).

EUSTYLE, an architectural term for the intercolumnation (*q.v.*) in which the distance between the adjacent columns is two and a half times the lower diameter of the column. The Greek word (εὔστυλος) signifies well columned, and is applied because this intercolumnation was considered, in general, the best (Vitruvius, III., 3).

EUTAW SPRINGS (Battle of). The last battle fought in the field in the Southern States during the American Revolutionary War. This action took place on Sept. 8, 1781, in the vicinity of Eutawville, a small village (pop. 1920, 285) in Orangeburg county, S.C., about 55m. N.N.W. of Charleston. The village lies on high ground near the Santee river, in a region abounding in swamps, limestone cliffs and pine forests. The neighbouring Eutaw springs issue first from the foot of a hill and form a large stream of clear, cool water, but this, only a few yards away, again rushes underground to reappear about ½m. farther on. Near these springs about 2,300 Americans, under Gen. Nathaniel Greene, attacked a slightly inferior force under Col. Alexander Stewart; at first the Americans drove the British before them, but later in the day the latter took a position in a brick house and behind palisades, and from this position the Americans were unable to drive them. On the night of the 9th, however, Col. Stewart retreated toward Charleston, abandoning 1,000 stand of arms. The battle has been classed as a tactical victory for the British and a strategical victory for the Americans, terminating a campaign which left Gen. Greene in virtual possession of the Carolinas, the British thereafter confining themselves to Charleston. The Americans lost in killed and wounded 408 men (including Col. William Washington, wounded and captured); the British, 693.

EUTECTIC MIXTURE, of two substances, that mixture which has the lowest freezing point and is further distinguished by the fact that its two components crystallize out simultaneously in the proportions in which they were present in the liquid. (*See* Alloys: *Cooling Curves;* and Chemistry: *Physical: Boiling-Point* and *Freezing-Point Curves*.)

EUTHYDEMUS, a native of Magnesia, who overturned the dynasty of Diodotus of Bactria, and became king of Bactria about 230 B.C. (Polyb. xi. 34; Strabo xi. 515 wrongly makes him the first king). In 208 he was attacked by Antiochus the Great, whom he tried in vain to resist on the shores of the river Arius, the modern Herirud (Polyb. x. 49). The war lasted three years, and was on the whole fortunate for Antiochus. But he saw that he was not able to subdue Bactria and Sogdiana, and so in 206 concluded a peace with Euthydemus, through the mediation of his son Demetrius, in which he recognized him as king (Polyb. xi. 34). Soon afterwards Demetrius (*q.v.*) began the conquest of India. There exist many coins of Euthydemus; those on which he is called god are struck by the later king Agathocles. Other coins with the name Euthydemus, which show a youthful face, are presumably those of Euthydemus II., who cannot have ruled long and was probably a son of Demetrius. (Ed. M.)

EUTIN, a town of Germany, belonging to Oldenburg, situated on the Lake Eutin, 20 m. N. from Lübeck by the railway to Kiel. Pop. 6,884. Eutin was, according to tradition, founded by Count Adolf II. of Holstein. In 1155 it fell to the bishopric of Lübeck, and after many changes during the middle ages and the Thirty Years' War, it came into the possession of the house of Holstein, and hence to Prussia in 1866. It possesses a palace with a fine park. In the neighbourhood is a beautiful tract of country, rich in beech forests and fjords, known as "the Holstein Switzerland," largely frequented in summer by the Hamburgers. Furniture and paper are manufactured here.

EUTROPIUS, Roman historian. He held the office of secretary (*magister memoriae*) at Constantinople, accompanied Julian on his expedition against the Persians (363), and was alive during the reign of Valens (364–378), to whom he dedicates his history. This work (*Breviarium historiae Romanae*) is a compendium, in ten books, of Roman history from the foundation of the city to the accession of Valens. It was compiled from the best accessible authorities, and is generally impartial. As the Latin is clear and simple the work was for a long time a favourite school-book. Its independent value is small, but it sometimes fills a gap left by the more authoritative records. The *Breviarium* was enlarged and continued by Paulus Diaconus (*q.v.*); and by Landolfus Sagax (*c.* 1000).

Of the Greek translations by Capito Lycius and Paeanius, the version of the latter is extant in an almost complete state. The best edition of Eutropius is by H. Droysen (1879), containing the Greek version and the enlarged editions of Paulus Diaconus and Landolfus; smaller critical editions C. Wagener (1884), F. Rühl (1887). J. Sorn's *Der Sprachgebrauch des Historikers Eutropius* (1892) contains a systematic account of the grammar and style of the author. There are numerous English school editions and translations.

EUTYCHES (*c.* 380–*c.* 456), a presbyter and archimandrite at Constantinople, first came into notice at the council of Ephesus (431), where, as a zealous adherent of Cyril (*q.v.*) of Alexandria, he vehemently opposed the doctrine of the Nestorians (*q.v.*), and affirmed that after the union of the two natures, the human and the divine, Christ had only *one nature*, that of the incarnate Word, and that therefore His human body was essentially differ-

ent from other human bodies. In this he went beyond Cyril and the Alexandrine school generally, who took care to guard against circumscribing the true humanity of Christ. It would seem, however, that Eutyches differed from the Alexandrine school chiefly in word, for equally with them he denied that Christ's human nature was transmuted into his divine nature. His imprudent assertions led to his being accused of heresy by Domnus of Antioch and Eusebius, bishop of Dorylaeum, at a synod at Constantinople in 448 which excommunicated him; at a council held in Ephesus (449) he was reinstated in his office, and Eusebius, Domnus and Flavian, his chief opponents, were deposed, the Alexandrine doctrine of the "one nature" receiving the sanction of the church. In Oct. 451, a council (the fourth oecumenical) which met at Chalcedon (*q.v.*) declared the Ephesus synod to have been a "robber synod," its proceedings were annulled, and, in accordance with the rule of Leo, Bishop of Rome, it was declared that the two natures were united in Christ without any alteration or absorption. Eutyches died in exile, but of his later life nothing is known. In the 6th century a monk, Jacob, who united the separated divisions of the Eutychians, or Monophysites (*q.v.*), into one church, now known as the Jacobite Church of Armenia, Egypt and Ethiopia, propagated his doctrines of Eutyches.

See Mansi, *Sacr. Conc. Collectio* vi.–vii.; R. L. Ottley, *The Doctrine of the Incarnation,* ii.; A. Harnack, *Hist. of Dogma,* iv. *passim;* F. Loofs, *Dogmengeschichte* (4th ed., 1906), and the art. in Herzog-Hauck, *Realencyk.*

EUTYCHIANUS, pope from 275 to 283. His original epitaph was discovered in the catacombs (*see* Kraus, *Roma sotterranea,* p. 154 *sqq.*), but nothing more is known of him.

EUTYCHIDES, of Sicyon, Greek sculptor of the latter part of the 4th century B.C., was a pupil of Lysippus. His most noted work was a statue of "Fortune," which he made for the city of Antioch (founded 300 B.C.). The goddess, who embodied the idea of the city, was represented seated on a rock, with the river Orontes at her feet. Copies of this group have been identified in a statue in the Vatican and in several bronze and silver statuettes in various museums. The composition also occurs on Syrian coins of Tigranes (83 B.C.). Most statues of cities since erected borrow something from this work of Eutychides.

EUYUK or **EYUK** (the *eu* pronounced as in French), a small village in Asia Minor, in the Angora vilayet, 12 m. N.N.E. of Boghaz Keui (*Pteria*), built on a mound which contains some remarkable ruins of a large building—a palace or sanctuary—anterior to the Greek period and belonging to the same civilization as the ruins and rock-reliefs at Pteria. These ruins consist of a gateway and an approach enclosed by two lateral walls, 15 ft. long, from the outer end of which two walls return outwards at right angles, one to right and one to left. The gateway is flanked by two huge blocks, each carved in front into the shape of a sphinx, while on the inner face is a relief of a two-headed eagle with wings displayed. Of the approach and its returning walls only the lower courses remain: they consist of large blocks adorned with a series of bas-reliefs similar in type to those carved on the rocks of Boghaz Keui. Behind the gateway is another vestibule leading to another portal which gives entrance to the building, the lateral walls and abutments of the portal being also decorated with reliefs much worn. These reliefs belong to that pre-Greek oriental art generally called Hittite, of which there are numerous remains in the eastern half of the peninsula. They represent scenes in the ritual of the indigenous naturalistic religion which was spread, in slightly varying forms, all over Asia Minor, and consisted in the worship of the self-reproductive powers of nature, personified in the great mother-goddess (called by various names Cybele, Leto, Artemis, etc.) and the god her husband-and-son (Attis, Men, Sabazios, etc.), representing the two elements of the ultimate divine nature (*see* GREAT MOTHER OF THE GODS). Here, as in the oriental mysteries generally, the goddess is made more prominent. Where Greek influence affects the native religion, emphasis tends to be laid on the god, but the character of the religion remains everywhere ultimately the same (*see* Ramsay, *Cities and Bishoprics of Phrygia,* ch. iii.).

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EVAGORAS, son of Nicocles, king of Salamis in Cyprus, 410–374 B.C. He claimed descent from Teucer, half-brother of Ajax, son of Telamon, and his family had long been rulers of Salamis until supplanted by a Phoenician exile. He regained the throne in 410. According to Isocrates, whose panegyric must however be read with caution, Evagoras was a model ruler, whose aim was to promote the welfare of his state and of his subjects by the cultivation of Greek refinement and civilization, which had been almost obliterated in Salamis by a long period of barbarian rule. He cultivated the friendship of the Athenians, and after the defeat of Conon at Aegospotami (405 B.C.) he afforded him refuge and hospitality. For a time he also maintained friendly relations with Persia, and secured the aid of Artaxerxes II. for Athens against Sparta. He took part in the battle of Cnidus (394), in which the Spartan fleet was defeated, and for this service his statue was placed by the Athenians side by side with that of Conon in the Ceramicus. But the energy and enterprise of Evagoras soon roused the jealousy of the Great King, and relations between them became strained. From 391 they were virtually at war. Aided by the Athenians and the Egyptian Hakor (Acoris), Evagoras extended his rule over the greater part of Cyprus, crossed over to Asia Minor, took several cities in Phoenicia, and persuaded the Cilicians to revolt. After the peace of Antalcidas (387), to which he refused to agree, the Athenians withdrew their support, since by its terms they recognized the lordship of Persia over Cyprus. For ten years Evagoras carried on hostilities single-handed, except for occasional aid from Egypt. At last he was totally defeated at Citium, and compelled to flee to Salamis. Here, although closely blockaded, he managed to hold his ground, and took advantage of a quarrel between the Persian generals to conclude peace (376). Evagoras was allowed to remain nominally king of Salamis, but in reality a vassal of Persia, to which he was to pay a yearly tribute. The chronology of the last part of his reign is uncertain. In 374 he was assassinated by a eunuch from motives of private revenge.

The chief authority for the life of Evagoras is the panegyric of Isocrates addressed to his son Nicocles; *see* also Diod. Sic. xiv. 115, xv. 2–9; Xenophon, *Hellenica,* iv. 8; W. Judeich, *Kleinasiatische Studien* (Marburg, 1892).

EVAGRIUS (*c.* 536–600), surnamed SCHOLASTICUS, Church historian, was born at Epiphania in Coele-Syria. His surname shows him to have been an advocate, and it is supposed that he practised at Antioch. He was the legal adviser of Gregory, patriarch of that city, whom he successfully defended at Constantinople against certain serious charges. This brought him to the notice of the emperor Tiberius Constantine, who honoured him with the rank of quaestorian; Maurice Tiberius made him master of the rolls. Evagrius's name has been preserved by his *Ecclesiastical History* in six books, extending over the period from the third general council (that of Ephesus, 431) to the year 593. It thus continues the work of Eusebius, Socrates, Sozomen and Theodoret. Though credulous and not wholly trustworthy, it is on the whole impartial, and appears to have been compiled from original documents, from which many valuable excerpts are given. It is particularly valuable for the history of dogma during the 5th and 6th centuries. Evagrius made use of the writings of Eustathius, John of Epiphania, John Malalas, Procopius, and (possibly) Menander Protector.

The best edition of the History is that of L. Parmentier and J. Bidez (London, 1898), which contains the Scholia; it is also included in Migne's *Patrologia Graeca,* lxxxvi. There is an English translation in Bohn's *Ecclesiastical Library. See* Krumbacher, *Geschichte der byzantinischen Litteratur* (1897); F. C. Baur, *Die Epochen der kirchlichen Geschichtsschreibung* (1852); L. Jeep, *Quellenuntersuchungen zu den griechischen kirchenhistoriken* (1884).

EVANDER (Gr Εὔανδρος), represented in a late and artificial legend as an Arcadian who settled very early on the Palatine, at Rome, where he founded a town named Pallantion, after his native place. He also had a son Pallas. He instituted the Lupercalia (q.v.), in imitation of the Arcadian Lycaa, and introduced

some of the blessings of civilization, including writing. He hospitably received Hercules (*see* HERCULES) and Aeneas (q.v.). His mother was the goddess Carmentis or Carmenta. His father was Hermes. The one bit of reality in all this is the name of Carmentis (Carmenta); the rest is bad etymologies of *Palatinus* and *Lupercalia;* perhaps *Euandros* is intended to mean "strong-man," in allusion to the name Roma, identified with Gr. ῥώμη, "strength."

See Schwegler, *Römische Geschichte,* I. 350 *et seq.;* Roscher's *Lexikon,* s.v.

EVANGELICAL ALLIANCE, an association of individual Christians of different denominations formed in London in Aug. 1846, at a conference of over 900 clergymen and laymen from all parts of the world, and representing upwards of 50 sections of the Protestant Church. The idea originated in Scotland in the preceding year, and was intended "to associate and concentrate the strength of an enlightened Protestantism against the encroachments of popery and Puseyism, and to promote the interests of a scriptural Christianity," as well as to combat religious indifference. The object of the alliance, according to a resolution of the first conference, is "to enable Christians to realize in themselves and to exhibit to others that a living and everlasting union binds all true believers together in the fellowship of the Church." At the same conference the following nine points were adopted as the basis of the alliance: "Evangelical views in regard to the divine inspiration, authority and sufficiency of the Holy Scriptures; the right and duty of private judgment in the interpretation of the Holy Scriptures; the unity of the Godhead and the Trinity of persons therein; the utter depravity of human nature in consequence of the Fall; the incarnation of the Son of God, His work of atonement for sinners of mankind, and His mediatorial intercession and reign; the justification of the sinner by faith alone; the work of the Holy Spirit in the conversion and sanctification of the sinner; the immortality of the soul, the resurrection of the body, the judgment of the world by our Lord Jesus Christ, with the eternal blessedness of the righteous and the eternal punishment of the wicked; the divine institution of the Christian ministry, and the obligations and perpetuity of the ordinances of Baptism and the Lord's Supper," it being understood, however, (1) that such a summary "is not to be regarded in any formal or ecclesiastical sense as a creed or confession," and (2) that "the selection of certain tenets, with the omission of others, is not to be held as implying that the former constitute the whole body of important truth, or that the latter are unimportant." The general conferences have been occupied with the discussion of the "best methods of counteracting infidelity, Romanism and ritualism, and the desecration of the Lord's Day," and of furthering the positive objects of the alliance. The latter are sometimes stated as follows: (*a*) "the world girdled by prayer," a world-wide week of prayer being advocated; (*b*) "the maintenance of religious liberty throughout the world"; (*c*) "the relief of persecuted Christians in all parts"; (*d*) "the manifestation of the unity of all believers and the upholding of the evangelical faith."

See D. S. Schaff, article "Evangelical Alliance" in Hastings, *Encyclopaedia of Religion and Ethics;* A. J. Arnold, *History of the Evangelical Alliance* (1897); the *Annual Reports* of the British and American branches; the *Proceedings* of the various General Conferences, especially the jubilee in London (1896); and the monthly journal *Evangelical Christendom.*

EVANGELICAL CHURCH, a religious body formerly known as the Evangelical Association, founded in America at the beginning of the 19th century by Jacob Albright (1759–1808), a German Pennsylvanian, born and reared in the Lutheran Church. Converted in 1791, he began to preach the Gospel to his German-speaking compatriots in 1796 and organized classes in 1800. The new body adopted in general the Wesleyan standards of doctrine, and in a somewhat more democratic form the polity of the M.E. Church. Albright was elected bishop in 1807 and died in 1808. The first General Conference was held in 1816. The General Conference, a delegated body composed of an equal number of ministerial and lay members representing the annual conferences, is the supreme administrative, legislative and judicial body in the church and meets quadrennially. In the quadrennium between 1887 and 1891 a division took place resulting from internal controversies. The majority section continued to function as the Evangelical Association, the name adopted in 1816, and the other as the United Evangelical Church, until in 1922, at a joint General Conference in Detroit, Mich., the two bodies reunited under the name the Evangelical Church. This church (1928) has a total membership of 252,000, 2,300 ministers and 2,600 churches. It is divided into 30 annual conferences, 24 in the United States, 2 in Canada, 3 in Europe and 1 in Japan. It has important missions in China and Africa. There are two publishing houses in America, one in Harrisburg, Pa., and one in Cleveland, O. There are in the United States three colleges, two seminaries, two orphan homes, six homes for the aged and ten hospitals. In Europe it has 32,000 members, chiefly in Germany, France, Switzerland, Poland and Latvia, 2 publishing houses, 1 seminary, 4 old peoples' homes, 15 hospitals and 600 deaconess-nurses. There are seven bishops, one of whom resides in Europe. (S. P. S.)

EVANGELICAL SYNOD OF NORTH AMERICA, a Protestant church dating from Oct. 1840, and known, in its early years, as the German Evangelical Church Association of the West. It was formed under the leadership of missionaries from the mission institutes of Basle and Barmen who were engaged in pioneer work in Missouri and Illinois. The original organization was strengthened in 1858 by amalgamation with the German Evangelical Church Association of Ohio, and later by the inclusion of the German United Evangelical Synod of the East (1860), the Evangelical Synod of the North-West (1872) and the United Evangelical Synod of the East (1872). The church bases its position on the Bible as interpreted by the symbols of the Lutheran and Reformed churches so far as they are in agreement, points of difference being left to "that liberty of conscience which prevails in the Evangelical Church." The church, which has 1,197 ministers and 350,000 communicant members, is divided into districts, with officers responsible to the General Synod, which meets every four years. There are boards for home and foreign missions, the latter operating chiefly in the Central Provinces of India and in Honduras, C.A. The literature of the church is in German and English, chiefly the latter.

EVANGELICAL UNION, a religious denomination which originated in the suspension of the Rev. James Morison (1816–1893), minister of a United Secession congregation in Kilmarnock, Scotland, for certain views regarding faith, the work of the Holy Spirit in salvation, and the extent of the atonement, which were regarded by the supreme court of his Church as anti-Calvinistic and heretical. Morison was suspended by the presbytery in 1841 and thereupon definitely withdrew from the Secession Church. His father, who was minister at Bathgate, and two other ministers, being deposed not long afterwards for similar opinions, the four met at Kilmarnock on May 16, 1843 (two days before the "Disruption" of the Free Church), and, on the basis of certain doctrinal principles, formed themselves into an association under the name of the Evangelical Union, "for the purpose of countenancing, counselling and otherwise aiding one another, and also for the purpose of training up spiritual and devoted young men to carry forward the work and 'pleasure of the Lord.'" The doctrinal views of the new denomination gradually assumed a more decidedly anti-Calvinistic form, and they began also to find many sympathizers among the Congregationalists of Scotland. At last, in 1896, after prolonged negotiation, the Evangelical Union was incorporated with the Congregational Union of Scotland.

See *The Evangelical Union Annual; History of the Evangelical Union,* by F. Ferguson (Glasgow, 1876); *The Worthies of the E.U.* (1883); W. Adamson, *Life of Dr. James Morison* (1898).

EVANGELISM: *see* REVIVALS, RELIGIOUS.

EVANS, SIR ARTHUR JOHN (1851–), British archaeologist, was born at Nash Mills, Herts, July 8, 1851, the eldest son of Sir John Evans, K.C.B. (*q.v.*). Educated at Harrow, Brasenose college, Oxford, and Göttingen, he was elected fellow of Brasenose and was keeper of the Ashmolean museum at Oxford from 1884 till 1908. He travelled in Finland and Lapland in 1873–74, and from 1875 onwards studied archaeological and ethnological conditions in the Balkan States. In 1882 he was arrested by the Austrians on a charge of complicity in insurrection in Dal-

matia. In 1893 he began his investigations in Crete, which have resulted in discoveries of the utmost importance concerning the early history of Greece and the eastern Mediterranean. An account of his discovery of the pre-Phoenician script and of the excavation of the palace of Knossos is given *s.v.* (*See* ARCHAEOLOGY; CRETE.) In 1911 he was knighted. Evans held academic honours from learned societies in many European countries. He presided over the British Association in 1916 and 1919.

His chief publications are: *Cretan Pictographs and Prae-Phoenician Script* (1896); *Further Discoveries of Cretan and Aegean Script* (1898); *The Mycenaean Tree and Pillar Cult* (1901); *Scripta Minoa* (1909); *Palace of Minos I.* (2 vols., 1921, 1928); and reports on the excavations at Knossos. He also edited and supplemented E. A. Freeman's *History of Sicily*, vol. iv. (1891).

EVANS, SIR GEORGE DE LACY (1787–1870), British soldier, was born at Moig, Limerick, in 1787, and educated at Woolwich academy. He entered the army in 1806 as a volunteer, and saw service in India, in the Peninsular War, and in America. He returned to England in 1815 and took part in the Waterloo campaign as assistant quartermaster-general on Sir T. Picton's staff. He went on half-pay in 1818. He was M.P. for Rye from 1830 to 1832, and for Westminster from 1833 to 1865, except for a short interval from 1841–46. In 1835 he commanded the Spanish Legion in the Carlist War, on the side of the queen of Spain. In 1854, as lieutenant-general he commanded the 2nd Division of the Army of the East in the Crimean War, where he was wounded at the battle of the Alma and on Oct. 26 defeated a large Russian force. Pennefather took his command when he was absent on account of illness, and on his return Evans declined to take back the command, but aided Pennefather with his advice in the struggle. He was invalided home in Feb. 1855. In 1861 Evans, who had received the G.C.B., was promoted full general. He died in London on Jan. 9, 1870.

EVANS, GEORGE ESSEX (1863–1909), Australian poet, was born in London on June 18, 1863. He was educated at Haverford West grammar school, and Guernsey, and in 1881 went to Australia. In 1882 his poems began to appear in the *Queenslander* under the pseudonym of "Christophus," and he afterwards contributed to other Australian papers, *The Brisbane Courier*, the *Sydney Bulletin*, and others. In 1888 he was appointed district registrar at Toowoomba. He edited, in 1892, 1893 and 1897 an unsuccessful literary annual, *The Antipodean*, and was also employed to write reports for the Queensland Government. He founded the Toowoomba Austral Association in 1903, and wrote several commemorative odes. His poetry reflects his enthusiasm for Australian life and for the country. He died at Toowoomba on Nov. 11, 1909.

His works include *The Repentance of Magdalene Despard, and other Verses* (1891), *Loraine, and other Verses* (Melbourne, 1898); *The Sword of Pain* (Toowoomba, 1905), *The Secret Key, and other Verses* (Sydney, 1906); and *Queen of the North* (*The Times*, Aug. 7, 1909), celebrating the 50th anniversary of Queensland.

EVANS, SIR JOHN (1823–1908), English archaeologist and geologist, son of the Rev. Dr. A. B. Evans, head master of Market Bosworth grammar school, was born at Britwell Court, Bucks, on Nov. 17, 1823. He was the author of three books, standard in their respective departments: *The Coins of the Ancient Britons* (1864, repr. 1890); *The Ancient Stone Implements, Weapons and Ornaments of Great Britain* (1872, 2nd ed. 1897); and *The Ancient Bronze Implements, Weapons and Ornaments of Great Britain and Ireland* (1881). He took a leading part in the affairs of various learned societies, was president of the Numismatic Society (1872–1908) and treasurer of the Royal Society (1878–98). As president of the Society of Antiquaries he was *ex officio* a trustee of the British Museum, and subsequently he became a permanent trustee. He was created K.C.B. in 1892. He died at Berkhamsted on May 31, 1908.

EVANS, OLIVER (1755–1819), American mechanician, was born at Newport (Del.), in 1755. He was apprenticed to a wheelwright, and at the age of 22 he invented a machine for making the card-teeth used in carding wool and cotton. In 1780 he became a partner with his brothers, who were practical millers, and soon introduced various labour-saving appliances which both cheapened and improved the processes of flour-milling. Turning his attention to the steam engine, he employed steam at a relatively high pressure. The plans of his invention were sent over to England in 1787 and it is said were seen by R. Trevithick. Evans made use of his engine for driving mill machinery; and in 1803 constructed a steam-dredging machine, which also propelled itself on land. He died in New York on April 16, 1819.

EVANSTON, a beautiful residential city of Cook county, Ill., U.S.A., on Lake Michigan, adjoining Chicago on the north. It is served by the Chicago and North Western, the Chicago, Milwaukee, St. Paul and Pacific, and the Chicago, North Shore and Milwaukee railways. The population was 37,234 in 1920, of whom 6,771 were foreign-born white and 2,522 were negroes, and was estimated locally at over 63,000 in 1928. Manufactures, though relatively unimportant, are increasing and in 1925 the output amounted to $13,647,674. The assessed valuation of property subject to taxation (not including the large exempt holdings of educational institutions) was $28,480,060 in 1926. The city grew up around Northwestern university (Methodist Episcopal; incorporated 1851) which in 1855 was located on the lake shore 12m. N. of the heart of Chicago. The campus now covers 75ac.; the enrolment (including the departments in Chicago) is about 10,-000; the endowment is over $14,000,000; the Dyche stadium, on the 12ac. athletic field, accommodates 45,000 spectators. The professional schools of medicine, law and dentistry are in Chicago. Evanston is also the seat of three Methodist Episcopal theological schools: the Garrett Biblical institute (1855), the Norwegian-Danish Theological seminary (1870) and the Wesley academy and Theological seminary (organized in Galesburg in 1870); and of the National Kindergarten and Elementary college, founded in Chicago in 1886. It was the home of Frances E. Willard, and the publishing offices of the National Woman's Christian Temperance Union are here. It was chartered as a town in 1863; as a city in 1892. The population had reached 19,259 in 1900 and was almost doubled in the next 20 years. Territory has been annexed from time to time, until the area of the city is 7·57 sq. miles.

EVANSVILLE, a city of south-western Indiana, U.S.A., on the Ohio river, 200m. (by the river, though only 75m. in a beeline) below Louisville; a port of entry and the county seat of Vanderburg county. It is on Federal highway 41, and is served by river steamers and by the Big Four, the Chicago and Eastern Illinois, the Evansville and Ohio Valley, the Evansville Suburban and Newburgh, the Illinois Central, the Louisville and Nashville, the Louisville, Henderson and St. Louis and the Southern railways. The population was 85,264 in 1920 (89% native white), and was estimated by the Census Bureau at 96,600 in 1927.

The city occupies 9·5 sq.m. of land around a sharp bend of the river, partly low and partly hilly and rugged. It is the seat of the Southern Indiana hospital for the insane, a United States Marine hospital, and Evansville college (Methodist), which was chartered in 1919 to succeed a college founded in 1856 at Moores Hill, Ind. The assessed valuation of property in 1927 was $132,856,810. The surrounding country is a rich agricultural and coal-producing region. There are two coal mines within the city limits and 150 within a radius of 50 miles. Because of this environment and its exceptional transportation facilities by land and by water, Evansville is the principal distributing point and manufacturing centre of southern Indiana. It is one of the leading hardwood lumber markets of the country and has an extensive shipping business in corn, wheat, pork and tobacco. The output of its factories in 1925 was valued at $67,467,886. Among the principal manufactures are auto trucks, auto bodies, electric and gas refrigerators, steam shovels, gas engines, agricultural implements, tools, electric headlights, glass bottles, infant foods, grain products, brick and furniture. Bank debits in 1926 amounted to $492,327,000. A city-plan commission was created under the permissive State legislation of 1921. Evansville was settled about 1812; laid out in 1817 and named after Robert Morgan Evans (1783–1844), one of the founders, who was an officer in the War of 1812. It soon became a thriving commercial town, with a large river trade; was incorporated in 1819 and chartered as a city in 1847. In 1850 its population was 3,235. The completion in 1853 of the Wabash and Erie canal from Evansville to Toledo (400m.) gave it a great

stimulus, and by 1860 the population had grown to 11,484. In the next 20 years it increased 155%; between 1880 and 1900, over 100%; and between 1900 and 1920, 44%.

EVAPORATION, in the chemical industry, consists in converting a liquid into a vapour in order to remove it from solids dissolved in it. While in some instances this can be done in open kettles, it is customary to use closed units called *evaporators,* which may be single, duplex, triple or quadruple in assembly. When so grouped, they are known as "effects." Thus, a "triple effect" evaporator is common in the sugar industry, being used to concentrate syrup by the removal of water. Evaporators enable work to be done under partial vacuum, which both increases the quantity of water that can be eliminated per pound of fuel used and also permits lower temperatures to be employed, the latter being important in handling some types of material. By maintaining a higher vacuum on each succeeding effect, the hot vapours from the preceding may be used to assist in heating the next effect in the series. Evaporators are of many types as to material employed in construction, means for increasing circulation of the liquid being evaporated and means for discharging crystals drawn out of solution. The size is also variable, one of the largest in operation being some 30 ft. in diameter.

Some evaporators are continuous and others operate on the batch system. The "sugar pan" of the refinery, a single, large evaporator, is usually of the batch type, and in it the "sugar boiler" manipulates syrups of various concentrations to produce crystals of the desired size in the final stages of concentrating sugar from syrups of various origins.

EVARISTUS, fourth pope (*c.* 98–105), was the immediate successor of Clement.

EVARTS, WILLIAM MAXWELL (1818–1901), American lawyer, was born in Boston (Mass.), Feb. 6, 1818. He graduated from Yale in 1837, attended Harvard Law school in 1839, was admitted to the bar in New York in 1841, and soon took high rank in his profession. In 1860 he was chairman of the New York delegation to the Republican national convention. He was chief counsel for President Johnson during the impeachment trial, and from July 1868 until March 1869 he was attorney-general of the United States. In 1872 he was counsel for the United States in the "Alabama" arbitration. During President Hayes' administration (1877–81) he was secretary of State; and from 1885 to 1891 he was one of the senators from New York. He died in New York on Feb. 28, 1901.

EVE is the name given in the early Yahwist narratives of the Creation and the Fall to the wife of the first man (Heb. *ḥawwah,* meaning uncertain = life, clan, or snake). The story goes that Yahweh, finding his man dissatisfied with the merely vegetable world in whose midst he lived, determined to create a suitable companion for him. His first attempt was made along the lines which had produced the man; *i.e.,* he modelled clay into various shapes, brought them to life, and introduced them to the man. At the sight of each creature as it came before him, the man uttered an exclamation, which became the creature's name, but the exclamations showed that none of the experiments was successful in providing what the man most needed. Another method was then adopted. Throwing the man into a hypnotic and anaesthetic slumber, Yahweh took from him a rib (carefully mending again the spot whence it was taken) and built this into a woman. The man's exclamation on seeing her proved the success of the method, and the narrator adds a comment explaining that this event is the origin of marriage (Gen. ii. 18–24). In Gen. iii. it is the woman who is more exposed than the man to the wiles of the serpent, and she falls into sin, dragging her husband with her. Her punishment lies in sexual attractions and subjection, and in the pains of childbirth. After the notice of the birth of her children (Gen. iv. 1, 2, 25) there is no further allusion to Eve in the Old Testament.

In post-biblical Jewish literature Eve is not infrequently mentioned. There is a reference in the Book of Tobit (viii. 6, 7), and there are new details in the Book of Jubilees (ch. iii.), while the Targum of Jonathan and Philo both add to the story. In the New Testament the comment in Gen. ii. 24 is cited as illustrating the true nature of marriage, and there are references in 2 Cor. xi. 3 and 1 Tim. ii. 13. In Christian theology the narratives are used chiefly in connection with the doctrines of Man and of Sin. (*See* ADAM.)

EVECTION (Latin for "carrying away"), in astronomy, the largest inequality produced by the action of the sun in the monthly revolution of the moon around the earth. The deviation expressed by it has a maximum amount of about 1° 15′ in either direction. It was discovered by Hipparchus about 150 B.C.

EVELETH, a city of St. Louis county, Minnesota, U.S.A., 61m. N.N.W. of Duluth; served by the Duluth and Iron Range and the Duluth, Missabe and Northern railways. The population was 7,205 in 1920 (37% foreign-born white) and was estimated locally at 9,000 in 1928. It is one of the iron-mining cities of the Mesabi range, which here makes a great bend, so that there are deposits south, south-west, west and north-west of the city. It has fine public schools, and a community recreation building with dance-hall and seating space for 4,000, a kitchen and dining-room, and a curling rink. Iron ore was discovered here in Oct. 1892, by David T. Adams, and the first shipment (5,600 tons) was made about two years later. Total shipments to 1927 amounted to 87,954,165 tons. In the early years underground mining prevailed. Later the open-pit system was extensively used, and over 42,000,000cu.yd. of material have been removed in stripping operations; but with the exhaustion of deposits near the surface the trend again turned to underground shafts. Eveleth was laid out in 1893, and was named after Erwin Eveleth, who visited the site in 1885, while exploring the timber resources of the region. In 1899–1900 practically the entire village was moved, as the original site was found to be underlain with ore. The first mine office, a log-house, has been preserved. The city was incorporated in 1902.

EVELYN, JOHN (1620–1706), English diarist, was born at Wotton House, near Dorking, Surrey, the younger son of Richard Evelyn, a large landowner. When John Evelyn was five years old he went to live with his mother's parents at Cliffe, near Lewes. He refused to leave his "too indulgent" grandmother for Eton, and when on her husband's death she married again, the boy went with her to Southover, where he attended the free school of the place. He was admitted to the Middle Temple in Feb. 1637, and in May he became a fellow commoner of Balliol college, Oxford. He left the university without taking a degree, and in 1640 was residing in the Middle Temple. In that year his father died, and in July 1641 he crossed to Holland. He was enrolled as a volunteer in Apsley's company, then encamped before Genep on the Waal, but his commission was apparently complimentary, his military experience being limited to six days of camp life, during which, however, he took his turn at "trailing a pike." He returned in the autumn to find England on the verge of civil war. Evelyn's part in the conflict is best told in his own words:—

> 12th November was the battle of Brentford, surprisingly fought. . . . I came in with my horse and arms just at the retreat; but was not permitted to stay longer than the 15th by reason of the army marching to Gloucester; which would have left both me and my brothers exposed to ruin, without any advantage to his Majesty . . . and on the 10th [December] returned to Wotton, nobody knowing of my having been in his Majesty's army.

At Wotton he employed himself in improving his brother's property, making a fishpond, an island and other alterations in the gardens. But he found it difficult to avoid taking a side; he was importuned to sign the Covenant, and obtained leave from the king in Oct. 1643 to travel abroad. From this date his *Diary* becomes full and interesting. He travelled in France and visited the cities of Italy, returning in the autumn of 1646 to Paris, where he became intimate with Sir Richard Browne, the English resident at the court of France. In June of the following year he married Browne's daughter and heiress, Mary, then a child of not more than 12 years of age. Leaving his wife in the care of her parents, he returned to England to settle his affairs. He visited Charles I. at Hampton Court in 1647, and during the next two years maintained a cipher correspondence with his father-in-law in the royal interest. In 1649 he obtained a pass to return to Paris, but in 1650 paid a short visit to England. The defeat of Charles II. at Worcester in 1651 convinced him that the royalist cause was

hopeless, and he decided to return to England. He went in 1652 to Sayes Court at Deptford, a house which Sir Richard Browne had held on a lease from the Crown. This had been seized by the parliament, but Evelyn was able to compound with the occupiers for £3,500, and after the Restoration his possession was secured. Here his wife joined him, their eldest son, Richard, being born in Aug. 1652. Under the Commonwealth Evelyn amused himself with his favourite occupation of gardening, and made many friends among the scientific inquirers of the time. He was one of the promoters of the scheme for the Royal Society, and in the king's charter in 1662 was nominated a member of its directing council. Evelyn was secretary of the Society in 1672, and as an enthusiastic promoter of its interests was twice (in 1682 and 1691) offered the presidency. Through his influence Henry Howard, duke of Norfolk, was induced to present the Arundel marbles to the University of Oxford (1667) and the valuable Arundel library to Gresham college (1678).

Meanwhile he had refused employment from the Government of the Commonwealth, and had maintained a cipher correspondence with Charles. In 1659 he published an *Apology for the Royal Party*, and in December of that year he vainly tried to persuade Colonel Herbert Morley, then lieutenant of the Tower, to forestall General Monk by declaring for the king. From the Restoration onwards Evelyn enjoyed unbroken court favour till his death in 1706; but he never held any important political office, although he filled many minor posts. He was commissioner for improving the streets and buildings of London, for examining into the affairs of charitable foundations, commissioner of the Mint, and of foreign plantations. In 1664 he accepted the responsibility for the care of the sick and wounded and the prisoners in the Dutch war. He stuck to his post throughout the plague year, contenting himself with sending his family away to Wotton. He found it impossible to secure sufficient money for the proper discharge of his functions, and in 1688 he was still petitioning for payment of his accounts in this business. In the reign of James II., during the earl of Clarendon's absence in Ireland, he acted as one of the commissioners of the privy seal. He was seriously alarmed by the king's attacks on the English Church, and refused on two occasions to license the illegal sale of Roman Catholic literature. He concurred in the revolution of 1688, in 1695 was entrusted with the office of treasurer of Greenwich hospital for old sailors, and laid the first stone of the new building on June 30, 1696. In 1694 he left Sayes Court to live at Wotton with his brother, whose heir he had become, and whom he actually succeeded in 1699. He spent the rest of his life there, dying on Feb. 27, 1706. Evelyn's house at Sayes Court had been let to Captain, afterwards Admiral John Benbow, who was not a "polite" tenant. He sublet it to Peter the Great, who was then visiting the dockyard at Deptford. The tsar did great damage to Evelyn's beautiful gardens, and, it is said, made it one of his amusements to ride in a wheelbarrow along a thick holly hedge planted especially by the owner. The house was subsequently used as a workhouse, and is now almshouses, the grounds having been converted into public gardens by Mr. Evelyn in 1886.

It will be seen that Evelyn's politics were not of the heroic order. But he was honourable and consistent in his adherence to the monarchical principle throughout his life. With the court of Charles II. he could have had no sympathy, his dignified domestic life and his serious attention to religion standing in the strongest contrast with the profligacy of the royal surroundings. But he made no enemies, and the king himself seems to have liked him. His *Diary* is therefore a valuable chronicle of contemporary events from the standpoint of a moderate politician and a devout adherent of the Church of England. He had none of Pepys's love of gossip, and was devoid of his all-embracing curiosity, as of his diverting frankness of self-revelation. Both were admirable civil servants, and they had a mutual admiration for each other's sterling qualities. Evelyn's *Diary* covers more than half a century (1640–1706) crowded with remarkable events, while Pepys only deals with a few years of Charles II.'s reign.

Evelyn was a generous art patron, and Grinling Gibbons was introduced by him to the notice of Charles II. His domestic affections were very strong. He had six sons, of whom John (1655–99), the author of some translations, alone reached manhood. He has left a pathetic account of the extraordinary accomplishments of his son Richard, who died before he was six years old, and of a daughter Mary, who lived to be 20 and probably wrote most of her father's *Mundus muliebris* (1690). Of his two other daughters, Susannah, who married William Draper of Addiscombe, Surrey, survived him.

Evelyn's *Diary* remained in ms. until 1818. It is in a quarto volume containing 700 pages, covering the years between 1641 and 1697, and is continued in a smaller book which brings the narrative down to within three weeks of its author's death. A selection from this was edited by William Bray, with the permission of the Evelyn family, in 1818, under the title of *Memoirs illustrative of the Life and Writings of John Evelyn, comprising his Diary from 1641 to 1705/6, and a Selection of his Familiar Letters*. Other editions followed, the most notable being those of Mr. H. B. Wheatley (1879) and Mr. Austin Dobson (3 vols., 1906). Evelyn's active mind produced many other works, and although these have been overshadowed by the famous *Diary* they are of considerable interest. They include: *Of Liberty and Servitude* . . . (1649), a translation from the French of François de la Mothe le Vayer, Evelyn's own copy of which contains a note that he was "like to be call'd in question by the Rebells for this booke"; *The State of France, as it stood in the IXth year of . . . Louis XIII.* (1652); *An Essay on the First Book of T. Lucretius Carus de Rerum Natura. Interpreted and made English verse by J. Evelyn* (1656); *The Golden Book of St. John Chrysostom, concerning the Education of Children. Translated out of the Greek by J. E.* (printed 1658, dated 1659); *The French Gardener: instructing how to cultivate all sorts of Fruit-trees* . . . (1658), translated from the French of N. de Bonnefons; *A Character of England* . . . (1659), describing the customs of the country as they would appear to a foreign observer, reprinted in *Somers' Tracts* (ed. Scott, 1812), and in the *Harleian Miscellany* (ed. Park, 1813); *The Late News from Brussels unmasked* . . . (1660), in answer to a libellous pamphlet on Charles I. by Marchmont Needham; *Fumifugium, or the inconvenience of the Aer and Smoak of London dissipated* (1661), in which he suggested that sweet-smelling trees should be planted in London to purify the air; *Instructions concerning erecting of a Library* . . . (1661), from the French of Gabriel Naudé; *Tyrannus or the Mode, in a Discourse of Sumptuary Laws* (1661); *Sculptura: or the History and Art of Chalcography and Engraving in Copper* . . . (1662); *Sylva, or a Discourse of Forest Trees . . . to which is annexed Pomona . . . Also Kalendarium Hortense* . . . (1664); *A Parallel of the Ancient Architecture with the Modern* . . . (1664), from the French of Roland Fréart; *The History of the three late famous Imposters, viz. Padre Ottomano, Mahomed Bei, and Sabatei Sevi* . . . (1669); *Navigation and Commerce . . . in which his Majesties title to the Dominion of the Sea is asserted against the Novel and later Pretenders* (1674), which is a preface to a projected history of the Dutch wars undertaken at the request of Charles II., but countermanded on the conclusion of peace; *A Philosophical Discourse of Earth* . . . (1676), a treatise on horticulture, better known by its later title of *Terra; The Compleat Gardener* . . . (1693), from the French of J. de la Quintinie; *Numismata* . . . (1697). Some of these were reprinted in *The Miscellaneous Writings of John Evelyn*, edited (1825) by William Upcott. Evelyn's friendship with Mary Blagge, afterwards Mrs. Godolphin, is recorded in the diary, when he says he designed "to consecrate her worthy life to posterity." This he effectually did in a little masterpiece of religious biography which remained in ms. in the possession of the Harcourt family until it was edited by Samuel Wilberforce, bishop of Oxford, as the *Life of Mrs. Godolphin* (1847), reprinted in the "King's Classics" (1904). The picture of Mistress Blagge's saintly life at court is heightened in interest when read in connexion with the scandalous memoirs of the comte de Gramont, or contemporary political satires on the court. Numerous other papers and letters of Evelyn on scientific subjects and matters of public interest are preserved, a collection of private and official letters and papers

(1642–1712) by, or addressed to, Sir Richard Browne and his son-in-law being in the British Museum (*Add. mss.* 15857 and 15858).

Next to the *Diary* Evelyn's most valuable work is *Sylva.* By the glass factories and iron furnaces the country was being rapidly depleted of wood, while no attempt was being made to replace the damage by planting. Evelyn put in a plea for afforestation, and besides producing a valuable work on arboriculture, he was able to assert in his preface to the king that he had really induced landowners to plant many millions of trees.

See *Handlist of works of John Evelyn and books connected with him* (1916) and, for his life, the introduction to Austin Dobson's edition of the *Diary* (1906); *Early Life and Education of John Evelyn* (Oxford Historical and Literary Studies, vol. 11, 1920).

EVERDINGEN, ALLART VAN (1621–?1675), Dutch painter and engraver, studied under Peter de Molyn at Haarlem and settled about 1657 at Amsterdam, where he remained till his death. Everdingen realized the large and effective system of coloured and powerfully shaded landscape which marks the precursors of Rembrandt. It is still an open question when de Molyn wielded influence on his clever disciple. We find Allart at first a painter of coast scenery. But on one of his expeditions he is said to have been cast ashore in Norway, and during the repairs of his ship he visited the inland valleys and thus gave a new course to his art. In early pieces he represents the sea in motion under varied, but mostly clouded, aspects of sky. Their general intonation is strong and brown and effects are rendered in a powerful key, but the execution is much more uniform than that of Jacob Ruysdael. A dark scud lowering on a rolling sea near the walls of Flushing characterizes Everdingen's "Mouth of the Schelde," in the Hermitage at Leningrad. Storm is the marked feature of sea-pieces in the Staedel or Robartes collections; and a strand with wreckers at the foot of a cliff, in the Munich Pinakothek, may be a reminiscence of personal adventure in Norway. But the Norwegian coast was studied in calms as well as in gales; and a fine canvas at Munich shows fishermen on a still and sunny day taking herrings to a smoking hut at the foot of a Norwegian crag. Everdingen was a precursor of Jacob Ruysdael in a certain form of landscape composition; but though very skilful in arrangement and clever in effects, Everdingen remains much more simple in execution; he is much less subtle in feeling or varied in touch than his great and incomparable countryman. Five of Everdingen's cascades are in the museum of Copenhagen alone; of these, one is dated 1647, another 1649. In the Hermitage at Leningrad is a fine example of 1647; another in the Pinakothek at Munich was finished in 1656. Of his etchings and drawings there are much larger and more numerous specimens in England than elsewhere. He died in Amsterdam and his collection of pictures was sold on March 11, 1676.

His two brothers, JAN and CAESAR, were both painters. CAESAR (1606–79) was mainly known as a portrait painter.

EVEREST, SIR GEORGE (1790–1866), British surveyor and geographer, was born at Gwerndale, Brecknockshire, on July 4, 1790, and educated at Marlow. He then went to Woolwich. He went to India as a cadet in 1806, and took part in the reconnaissance of Java (1814–16). From then to his retirement in 1843 he was employed on surveys in India. For the rest of his life he lived in England, was knighted in 1861, and died at Greenwich on Dec. 1, 1866. His geodetical work ranks among the finest of its kind; his measurement of the meridional arc of India, $11\frac{1}{2}°$ in length, is accounted as unrivalled in the records of the science. In great part the Indian survey is what he made it. Mount Everest is named after him.

EVEREST, MOUNT, the highest mountain in the world. It is a peak of the Himalayas situated in Nepal almost precisely on the intersection of the meridian 87 E. long. with the parallel 28 N. lat. Its elevation as at present determined by trigonometrical observation is approximately 29,140 ft. The peak has been called Everest after Sir George Everest (*q.v.*), who completed the trigonometrical survey of the Himalayas in 1841 and first fixed its position and altitude. *See* MOUNTAINEERING.

(X.)

ASCENT OF MOUNT EVEREST

A description of the attempts to climb Mt. Everest may be divided under three headings: the reconnaissance expedition of 1921; the first attempt, in 1922, and the second, in 1924.

Previous attempts had been made to obtain permission to travel in that part of Tibet and to explore and attempt to climb Mt. Everest, but only the expeditions of 1921, 1922, and 1924 are dealt with here. The extraordinary advance in the relations between Tibet and the outside world made it possible in 1920 to approach the Tibetan Government with every hope of success in obtaining from them permission to approach the mountain and explore its surroundings. As a preliminary, Col. Howard-Bury, in 1920, visited Phari Dzong. His negotiations were successful and in the winter of that year the first expedition was organized to reconnoitre and explore all the approaches to the great group and to make preliminary climbs on the mountain to ascertain the conditions and favourable points of attack.

THE RECONNAISSANCE EXPEDITION OF 1921

This preliminary expedition carried out its work in the most complete manner the following summer. Routes to Everest, through the district of Shekar and Kharta Sheka, were thoroughly explored and mapped. The approaches to Mt. Everest on all its northern faces were thoroughly examined. Relations were established with all the local authorities. This expedition was excellently constituted for the work in hand. Under the leadership of Lt.-Col. C. K. Howard-Bury, D.S.O., the climbing party consisted of C. H. Bullock, Dr. A. M. Kellas, G. L. Mallory, and Harold Raeburn. Maj. H. T. Morshead, D.S.O., and Maj. O. E. Wheeler, M.C., went as surveyors and Dr. A. M. Heron as geologist. A. F. R. Wollaston, D.S.C., was doctor, naturalist, and botanist. Among them was one mountaineer and scientist whose name stands out pre-eminently in the exploration of the Himalaya—Dr. Kellas, who, unfortunately, died during the march through Tibet.

The Rongbuk Valley.—The first object was to explore the Rongbuk valley beyond the Rongbuk monastery. From there the mountaineering party pushed up the west Rongbuk glacier, which descends directly from the northern faces of Mt. Everest, but failed to find the true approach to the mountain up the narrow mouth of the east Rongbuk glacier. This glacier was later on in the year surveyed by Wheeler and the true approach was established. Later, the expedition crossed over to the low-lying country to the east of Mt. Everest at Kharta Sheka.

From there a pass was found named the Lhakpa La, 22,000ft., which led to the head of the east Rongbuk glacier. From this point the mountaineering members of the party were able to trace the most likely line of attack on the mountain and actually mounted by difficult snow and ice slopes to a col on the main north ridge, descending from Everest, which they named the Chang La or North Col. By this time the season was late, the weather was breaking and no more work could be effected. The reconnaissance expedition had collected an immense amount of information and had mapped the country to the north of Everest.

THE ATTEMPT OF 1922

On the information and experience of the reconnaissance expedition the second expedition to Everest was organized, which was to complete the exploration of the group and to carry out the ascent of the great mountain. Brig.-Gen. the Hon. C. G. Bruce, C.B.,M.V.O., was in command, with Col. E. L. Strutt as second-in-command. The climbing party consisted of Mr. G. L. Mallory, Maj. E. F. Norton, D.S.O., R.A., Dr. T. H. Somervell, Dr. A. W. Wakefield, and Capt. G. I. Finch, who was oxygen officer to this party. Dr. T. G. Longstaff was doctor and naturalist. Mr. C. G. Crawford, I.C.S., Capt. J. G. Bruce, M.C., and Capt. C. J. Morris were the transport officers. Maj. H. T. Morshead, D.S.O., was surveyor, and Capt. J. B. L. Noel photographer.

Choice of Season.—It had been found necessary to make the attempt early in the year, as giving a better chance of good weather and of finding the snowy conditions on the mountain more favourable to an assault; but this early start also carried with it a great deal more exposure and fatigue on the journey

from Darjeeling to Everest; for on this route the passes cut off the southern Himalaya from the north and several high and exposed ridges have to be crossed. Naturally, too, the outfit was much greater, and for the first time in the exploration of the mountains experiments were to be made in the artificial administration of oxygen as an assistance in counteracting the effects of low atmospheric pressure. By the end of April 1922 the expedition was collected in the Rongbuk valley and the base camp established within two miles of the snout of the west Rongbuk glacier. A vast amount of stores of all descriptions had been transported to this spot, employing some 350 transport animals.

The Transport Problem.—It is necessary at this point to explain how great is the problem of attacking such a mountain as Everest. It differs from an ordinary mountaineering expedition in that many of the methods necessary for polar exploration must be put in force. A large number of first-class porters are required. For them special clothing and food are necessary, which greatly adds to the difficulties of supply. The expedition drew its porters mainly from subjects of Nepal, belonging to a tribe known as Sherpas. They are true Tibetans, who for many generations have settled on the southern slope of the Himalaya. They live in a steeper and slightly less elevated country than Tibet and are thoroughly suitable for the work; but among them there were also certain true Tibetans of Tibet. These men proved a great success through all the expeditions.

Importance of the Monsoon.—But the real problem is the race with the monsoon. The period from May 1 to early June is the only suitable time for the attack on the mountain, and even this is dominated by the approach of the monsoon. Up to the arrival of the south-west monsoon all the northern slopes of the Himalaya are swept by an intensely dry and cold wind. While these conditions continue the mountains are safe, if human beings can endure the terrible cold, fatigue and low atmospheric pressure. When once the humid and warm south-west monsoon is established the mountains are unapproachable, snows thaw, avalanches fall, and progress is made impossible. Hence great exertion has to be made in a short time.

Camps Established.—Up the east Rongbuk glacier camps were established from the base camp at 16,500ft. above sea-level to camp 3, three stages higher up, which was placed near the foot of the slopes leading to the Chang La or North Col. At camp 3 the advanced base of the expedition was established, at a height of 21,000ft., and here were accumulated stores of every description for the attack on the mountain. From here a high camp was successfully established in good weather on the North Col. From this camp the first attempt without the assistance of oxygen was made.

First Assault on the Mountain.—The four members of the party who were chosen for this effort, Norton, Somervell, Mallory and Morshead, set out from the North Col. With great difficulty they established a camp at about 25,000ft. on the sheltered side of the great north ridge which descends from Everest. This camp was carried up for them and pitched by the special Sherpa porters. It is worthy of note that until this expedition only once in the whole history of mountain exploration has a camp been pitched as high as 23,000ft., the height of the Chang La, and that was only for one night. The camp referred to was that of Meade's expedition on Kamet in Garhwal. This camp at 25,000ft. was occupied on May 19. The following morning three of the climbers, Somervell, Norton and Mallory, continued their attempt on Everest, Morshead having to be left behind as he was suffering from frost-bite and exhaustion. The climbing party pushed on under trying conditions of wind and weather until they attained the height of 26,985ft., the highest point reached by human beings up to that time. Here time and strength gave out, and a retreat was made. The descent was most toilsome, but finally the camp at 25,000ft. was reached, and Morshead, now worse, had to be conducted back from this point in bad weather to the North Col. In traversing back from the gite on the face of the mountain, an accident nearly occurred from a slip; but after a dramatic and exciting incident the laborious descent was continued, and finally, completely worn out, they reached the camp on the North Col at midnight. Everyone was more or less frost-bitten, Morshead severely.

First Attempt with Oxygen.—Later, on May 25, a second attempt was made by Finch and J. G. Bruce, using the oxygen apparatus from as low down as camp 3. They were accompanied by Naik Tejbir Bura, a young Gurkha non-commissioned officer who belonged to Capt. Bruce's regiment, the 6th Gurkha Rifles. This party followed in the footsteps of the previous one, camping, however, some 500ft. higher, at a height of 25,500ft. on the main ridge itself, their porters thus surpassing the efforts of the previous party. The porters returned to the North Col, but the climbing party were caught that night in a furious hurricane and were camp-bound for two nights and a day. The morning of the second day, the weather having calmed, they set out, using the full oxygen apparatus and employing the Gurkha non-commissioned officer to carry spare oxygen bottles. On reaching the height of 26,000ft. this young man could proceed no farther. The two mountaineers continued alone from this point and reached a height of some 27,300ft. Their return journey, still using oxygen and picking up reserve oxygen supplies on the way down, was in great contrast to the terrible experiences of the first party. They not only descended the mountain at good speed, but continued from the North Col or Chang La directly down to the advanced base at camp 3. The expedition then returned to the base camp for rest, all members of the party being greatly exhausted. From here certain members of the expedition, including Morshead, were too ill to stay on, and returned to India.

Third Assault.—A third attempt was organized, and the party left on June 3, consisting of Finch, Mallory, Somervell, Crawford, and Wakefield. Finch soon had to turn back and join the homing party. The remainder again camped at the advanced base, and on the morning of June 7, attempted to reach the North Col; but unfortunately they had been overtaken three days before by bad weather and heavy snow, and following the route formerly used to the North Col, they were obliged to traverse snow slopes rendered extremely dangerous by the accumulation of fresh snow. They were caught in a great avalanche, which swept down the face of the mountain side and carried down the whole of the party of 17, roped in groups of four and five. Two of these groups, one of four and one of five men, were swept over an ice cliff some 60ft. high, and only two out of the nine men thus carried away were saved. The leading rope consisting of three climbers, Crawford, Mallory and Somervell, was carried down for some 150ft. by the avalanche and stopped unharmed well above the danger point. This third attempt ended the expedition of 1922, which had added immensely to the knowledge of the possibilities of further acclimatization at high altitudes.

THE ATTEMPT OF 1924

The 1924 expedition consisted of Brig.-Gen. the Hon. C. G. Bruce, C.B., M.V.O., in command, and of Lt.-Col. E. F. Norton, D.S.O., R.A., second-in-command. The climbing party consisted of Capt. J. G. Bruce, M.C., Messrs. Bentley Beetham, J. de V. Hazard, A. C. Irvine, G. L. Mallory, N. E. Odell and Dr. T. H. Somervell. Mr. E. O. Shebbeare was transport officer, Maj. R. W. G. Hingston, M.C., I.M.S., doctor and naturalist, and Capt. J. B. L. Noel was again photographer. Leaving Darjeeling at about the same time as before, it arrived a few days earlier at the same base camp at Rongbuk. Its transport had been improved and increased. Unfortunately, during the march up, Gen. Bruce was obliged to return to India owing to illness.

Bad Weather at Base Camp.—On arrival at the base camp, every effort was made to establish a line of intermediate camps between the base camp and camp 3 with the greatest possible rapidity; but the expedition was overtaken by hurricane after hurricane during the month of May, at a time when fair weather is ordinarily to be expected. The temperatures experienced were very much lower than in 1922, and it was very soon discovered that a low temperature, high wind, hard work, and a low atmospheric pressure together are enough to wear out the very strongest constitution in a very short period. So for some three weeks the expedition struggled in a continuous battle to establish

not only the camps on the line of communication but also the alpine base on the summit of the North Col. This terrible fight against the elements, occasioning several returns for recuperation to the base camp, not only delayed the expedition very much indeed but reduced their strength and that reserve of power which is necessary for the final great assault—the great test of all; nor at high altitudes can that lost strength ever be adequately regained.

New Route to North Col.—The route that it was necessary to utilize between camp 3 at 21,000ft. and the North Col camp at 23,000ft. was far steeper and more difficult than that of 1922; but it had the advantage of being safe from the avalanches which render the easier slopes of the 1922 route most dangerous after such weather as was experienced in this season. But it was on this route that another accident almost occurred. After the new difficult route to the North Col had been forced by Norton, Hazard led the first party of porters and established the camp on May 22. On the following day, on his descent from the North Col camp to camp 3 in bad weather, it was discovered that four porters had remained actually on the North Col itself. A hurricane that night and the following day prevented communication with them, but on the day succeeding, Norton, Somervell and Mallory formed a rescue party to extricate these men from their dangerous position. This they successfully accomplished after a most dramatic incident, two of the porters, when crossing a dangerous face, slipping down and being brought up at the edge of an ice cliff. From this position they were rescued after heroic efforts. It was a most brilliant performance, but all members of the party were now terribly worn by exposure to wind and low temperatures, $-23°$ being registered even at camp 3. After this the expedition retired to the base camp for a complete rest.

The climbers and porters alike were completely worn out. Norton led them down to the monastery at the mouth of the Rongbuk valley, presided over by a remarkable Lama, a man in whom every Buddhist member of the party placed absolute faith. Here a service was held, the Lama blessed and encouraged the men, and then, when morale was re-established, Norton led the whole expedition back again to the advanced base camp 3. Hopes were now raised by the splendour of the weather. With reorganized plans, on June 1 camp 4 was re-established on a larger scale than ever, and from this camp the climbing party started the real assault on the mountain. There were few porters left who were fit to make such an immense effort as was required of them, and therefore several attempts were made by parties of two climbers, assisted by whatever porters were available. Mallory and J. G. Bruce pitched camp 5 at 25,000ft., but owing to the exhaustion of their porters were obliged to return.

They were followed on June 3 by Norton and Somervell, who, passing them, actually pitched a camp at 26,800ft. elevation, three men having been found fit enough to carry loads without the assistance of oxygen to this great height. From this point, with the greatest pain and trouble, Somervell and Norton reached a height on the following day of 28,200ft.; they again descended to the North Col. Somervell had been working under disadvantageous conditions, suffering terribly from a high altitude throat. So parched does one's throat become in this intensely cold and dry air that it forms more than an inconvenience, even a danger. Norton had been fit and well, but the following morning awoke suffering from snow blindness. An unforgettable episode occurred when, quite blind, he was taken down that steep and difficult descent by Hingston and Hazard.

The Last Attempt.—There was still one more attempt to be made by Mallory and Irvine. There had been defects in the oxygen apparatus and but little oxygen was available. They were assisted by a supporting party consisting of Odell and Hazard. On June 6 they left the 25,000ft. camp with three porters, who again carried loads for them to 27,000 feet. On June 8 they left camp 6 for their attempt. Odell on that morning arrived alone at this highest camp, to watch their progress and report on it, and to take such steps for their comfort as were considered necessary. He caught a glimpse of the climbers for a few moments high up on the mountainside; the mists blew across and he saw them no more. Returning to camp 4 he awaited their return; but on the following morning, seeing no sign of them, he searched the mountainside without effect. On June 10, for the third time, he mounted the slopes to the 27,000ft. camp—in itself an unprecedented effort—but could find no signs of Mallory and Irvine, and, communicating with Norton, evacuated the mountain.

Thus stood the battle with Everest up to 1928. Unfortunately, the expedition also lost one young Gurkha non-commissioned officer from over-exposure, and one Tibetan follower from frostbite and pneumonia. At the base camp stands a monument to the 13 who gave their lives in this great attempt. (C. G. B.)

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EVERETT, ALEXANDER HILL (1790–1847), American author and diplomatist, was born in Boston, Mass., on March 19, 1790. He was the son of Oliver Everett (1753–1802), a Congregational minister in Boston, and the brother of Edward Everett. He graduated at Harvard in 1806, taking the highest honours of his year, though the youngest member of his class, and in 1807 began the study of law in the office of John Quincy Adams. In 1809 Adams was appointed minister to Russia, and Everett accompanied him as his private secretary, remaining attached to the American legation in Russia until 1811. From 1825 to 1829, during the presidency of John Quincy Adams, he was the United States minister to Spain. Everett was a member of the Massachusetts legislature in 1830–35, was president of Jefferson college in Louisiana in 1842–44, and was appointed commissioner of the United States to China in 1845. He died on May 29, 1847 at Canton, China. Everett is known rather as a man of letters than as a diplomat. In addition to numerous articles, published chiefly in the *North American Review*, of which he was the editor from 1829 to 1835, he wrote: *Europe, or a General Survey of the Political Situation of the Principal Powers, with Conjectures on their Future Prospects* (1822), which was translated into German, French and Spanish; *New Ideas on Population* (1822); *America, or a General Survey of the Political Situation of the Several Powers of the Western Continent, with Conjectures on their Future Prospects* (1827), which was translated into several European languages; a volume of *Poems* (1845); and *Critical and Miscellaneous Essays* (first series, 1845; second series, 1847).

EVERETT, EDWARD (1794–1865), American statesman and orator, was born in Dorchester, Mass., on April 11, 1794, of colonial ancestors. His father, a minister, died in 1802, and his mother removed to Boston with her family after her husband's death. At 17 Edward Everett graduated from Harvard college, taking first honours in his class. While a student he distinguished himself by his remarkable memory and his literary tastes. His earlier predilections were for the law, but the advice of Joseph Stevens Buckminster, a preacher in Boston, led him to prepare for the pulpit, and as a preacher he at once became prominent. He was called to the ministry of the Brattle street church (Unitarian) in Boston before he was 20 years old. The melody of his voice and the splendour of his images enthralled his hearers; and he further demonstrated his ability and zeal by his publication in 1814 of a volume entitled *Defence of Christianity*, written in answer to *The Grounds of Christianity Examined* (1813), by G. B. English.

Everett's tastes, however, were then, as always, those of a scholar; and in 1815, after little more than a year in the pulpit, he resigned his charge to accept a professorship of Greek literature in Harvard college. After nearly five years spent in Europe in preparation, during which time he was the first American to receive the Ph.D. degree from Göttingen, he entered with his usual industry on his duties. For five years more he won the affectionate admiration of his students and, through his lectures and sermons, the plaudits of a wider audience. He was increasingly restless in his teaching, however, and threw himself with energy into the editorship of the *North American Review* (1820–24), the influence of which he greatly extended. His election to the House of Representatives forced him to vacate his professorship, and

thereafter his career was largely political. As congressman (1825–35) he supported generally the administration of President J. Q. Adams and opposed that of Jackson, which succeeded it. He bore a part in almost every important debate, and was a member of the committee on foreign affairs during the whole time of his service in Congress as well as a member of nearly all the most important select committees, such as those on the Apportionment bill and the Bank of the United States. Although he aroused much criticism by his unnecessary defence of slavery in the event of a slave insurrection, honour is due to him for his unsuccessful opposition to the Indian policy of Gen. Jackson (the removal of the Cherokee and other Indians, without their consent, from lands guaranteed to them by treaty).

In 1835 he was elected governor of Massachusetts. He brought to the duties of the office the untiring diligence which was the characteristic of his public life. A few of the measures which received his efficient support were the establishment of the first board of education and normal school in the United States, the scientific surveys of the State (the first of such public surveys), the criminal law commission, and the preservation of a sound currency during the panic of 1837. Everett filled the office of governor for four years, and was then defeated by an exceedingly small majority, largely through the lethargy of the Whigs.

In the following spring he made a visit with his family to Europe. In 1841, while residing in Florence, he was nominated U.S. minister to Great Britain, and arrived in London upon the duties of his mission at the close of that year. Critical questions were at that time open between the two countries—the north-eastern boundary, the affair of M'Leod, the seizure of American vessels on the coast of Africa, in the course of a few months the affair of the "Creole," to which was soon added the Oregon question. Although direct negotiations were handled at Washington, Everett's conduct of his legation won the approbation of Webster and his successors and the esteem of the English court.

Immediately after the accession of Polk to the presidency Everett was recalled. From Jan. 1846 to 1849, as the successor of Josiah Quincy, he was president of Harvard college, but found disciplinary matters trying. One of the outstanding achievements of his administration was the foundation of the Lawrence scientific school, to which he brought Louis Agassiz as professor.

On the death in Oct., 1852, of his friend Daniel Webster, to whom since his school days he had been closely attached, he succeeded him as secretary of State. This post he held for the remaining months of Fillmore's administration, leaving it to go into the Senate in 1853 as one of the representatives of Massachusetts. Under the work of the long session of 1853–54 his health gave way. In May, 1854, he resigned his seat, on the orders of his physician, and retired to what was called private life. But, as it proved, the remaining ten years of his life most widely established his reputation and influence throughout America.

As early as 1820 he had established a reputation as an orator such as few men in later days have enjoyed. Careful preparation, an extraordinary memory and brilliance of style and delivery all blended to make him a superb, although possibly a too ornate, speaker. Eager to avert, if possible, the impending conflict of arms between the North and South, he prepared an "oration" on George Washington, which he delivered in every part of America. In this way he raised about $70,000 for the purchase of the old home of Washington at Mt. Vernon, adding $10,000 more to it by contributing weekly articles for a year to the *New York Ledger*. These were published in book form as *Mount Vernon Papers* (1859). Everett also prepared for the *Encyclopædia Britannica* a biographical sketch of Washington, which was published separately in 1860. In 1860 Everett was the candidate of the short-lived Constitutional-Union Party for the vice presidency, on the ticket with John Bell (*q.v.*), but received only 39 electoral votes. During the Civil War he zealously supported the national Government, was frequently consulted by the administration and was called upon in every quarter to speak at public meetings. He delivered the last of his great orations at Gettysburg, after the battle, on the consecration of the national cemetery there. On Jan. 9, 1865, he spoke at a public meeting in Boston to raise funds for the Savannah sufferers. At that meeting he caught cold, his death resulting on Jan. 15, 1865. (E. E. H.)

Everett's *Orations and Speeches on Various Occasions* was first published in 1836. Later additions resulted in a four-volume collection (1850–68). P. R. Frothingham's *Edward Everett, Orator and Statesman* (1925) is a belated but generally adequate biography.

EVERETT, a city of Middlesex county, Massachusetts, U.S.A., 3 m. N. of Boston, adjoining Chelsea. It is served by the Boston and Maine and (for freight only) the Boston and Albany railways. Pop. (1920) 40,120 (27·6% foreign-born white). It has important manufactures (notably coke and petroleum products) with an output in 1925 valued at $51,517,163. The assessed valuation of property in 1926 was $60,113,250. Everett was settled about 1630. Until 1870, when it was incorporated as a town, it was part of Malden, and was known as South Malden. In 1892 it was incorporated as a city.

EVERETT, a city of Washington, U.S.A., 28m. N. of Seattle, on Puget sound, at the mouth of the Snohomish river; a port of entry and the county seat of Snohomish county. It is on Federal highway 99, and is served by the Chicago, Milwaukee, and St. Paul and Pacific, the Great Northern and the Northern Pacific railways, and by coastwise and Oriental steamers. The population was 7,838 in 1900; 27,644 in 1920; and was estimated locally at over 37,000 in 1928.

Facing the city is Whidbey island, beyond which rise the Olympic mountains. The eastern horizon is bounded by the Cascades. Mt. Baker and Mt. Rainier stand out to the north and south. The fine land-locked harbour, with a controlling depth of 30ft. at the wharves, had in 1925 traffic amounting to 886,184 tons of cargo and 978,584 tons of floated logs, with a total valuation of $28,464,233. Coastwise shipments of lumber, logs, cedar poles, lath, shingles and paper constitute 60% of the total commerce, by value. The city has many lumber, shingle and wood-working mills, a large paper mill, several iron and steel works, railroad shops, creosoting plants, factories making machinery for saw mills and shingle mills, and salmon, fruit and vegetable canneries. The output of the factories within the city in 1925 was valued at $24,087,142. The assessed valuation of property in 1927 was $16,688,000.

Everett was settled in 1891 and incorporated in 1893. Between 1900 and 1910 its population increased more than threefold. Between 1900 and 1925 the tonnage of the commercial cargo entering and leaving its harbour was multiplied by sixteen. In 1923 the vessel traffic amounted to 1,020,622 tons, and there were also 864,838 tons of floated timbers.

Just west of Everett is the spot where Capt. Vancouver landed in June 1792. In every direction are scenic features of great beauty, including the Index mountains, Lake Stevens, Silver lake, Deception Pass State park, Monte Cristo and Snoqualmie falls.

EVERGLADES, a great saw-grass morass fringed by broad cypress swamps and savanna, and intermingled with pine-land, salt meadows and the mangrove thickets of the coast, which occupies the greater portion of southern Florida, U.S.A. The Everglades extend from the southern and south-western sides of Lake Okeechobee, one of the most prominent features of the region, with a width of nearly 50 m. and an area of 5,000 square miles. Some of the tallest and finest cypress in Florida grow along the eastern and most of the northern shores of the lake. The relief of the higher drier parts is slight indeed and the actual boundary between saw-grass morass, and cypress swamp, prairie, pine-land or coastal swamp is indefinite and devious. A rise of 2 ft. in water level may change hundreds of square miles into swamp and shallow lake. East of Lake Okeechobee the Everglades merge gradually but irregularly with the Allapattah flats, a region largely submerged by the end of each rainy season. Farther south prairies and cypress swamps border the Everglades. Westward the Everglades from Whitewater bay to Lostmans river extend to the fringing coasting mangrove thickets. The copious rainfall and slight relief of southern Florida give origin to the Everglades.

The Everglades are now being drained, part of the expense being borne by the United States, part by Florida, and part by

private land companies. A huge canal has been cut to the sea, to which laterals are being run. By the initial project 1,500,000 ac. were drained, and by other series of subsequent plans 2,500,000 ac. more would be reclaimed. The work is done at tremendous cost. Some of the land reclaimed has been occupied by settlers, and many kinds of sub-tropical fruits and vegetables are being grown. The soil, except along the shores of the lake and smaller pools where the lime from the shells of the water life has been mixed with the peat, is acid, and generally deficient in plant food.

See S. Sanford, "Topography and Geology of Southern Florida" in the Florida Geological Survey *Second Annual Report* (1909); and D. A. Willey, "Reclaiming the Everglades of Florida" in *Scientific American*, vol. cxv., No. 12 (1916). (W. E. E.)

EVERGREEN, a general term applied to plants always in leaf, as contrasted with deciduous trees which are bare for part of the year (*see* HORTICULTURE). In temperate or colder zones where a season favourable to vegetation is succeeded by an unfavourable or winter season, leaves of evergreens must possess some protection from the frost and cold drying winds, and are therefore tougher or more leathery in texture than those of deciduous trees, and frequently, as in pines, firs and other conifers, are needle-like, thus exposing a smaller surface to the drying action of cold winds. The number of seasons for which the leaves last varies in different plants; every season some of the older leaves fall, while new ones are regularly produced. The English bramble is practically evergreen, the leaves lasting through winter and until the new leaves are developed next spring. In privet also the leaves fall after the production of new ones in the next year. In other cases the leaves last several years, as in conifers, and may sometimes be found on eleven-year-old shoots.

EVERLASTING or IMMORTELLE (*Helichrysum orientale*), a plant belonging to the division *Tubuliflorae* of the family Compositae. It is a native of north Africa, Crete and the parts of Asia bordering on the Mediterranean; and it is cultivated in many parts of Europe. In common with several other plants of the same group, known as "everlastings," the immortelle plant possesses a large involucre of dry scale-like or scarious bracts, which preserve their appearance when dried, provided the plant be gathered in proper condition. The chief supplies of *Helichrysum orientale* come from lower Provence, where it is cultivated in large quantities on the ground sloping to the Mediterranean, in positions well exposed to the sun. The plant begins to flower in June. It requires a light sandy or stony soil, and is readily injured by rain or heavy dews. It can be propagated by offsets from the older stems. The flowering stems are gathered in June, all the fully-expanded and immature flowers being rejected. The plant is tufted in its growth, each plant producing 60 or 70 stems, while each stem produces an average of 20 flowers. The colour of the bracts is deep yellow. The natural flowers are used for garlands for the dead, or plants dyed black are mixed with the yellow ones. The plant is also dyed green or orange-red. Other species of *Helichrysum* and species of allied genera with scarious heads of flowers are also known as "everlastings." One of the best known is the Australian species *H. bracteatum*, with several varieties, including double forms of different colours. *H. vestitum* (Cape of Good Hope) has white satiny heads. Others are species of *Helipterum* (West Australia and South Africa), *Ammobium* (Australia) *Achyrachaena* (United States), *Antennaria* (extra-tropical except Africa), *Gnaphalium* (cosmopolitan) and *Xeranthemum* (south Europe). In North America the pearly everlasting (*Anaphalis margaritacea*) is very widely distributed, occurring in dry soils from Newfoundland to Alaska and south to North Carolina and California. Several members of the family Amarantaceae have also "everlasting" flowers; such are *Gomphrena globosa*, with rounded or oval heads of white, orange, rose or violet, scarious bracts, and *Celosia pyramidalis*, with its elegant, loose, pyramidal inflorescences.

EVERLASTING LEAGUE, a league formed in Switzerland on Aug. 1, 1291 between Uri, Schwyz and Nidwalden for the purpose of self-defence. After the defeat of Austria at the battle of Mortgarten representatives of the victorious confederates met at Brunner on Dec. 9, 1315 and a renewed treaty was drawn up, the second document being largely an expansion of the first, with the addition of certain important clauses stipulating that no government was to be recognized or negotiations made except with the consent of the three districts constituting the League. *See* SWITZERLAND.

EVERSLEY, CHARLES SHAW-LEFEVRE, 1ST VISCOUNT, cr. 1887 (1794–1888), Speaker of the House of Commons, eldest son of Charles Shaw, was born in London on Feb. 22, 1794, and educated at Winchester and Trinity college, Cambridge. He was called to the bar in 1819. In 1830 he became M.P. for Downton, in 1831, for Hampshire and in 1832 for North Hampshire. For some years he was chairman of the committee on petitions for private bills. His judicial fairness, tact and courtesy, led in 1839 to his nomination by the Liberals for the chair of the House. He was elected by 317 votes to 299, and was Speaker until 1857. The viscountcy became extinct on his death (Dec. 28, 1888).

His younger brother, SIR JOHN GEORGE SHAW-LEFEVRE (1797–1879) was under-secretary for the colonies, and one of the first civil service commissioners. He was one of the founders of the University of London, of which he was vice-chancellor for 20 years. He also helped to found the Athenaeum Club.

EVESHAM, a market town and municipal borough in the Evesham parliamentary division, Worcestershire, England, 107 m. N.W. of London by G.W. and L.M.S. railways. Pop. (1921) 8,688. On the right (north) bank of the Avon, in the rich and beautiful Vale of Evesham, the district, mainly agricultural, is devoted to market-gardening and orchards. Evesham is a place of considerable antiquity; a Benedictine house was founded here by St. Egwin in the 8th century. It became a wealthy abbey, but was almost wholly destroyed at the Dissolution. The churchyard is entered by a Norman gateway, and there survives a magnificent isolated bell-tower (1533), of the best ornate Perpendicular workmanship. A single decorated arch is almost all that remains of the abbey walls, but near the bell-tower are the parish churches of St. Lawrence (16th century) and All Saints as well as the chapel of Abbot Lichfield, who built the bell tower. Other buildings include an Elizabethan town hall, the grammar school, founded by Abbot Lichfield, and the picturesque almonry. The borough includes the parish of Bengeworth St. Peter. Evesham (Homme, Ethomme) grew up around the Benedictine abbey, and in 1055, Edward the Confessor gave it a market and the privileges of a commercial town. It is mentioned in Domesday but it is uncertain when the town first became a borough. Before 1482 the abbot practically had control of the town, and his steward presided over the court at which the bailiffs were chosen. After the Dissolution the manor, markets, fairs and other privileges were granted to Sir Phillip Hoby. In 1604 James I. granted the burgesses their first charter, but in the following year, by a second charter, he incorporated Evesham with the village of Bengeworth. Evesham received two later charters, but in 1688, that of 1605 was restored and still remains the governing charter of the borough. Evesham returned two members to parliament in 1295 and again in 1337, after which date the privilege lapsed until 1604. Its two members were reduced to one by the act of 1867, and the borough was disfranchised in 1885.

The Battle.—Evesham gave its name to the famous battle, fought on Aug. 4, 1265, between the forces of Simon de Montfort, earl of Leicester, and the royalist army under Prince Edward. As the result of the victory of Lewes (*q.v.*), the baronial party was supreme throughout most of England. Only on the Welsh March was the royal cause sustained and thither de Montfort moved, taking with him the king and Prince Edward. But at Hereford, on May 28, Edward escaped to join his adherents in the border counties. As a counterbalance de Montfort enlisted the aid of the Welsh themselves, and took the castles of Monmouth and Usk. Meanwhile, however, Edward and the royalists had secured all the bridges over the Severn in his rear, Gloucester being the last, and then moved down the west bank against de Montfort, now at Newport. They not only threw him back across the Usk but frustrated his plan of transporting his army back to England by a successful sea-raid with three galleys against the ships which he had collected at Newport. De Montfort was thus

forced to undertake a roundabout and trying march north through the barren districts of Wales, while Edward, after abandoning the pursuit, fell back to Worcester to hold afresh the Severn against him. A new factor was introduced by the approach of de Montfort's son with an army of relief from eastern England. Placed between two opposing armies, closing upon him, if gropingly, Edward showed a real and, for his time, remarkable grasp of strategy. While de Montfort himself was still some distance from the Severn, Edward left Worcester on the evening of Aug. 1, marched during the night the 30 miles to Kenilworth, where de Montfort's son lay and, taking the baronial army by surprise in the early dawn, captured and destroyed the bulk of it without resistance. Edward, without delay, countermarched to Worcester, to find that de Montfort himself had meantime ferried his army across the Severn at a point four miles south of the town. It was clear that, in ignorance of his son's defeat, he would be moving to join him at Kenilworth. Leaving Worcester once more on the evening of Aug. 3, Edward's army moved in three columns by different roads but all converging on Evesham where they would bar de Montfort's route to Kenilworth. Although the surprise was not so complete as at Kenilworth it was sufficient to give Edward an initial advantage over a hastily assembled enemy, whose first idea was that the approaching force was his son's from Kenilworth, a delusion fostered by Edward's ruse of displaying enemy banners. Caught in the bend of the river Avon by the converging columns, and surrounded on all sides, the old earl attempted to cut his way out of the town to the northward. At first the fury of his assault forced back the superior numbers of the prince; but Simon's Welsh levies melted away and his enemies closed the last avenue of escape. The final struggle took place on Green Hill, a little to the north-west of the town, where the devoted friends of de Montfort formed a ring round their leader and died with him. The spot is marked with an obelisk.

EVIDENCE, a term which may be defined briefly as denoting the facts presented to the mind of a person for the purpose of enabling him to decide a disputed question. Evidence in the widest sense includes all such facts. In the narrower sense employed in English law, however, it includes only such facts, testimony and documents as may be received in legal proceedings in proof or disproof of the facts under enquiry. Taylor applies the word to "all the legal means, exclusive of mere argument," used for such purpose; but this is too wide, since it would embrace judicial notice, presumptions of law, and inspection, which are not usually included under the term. On the other hand Stephen restricts the word to testimony and documents, exclusive of facts, which is too narrow, and, moreover, conflicts with other parts of his *Digest*, *e.g.*, an admission which by art. 15 is a relevant "fact" is declared by art. 64 to be primary "evidence"; while elsewhere, to the question "what is evidence?" it is said, "the only possible answer is that one fact is, or is not, relevant to the other."

History.—The English law of evidence as at present administered is of comparatively modern growth, having for the most part been built up by the judges in the last two centuries, with special reference to trials by jury, and it consists of this judge-made law as modified by various statutory enactments. Although, however, it was with a view to trial by untrained jurors that these rules were originally formed, and that their peculiarities are mainly to be explained, yet the sources of many of them reach back to very early times. In pre-Norman days, neither trials nor evidence in the modern sense existed. The primitive trials, or proofs, were mainly by ordeal, battle, or compurgation, which were appeals to the supernatural; while the judgments of the court respecting them, instead of following the trial, preceded it, the tribunal merely deciding by a medial judgment the preliminary questions of which litigant should have the burden of proof, and what mode of this should be adopted. The trial or "proof" then took place. If the litigant upon whom the above burden was imposed performed the task, he won; if not, he lost. But the court had no desire to hear or weigh conflicting testimony, since this would have been foreign to the whole spirit and traditions of the age. In the case of compurgation, the party himself swore, supported by a fixed number of oath-helpers who might know nothing of the facts, but merely guaranteed their principal's veracity. In a few cases, also, *e.g.*, sales and the execution of charters, pre-appointed witnesses of the transaction were employed, but these swore only in a set form and were not cross-examined. Neither compurgators, nor transaction-viewers, therefore, were witnesses in the modern sense. By the 13th century the above modes of trial had been largely superseded, both in civil and criminal proceedings, by the inquest, a Norman introduction whereby facts were determined by the sworn verdict of jurors drawn from the particular locality and personally cognizant of the matters in question. Later, this finding had, in criminal cases, to be followed by the verdict of a second jury, the former finding being treated not as testimony, but as accusation, or indictment; and it was from this embryo that the existing system of enquiry by grand jury and trial by petty jury developed. Later still, about the 15th century, the practice arose of supplementing the jury's own knowledge by information, both sworn and unsworn, from outside sources; and finally, soon after the year 1700, verdicts began in all cases, civil or criminal, to be based on the sworn testimony of witnesses given and tested in the modern way, and personal knowledge by the jurors might only be considered if delivered to the court on oath.

PRELIMINARY MATTERS

Judge and Jury. Law and Fact.—In a trial by jury two classes of questions arise, questions of law and questions of fact, but they are answered by different persons. The judge lays down the law; the jury, under his guidance, find the facts. Questions as to the production and admissibility of evidence belong to the former class; questions as to its credibility and weight to the latter. Whether there is any evidence, therefore, is for the judge; whether there is sufficient evidence is for the jury. Thus, in actions for negligence, it is for the judge to say whether from the facts proved negligence can be imputed, and for the jury to find whether it ought to be; in libels it is for the former to rule whether the words used were capable of the meaning alleged, and for the latter whether they bore it. The following matters of fact, however, are by exception determined by the judge: (1) what is reasonable in certain cases, *e.g.*, reasonable and probable cause in an action for malicious prosecution, or the reasonableness of a covenant in restraint of trade; (2) the existence of facts on which the admissibility of evidence depends, *e.g.*, those which show a confession to be voluntary, or a communication privileged; and (3) foreign law, which includes Scotch, Irish (when differing from English), and colonial law, and which, unlike English law, is treated by the courts as a question of fact to be proved by experts.

Facts Proved Otherwise Than by Evidence.—Proof in legal proceedings may be effected not only by evidence, but by Judicial Notice, Presumptions and Inspection. (*a*) Judicial Notice is the cognizance taken by the court itself of matters which are so notorious, or clearly established, that evidence of their existence is unnecessary. (*See* NOTICE.) (*b*) Presumptions are either of law or fact. Presumptions of law are arbitrary results attached by law to particular facts, and may be conclusive, as that a child under seven is incapable of committing a felony, or rebuttable, as that a person not heard of for seven years is dead, or that a bill of exchange has been given for value. Presumptions of fact are inferences which the mind naturally and logically draws from particular facts. (*c*) Inspection by the court, which is a further and valuable means of proof is, in general, allowed whenever it is reasonably practicable, and will assist the tribunal in arriving at a decision. Familiar instances thereof occur with respect to the demeanour of witnesses, the age of individuals and the comparison of handwriting or trade-marks.

Burden of Proof.—The general rule is that he who asserts a fact must prove it, and not he who denies; and this applies whether the fact is alleged in an affirmative form, as the making of a contract or the commission of a criminal act, or a negative one, as in an action for the non-repair of premises or for the unsoundness of a warranted article. In law, however, the phrase "burden of proof" has two distinct and often confused meanings,

the burden of proof as a matter of law and pleading, and the burden of adducing evidence. The burden of proof in the former sense ordinarily rests upon the plaintiff or prosecutor, though in all but the simplest cases the defendant has also one or more of the issues cast upon him. Thus, in actions of contract, the plaintiff has the onus of proving the contract, conditions precedent, breach and damages; while the defendant has the onus of facts pleaded in confession and avoidance, *e.g.*, infancy, rescission, fraud, etc. But there are two cases in which the burden of adducing evidence does not rest upon the parties above indicated: (1) when there exists a rebuttable presumption of law in favour of either party, it rests upon his opponent to rebut it, *e.g.*, a party suing on a bill of exchange need not allege, nor at the outset prove, that he gave value for the bill, or that the defendant is of full age, or sane, for the law presumes such conditions; (2) when the fact alleged is peculiarly within the knowledge of his opponent, it lies upon the latter to rebut the allegation. Indeed, many statutes expressly direct that the proof of lawful excuse or authority, or the absence of fraudulent intent, shall lie on the accused and not on the prosecution. And the Summary Jurisdiction Acts 1848 and 1879 provide that if the information or complaint in summary proceedings negatives any exemption, exception, proviso or condition in the statute on which it is founded, the prosecutor or complainant need not prove the negative, but the defendant may prove the affirmative in his defence.

Proof in Civil and Criminal Cases.—The rules of proof, though generally the same in civil and criminal proceedings, are subject to the following differences:—(1) In civil cases the rules of proof may be relaxed by consent of the parties, or order of the court; thus, the parties may elect to try their case on affidavits, may interrogate each other before the trial about the facts in dispute, and may, in some cases, obtain leave to prove facts at the trial by hearsay, or documents by secondary evidence. (2) The provisions relating to complaints, character, confessions, dying declarations and the competency of witnesses are wholly or partially peculiar to the criminal law; moreover, in criminal trials, the accused may make unsworn statements in place of, or in addition to, his sworn testimony. (3) Civil cases may be proved by a preponderance of evidence; criminal issues when arising in criminal, but not generally in civil, proceedings, must be proved beyond a reasonable doubt.

Classification of Evidence.—Bentham gives in all nine heads of evidence, but the following, which are commonly observed in practice, are all that are important. (1) *Direct, Circumstantial and Real Evidence.* By direct evidence is meant that a given fact is proved either by its actual production, or by the testimony or admissible declaration of someone who has himself perceived it. By indirect, circumstantial or presumptive evidence is meant that other facts are thus proved from which the existence of the given fact may be logically inferred. The two forms are equally admissible, and the testimony, whether to the *factum probandum*, or the *facta probantia*, is equally direct. Material objects, other than documents, produced for the inspection of the court are often called real evidence. (2) *Original and Hearsay Evidence.* The term original evidence as distinct from hearsay is used in two senses, (a) to mean the proof of facts by testimony, as opposed to their proof by statements made out of court; and (b) to mean statements made out of court which are used circumstantially, *i.e.*, as relevant irrespective of their truth or falsity, as opposed to those used testimonially, *i.e.*, to prove the truth of the facts asserted. Thus, the information on which a party has acted is often material to explain his conduct, and when tendered merely for that purpose and without reference to its truth, it is admissible as original evidence; while, if the same statement be used to prove the truth of its contents, it is hearsay and only admissible in certain clearly defined and exceptional cases. The test of whether a declaration belongs to one class or the other is, therefore, the purpose for which it is tendered. (3) *Primary and Secondary Evidence.* These terms apply to the kinds of proof that may be given of the contents of a document irrespective of the purpose for which the contents, when proved, may be used. Primary evidence may be given by production of the document, or an admission of its contents. Secondary evidence may be given by copies of various kinds (*e.g.*, Government printers' or gazette copies, office copies of judicial documents and certified copies of non-judicial ones); oral testimony by one who has read the document; and entries respecting it by deceased persons against interest, or in discharge of their duty. Copies of copies, however, are only admissible if the second has been examined with the first, and the first with the original.

The Best Evidence Rule.—The maxim that the "best evidence must be given of which the nature of the case permits," first appeared in a case decided in 1700, and for more than a century it largely regulated the subject. Thus, on the strength of this principle, circumstantial evidence used to be excluded if direct could be obtained, extrinsic proof of a party's handwriting or consent rejected if his own testimony were available, and various other forms shut out when better might be had. The rule was adopted for the prevention of fraud, it being presumed that when the best evidence was withheld, some sinister motive actuated. About the beginning of the 19th century, however, a reaction set in, and perhaps the most conspicuous feature of the modern law has been its persistent recession from this once famous principle. It began to be recognized that a prudent relaxation of strict rules tended not to encourage fraud, but to promote economy, convenience and despatch, while the risk of losing cases supplied an ample inducement to procure the best evidence available. Further inroads in the rule were made by statutes extending the competency of witnesses, or permitting secondary evidence of documents in various cases. On the other hand, strict proof is still, in certain cases, exacted, *e.g.*, of marriage in cases of bigamy and divorce, of age on a plea of infancy, and generally of the contents of a private document by its production.

FACTS

Facts in Issue. Relevancy and Admissibility.—The facts which may be proved in a judicial enquiry are facts in issue, facts relevant to the issue, and any facts, whether relevant to the issue or not, which affect the legal reception or weight of the evidence tendered. Facts in issue are those necessary by law to establish the claim, liability or defence involved in the proceedings, and which, either by the pleadings or implication, are in dispute between the parties. Facts relevant to the issue are those which render probable the existence or non-existence of a fact in issue, or some relevant fact. Although legal admissibility is for the most part based on logical relevancy, the two classes do not wholly coincide. Thus, certain facts, *e.g.*, similar occurrences, or the known character of the parties, which in ordinary life are relied on in proof of facts, the law, with certain exceptions, rejects for reasons of policy and fairness. On the other hand, numerous facts, *e.g.*, the fact that, at the date of the trial, a document was 30 years old and so proved itself, or if lost had, or had not, been searched for sufficiently to admit a copy; or that, on a charge of receiving stolen property, seven days' notice had been given to the accused so as to admit evidence of other frauds by him within the preceding five years, are legally admissible, though they may have no logical bearing on the issue. It has been suggested that the word "relevant" should be eliminated altogether, and "admissible" substituted for it throughout; but this would exchange a word which expresses the leading principle of the law of evidence, for one expressing no principle at all, but merely a collection of arbitrary rules. Both terms should, therefore, be retained, the former as indicating the guiding principle, and the latter its limits.

It is not possible satisfactorily to classify relevant facts since their variety may be infinite. But in legal trials they tend to group themselves under three principal heads or issues, dealing respectively with the existence of the main fact or transaction, the identity of the parties and the states of mind (*e.g.*, knowledge, intent, fraud or malice) of the latter with reference to the main fact.

Existence of the Main Fact. Res Gesta.—In civil cases, *e.g.*, contract or tort, the main fact is generally provable by direct testimony, or production of the documents involved; in criminal cases, however, direct evidence is less often obtainable. But in either case, what was said or done by the parties at the time, and with reference to the matter, is generally admissible as part of the

transaction, or *pars rei gestae*. Questions of evidence under this head usually arise with regard to statements, since with other incidents there is less danger of the jury being misled. Such statements must, to be admissible, have been substantially contemporaneous with the act, *i.e.*, made during, or just before or after its occurrence, but not at such an interval therefrom as to allow of fabrication or reduce them to mere narrative; they must relate to the fact they accompany, and not to prior or subsequent facts; and, though admissible to explain the transaction, or the state of mind of the parties thereto, they are no proof of the truth of the matters asserted, *i.e.*, they are original evidence, as above defined, and not hearsay admitted by exception. Among facts which, though not part of the main transaction, are relevant to prove or disprove its existence, the following should be noted: *Consistent and Inconsistent Facts, e.g.*, on a question of paternity, the resemblance or non-resemblance of the child to the alleged father; on a claim for money lent, the poverty of the alleged lender as rendering the loan improbable; or, on a claim for rent, the production of a receipt for later rent, from which it may be presumed that the earlier rent was paid. *Prior or Subsequent Existence of Facts:* In certain cases, the existence of the main fact at a given time, *e.g.*, of life, marriage, sanity, opinions, partnership, official character or domicil, may be shown by its existence prior or subsequent thereto, there being a probability that such facts continue. The presumption of continuance, which is one of fact and not of law, weakens, however, with time, and only prevails until the contrary is shown, or a different presumption arises from the nature of the case. Thus, to show that A., when taking a certain oath, had no belief in a Deity, evidence that he had no such belief four years before, was admitted, though had the interval been 30 years, the evidence would have been rejected, since the inference of continuance would then have been unreasonable. This presumption may also apply retrospectively; *e.g.*, proof that a vessel was, during a voyage and without visible cause, unseaworthy, is evidence that it was so at the time of sailing. *Course of Business:* To prove that a given act was done, it is relevant to prove that in the ordinary course of business or office it would ordinarily have been done, *e.g.*, to prove the posting of a letter, testimony by a clerk that he habitually posted the letters, though he had no recollection of the particular one, was held sufficient. *Custom:* Proof of usage is admissible to annex unexpressed incidents (not inconsistent with those expressed) to oral or written contracts, grants or wills, it being presumed that a party dealing in a particular market or place, intends to adopt its usages. Custom may be proved by the direct testimony of witnesses, or by similar instances in which it has been followed, or by reported cases in which it has been upheld, when it will be judicially noticed without evidence. *Standards of Comparison:* On questions of negligence, the acts or precautions proper to be taken under the circumstances, or the general practice of the community on the subject, are relevant. So, in cases of disputed handwriting, comparison may be made with specimens proved to the judge to be genuine, and the party whose writing is in dispute may be required to write in the judge's presence. *Acting in a capacity* is in general evidence of title thereto, even in favour of the party so acting. Thus, acting in a public office (though not usually in a private one) is admissible, even though the appointment is required to be by deed; trading as a public company is evidence of incorporation; and cohabitation evidence of a valid marriage, its weight varying with the circumstances. Similarly, title to property may be inferred from acts of ownership, *e.g.*, possession, receipt of rents, or execution of repairs; while, in rebuttal, these may be shown to have been disputed, or done in the absence of persons entitled to dispute them. *Complaints:* In cases of rape and similar sexual crimes, complaints (with their particulars) made by the prosecutrix shortly after the outrage are admissible to confirm her testimony and rebut consent, but not to prove the truth of the facts stated. Complaints in these special cases are receivable irrespective of the *res gesta* rule, which latter applies generally, but under much stricter conditions.

Identity of Parties and States of Mind.—When a party's identity with a known individual is in question, it may be proved not only by direct testimony, but presumptively by similarity of their personal characteristics or former history. When, however, a party's identity is only material as showing that he did some specific act, the range of relevant facts is much narrower. In civil cases, this question usually arises in connection with the execution of documents, and here, apart from the production of direct testimony, identity of name and handwriting will generally suffice. In criminal cases, when the occurrence of the act has been proved, the identity of the accused may be inferred from motive, means and opportunity, preparation or previous attempts, knowledge of circumstances, or possession of special skill, enabling him to do the act, or subsequent flight, change of habits, suppression or fabrication of evidence, foot-marks, finger-prints, or articles of his found at the spot, or those of others found upon him. On the other hand, the accused may rebut these, or set up an alibi, or show that the act was more likely to have been committed by the prosecutor or third persons. Neither confessions, acquittals, nor convictions of third persons are, however, evidence for, or against, the defendant for this purpose. Thus, the deathbed confession of a third person that it was he, and not the prisoner, who had killed the deceased, has been rejected in a murder trial.

States of mind as to a fact may be proved by the party's own testimony (though not by that of others), or by the facts of the transaction itself, or by matters previous or subsequent thereto. Statements made out of court and tendered for this purpose, however, are no evidence of the truth of the matter asserted, except against the party as admissions. As instances under the present head, knowledge of facts may be shown either by the party's own testimony, or presumptively from its being his duty to know, or from his having the means of knowledge; and good faith in doing an act may generally be inferred from any facts which would justify its doing.

Rules of Exclusion.—Facts, although logically relevant to the issue, are, as has been shown, not invariably admissible; and there are five classes thereof, viz., similar facts, character, privileged matters, hearsay, and opinions, which, subject to important exceptions, are shut out by as many excluding rules, either because they are too vague and uncertain to form the basis of judicial decisions, or because they would embarrass the enquiry with collateral issues, or would unfairly prejudice the parties with the jury.

(a) *Similar Facts.*—Facts which are relevant merely from their general similarity to the main fact, and not from their specific connection therewith, are inadmissible to show its existence; nor, to prove that a party did an act, may evidence be given of similar acts done by him in order to show his tendency to do such acts, and consequent probability of his having done the act in question. On the particular charge of receiving goods knowing them to be stolen, and for the purpose of showing such knowledge, an exceptional licence is allowed to the prosecution by the Larceny Act 1916, s. 43, proof being receivable (a) that other property, stolen within twelve months preceding the offence, was or had been in the accused's possession, and (b) after seven days' notice to him and proof of such possession, that he had within five years preceding the offence been convicted of fraud or dishonesty.

(b) *Character.*—When a party's character is in issue, proof must necessarily be received of what that character is, or is not. But when a party's character is tendered in proof, or disproof, of some other issue, it is usually excluded, not as being logically irrelevant, but because it is unfair to rake up a person's whole career without notice. *Exceptions:* (1) *Parties.* In criminal cases, the accused is, on grounds of humanity, allowed the privilege of proving his good character (either by his own or other testimony, or by cross-examination) for the purpose of raising a presumption of his innocence. The character proved must be of the kind impeached, *e.g.*, honesty where dishonesty is charged, and should refer to a date proximate to that of the offence. When such evidence is given, the prosecution may rebut it either by cross-examination, or by proof of the defendant's general bad character, or previous conviction for crime. Moreover, under the Criminal Evidence Act 1898, the prosecution may give such evidence not only in rebuttal of evidence of good character, but also if the

defendant has impeached the character of the witnesses for the prosecution, or given evidence against a co-defendant. In civil actions, good character, being presumed, may not (except in rebuttal) be proved in aggravation of damages; but in cases of libel, or breach of promise, the bad character of the plaintiff may be proved in reduction of damages. (2) *Third Persons*. In cases of rape, the bad character of the prosecutrix is admissible in defence; and to show consent, previous immoral acts with the prisoner may be shown by cross-examination or independent proof, and similar acts with other men may also be suggested in cross-examination, but if denied cannot be proved. In actions for seduction, or petitions for damages for adultery, the bad character of the woman betrayed may be proved in reduction of damages. And the character of the witnesses, whether parties or not, is also always admissible as affecting credit.

(c) *Public Policy and Privilege*.—Evidence of the following matters is excluded on grounds of public policy:—(1) affairs of State: *e.g.*, communications between the governor of a colony and the secretary of State; (2) information for the detection of crime: this may only be disclosed if necessary to show the innocence of the accused; (3) judicial disclosures: judges and barristers are not compellable, nor are jurors allowed, to testify as to matters arising in the discharge of their duties; (4) statements by parents bastardizing their offspring: neither the testimony, nor the statements out of court, of the parents are admissible in any legal proceeding to prove their access, or non-access, during marriage so as to bastardize their offspring, though either fact may be proved by other means. The following matters are protected from disclosure on grounds of privilege:—(1) professional confidences: a client cannot be compelled, nor a legal adviser permitted, without his client's consent, to disclose communications made between them in professional confidence. This protection, which does not extend to priests, doctors or agents, is confined to matters within the usual scope of professional employment, and such matters once privileged, are always privileged, *e.g.*, in future litigation, on change of advisers, or on the death of the client. The privilege may be waived by the client, either expressly or impliedly, though not by the adviser. But advice obtained for purposes outside the above limit, *e.g.*, to further a fraud, is not protected, even though the adviser is ignorant of the fraud. (2) Criminating questions: subject to the exceptions below, no witness is compellable to answer questions, or produce documents, tending to expose him, her, or their respective consorts, to any criminal charge, penalty or forfeiture. Answers subjecting the witness to claims for debt, or incriminating co-defendants, are not within the protection; and under the Criminal Evidence Act 1898, the Bankruptcy Act 1915, and the Larceny Act 1916, criminating answers may, with certain qualifications, be compelled. (3) Matrimonial communications: husbands and wives are not compellable to disclose communications made between them during marriage. (4) Admissions of adultery in divorce cases: in cases of divorce, but not in nullity, legitimacy or ordinary cases, witnesses are not liable to be asked or bound to answer imputations of adultery, unless they have already denied that fact in the same proceedings.

(d) *Hearsay*.—Statements, oral or written, made by persons not called as witnesses, are inadmissible to prove the truth of the the facts stated, except in the cases enumerated below. Statements made out of court may, as has been shown, be either what is awkwardly called "original" evidence, *i.e.*, where the statement is offered as relevant irrespective of its truth, or hearsay, *i.e.*, where it is offered testimonially in proof of the matters asserted. Thus, statements tendered as constituting a libel, contract, or threat, or as forming a part of the *res gesta*, or as conveying knowledge or notice, or as showing a party's good or bad faith or malice, are admissible as "original" evidence; while, an entry by a shop-man, debiting a customer with goods and tendered to prove the truth of the sale asserted, is hearsay, and only admissible in exceptional cases. The test of whether a statement belongs to one class or the other, is, therefore, the purpose for which it is tendered. The essential grounds for the exclusion of hearsay are the absence of the safeguards of oath, cross-examination, and opportunity of observing demeanour, which, in the case of witnesses, tend to ensure the reliability of their testimony. The hearsay rule is, however, subject to three important groups of exceptions:—(1) admissions, statements in the presence of a party, and confessions; (2) declarations by deceased persons made under conditions of special credibility; and (3) statements contained in public documents.

(1) *Admissions, etc.*—In civil cases, statements made by a party to the proceedings, or by a person identified in interest with him, are admissible to prove the facts stated against him, but not in his favour, otherwise everyone, when in a difficulty might make evidence for himself. Thus, in an action by A. against B. for goods, an entry by A., in his shop-books, debiting them to C., is admissible against him, but an entry debiting them to A. is not admissible for him. The circumstances of the admission may generally be proved to impeach or enhance its credibility, *e.g.*, that it was made in mistake, ignorance, levity or an abnormal state of mind, while its weight is increased by deliberation. In the special case, however, of offers of compromise made, expressly or implied by, "without prejudice," these are, on grounds of public policy, altogether excluded. When an admission is tendered against a party he may prove so much of the whole statement or correspondence as is necessary to explain it, including parts favourable to himself, but the jury may attach different degrees of credit to the different parts, and distinct matters cannot be proved in explanation. Statements made in the presence and hearing of a party, and documents in his possession, are also evidence against him of the truth of the matters stated, if by his conduct or silence he has acquiesced in their contents. Confessions made by an accused person voluntarily are evidence against him of the facts stated. (*See* CONFESSION LAW.) When property has been discovered by means of an inadmissible confession, the discovery and so much of the confession as strictly relates thereto, may be proved since this portion cannot be untrue, but the other portions will be rejected.

(2) *Declarations by Deceased Persons*.—The second main group of exceptions to the hearsay rule consists of statements by persons since deceased made against interest, or in the course of duty, or as to public rights, pedigree, or homicide, which are admissible to prove the facts stated, the truth of such statements being *prima facie* guaranteed by the special conditions imposed. In the first two cases the declarations are admissible on any issue; in the last three they are only receivable from the necessity of the case, and in proof of the particular issues named. (*a*) *Declarations Against Interest*. The interest involved must have been pecuniary or proprietary, and the declarations are evidence not only of the precise fact against interest, but of any connected facts necessary to explain it, though not against interest. Unconnected facts, however, though contained in the same statement or document are inadmissible. (*b*) *Declarations in Course of Duty*. Declarations made by the deceased in the ordinary course of duty, contemporaneously with the facts stated, and without motive to misrepresent, are admissible in proof of their contents. The duty must have been to a third person, and not a mere personal custom; and, unlike those against interest, the declarations here are only evidence of the precise matter it was the duty of the deceased to perform and record. (*c*) *Declarations as to Public Rights*. Statements by deceased persons of competent knowledge, made before dispute had arisen, are admissible in proof of ancient rights of a public or general nature, *e.g.*, rights of common, highway or ferry, or the boundaries of a parish or manor. Maps, copies of court rolls, old deeds and depositions, verdicts or judgments in former suits, are admissible under the present exception, though not awards, or unprosecuted claims. (*d*) *Declarations as to Pedigree*. On issues involving pedigree, *e.g.*, family succession (testate or intestate), relationship or legitimacy, statements by deceased relations, made before the question was controverted, are admissible. Thus, the birth, marriage or death of members of the family may be so proved if required for some genealogical purpose, but not otherwise. (*e*) *Declarations as to Homicide*. In trials for murder or manslaughter, only, the dying declarations of the deceased, made

when all hope of recovery was abandoned, are admissible to prove the cause and circumstances of his death.

(3) *Public Documents.*—The third main group of exceptions to the hearsay rule comprises statements contained in public documents, which, subject to various qualifications, are admissible, even against strangers, in proof of the facts recorded, upon the general grounds that they have been made by the authorized agents of the public, and as to matters of public interest or concern. Under this head are included statutes, parliamentary journals, the Government gazettes of London, Edinburgh and (now) Belfast, and public registers of births, marriages and deaths and the like.

(4) *Opinions and Judgments.*—The last of the classes excluded by the rules above mentioned, consists of opinion evidence, which, either in the form of general reputation, or of individual opinion and belief, is in general inadmissible to prove material facts, since if founded on no evidence, or illegal evidence, it is worthless, and if founded on legal it tends to usurp the functions of the tribunal whose business alone it is to draw conclusions of law or fact. There are, however, exceptions under each of these headings. Thus, reputation based on general opinion, but not on individual statements, is admissible in proof of public rights, pedigree, marriage, and the identification of persons referred to in libels or threats. The opinion of experts is admissible on subjects the knowledge of which requires a course of special study or experience, *e.g.*, science, art, trade, technical terms, handwriting, or foreign law. When, however, (i) the tribunal is as capable of forming an opinion as the witness, as in disputed points of duty, morality, or etiquette; or (ii.) the court is assisted by assessors, as in admiralty cases involving nautical skill, the evidence is inadmissible. (*See* ASSESSOR and EXPERT.) When opinion evidence takes the form of a judgment of a court of law, more technical rules apply; but, broadly speaking, judgments *in rem* (*i.e.*, those affecting status) are conclusive evidence of the facts actually decided, when tendered in future proceedings between either parties or strangers, while judgments *in personam* (*i.e.*, those in contract, tort, or crime) are conclusive evidence both of the fact decided and the grounds of the decision, but only between parties and those in privity with them, being in general wholly inadmissible between strangers.

WITNESSES

Attendance.—If a witness does not attend a trial voluntarily he can be required to attend in the High Court by a writ of *subpoena*, in the superior criminal courts by recognisance, or *subpoena*, and in the county courts, or before magistrates, by summons.

A witness is incompetent if, in the opinion of the court, he is prevented by extreme youth, disease affecting his mind, drunkenness, or any other cause of the same kind, from recollecting the matter on which he is to testify, from understanding the questions put to him, from giving rational answers to those questions, or from knowing that he ought to speak the truth. A witness unable to speak or hear is not incompetent, but may give his evidence by writing or by signs, or in any other manner in which he can make it intelligible.

Under the general law as it stood before the Criminal Evidence Act 1898 came into force, a person charged with an offence was not competent to give evidence on his own behalf. But many exceptions had been made to this rule by legislation, and the rule itself was finally abolished by the act of 1898. Under that law a person charged is a competent witness, but he can only give evidence for the defence, and can only give evidence if he himself applies to do so. Under the law as it stood before 1898, persons jointly charged and being tried together were not competent to give evidence either for or against each other. Under the act of 1898 a person charged jointly with another is a competent witness, but only for the defence, and not for the prosecution. If, therefore, one of the persons charged applies to give evidence his cross-examination must not be conducted with a view to establish the guilt of the other. Consequently, if it is thought desirable to use against one prisoner the evidence of another who is being tried with him, the latter should be released, or a separate verdict of not guilty taken against him. A prisoner so giving evidence is popularly said to turn king's evidence. It follows that, subject to what has been said above as to persons tried together, the evidence of an accomplice is admissible against his principal, and vice versa. The evidence of an accomplice is, however, always received with great jealousy and caution. A conviction on the unsupported testimony of an accomplice may, in some cases, be strictly legal, but the practice is to require it to be confirmed by unimpeachable testimony in some material part, and more especially as to his identification of the person or persons against whom his evidence may be received. The wife of a person charged is now a competent witness, but, except in certain special cases, she can only give evidence for the defence, and can only give evidence if her husband applies that she should do so. The special cases in which a wife can be called as a witness either for the prosecution or for the defence, and without the consent of the person charged, are cases arising under particular enactments scheduled to the act of 1898, and relating mainly to offences against wives and children, and cases in which the wife is by common law a competent witness against her husband, *i.e.*, where the proceeding is against the husband for bodily injury or violence inflicted on his wife. The rule of exclusion extends only to a lawful wife. There is no ground for supposing that the wife of a prosecutor is an incompetent witness.

Oaths.—Except in the case of children, when very young, witnesses merely producing documents, or counsel and judges explaining cases in which they have been professionally concerned, oral evidence must be given under the sanction of an oath, or solemn affirmation, the form of which will differ according as the witness has, or has not, a religious belief. A believer must be sworn either in the usual way, or in some other that he declares to be binding, unless he states that an oath is contrary to his religion, when he will be allowed to affirm. If, however, he objects on grounds other than the above, or will not state what form of oath is binding on him, his testimony will be excluded. The testimony of an atheist is admissible if he has been sworn without objection, or has been allowed to affirm because he has no religious belief.

Witnesses at the trial of any action or criminal charge must in general give their evidence *viva voce*, and in open court; but in certain statutory cases, and in proceedings affecting lunatics and wards of court, or where publicity would defeat the ends of justice, the hearing may be had *in camera*.

Examination.—The normal course of procedure is this. The party who begins, *i.e.*, ordinarily the plaintiff or prosecutor, calls his witnesses in order. Each witness is first examined on behalf of the party for whom he is called. This is called the examination in chief. Then he is liable to be cross-examined on behalf of the other side. And, finally, he may be re-examined on behalf of his own side. After the case for the other side has been opened, the same procedure is adopted with the witnesses for that side. In some cases the party who began is allowed to adduce further evidence in reply to his opponent's evidence.

In the examination in chief questions must be confined to matters bearing on the main issue, and a witness must not be asked as to facts protected by public policy or privilege, nor must material matters in general be elicited by leading questions, *i.e.*, questions suggesting the answer which the person putting the question wishes or expects to receive, or suggesting disputed facts about which the witness is to testify. But the rule about leading questions is not applied where the questions asked are simply introductory, and form no part of the real substance of the inquiry, or where they relate to matters which, though material, are not disputed. And if the witness called by a person appears to be directly hostile to him, or interested on the other side, or unwilling to reply, the reason for the rules applying to examination in chief breaks down, and the witness may be asked leading questions and cross-examined, and treated in every respect as though he was a witness called on the other side, except that a party producing a witness must not impeach his credit by general evidence of bad character (Evidence and Practice on Criminal

Trials Act 1865). A witness under examination may refresh his memory by referring to any writing made by himself at or about the time of the occurrence to which the writing relates, or made by any other person, and read and found accurate by the witness at or about the time. An expert may refresh his memory by reference to professional treatises.

In cross-examination questions not bearing on the main issue and leading questions may be put and (subject to the rules as to privilege) must be answered, as the cross-examiner is entitled to test the examination in chief by every means in his power. The licence allowed in cross-examination has often been seriously abused, and the power of the court to check it is recognized by one of the rules of the supreme court (R.S.C. xxxvi. 39, added in 1883). It is considered wrong to put questions which assume that facts have been proved which have not been proved, or that answers have been given contrary to the fact. A witness ought not to be pressed in cross-examination as to any facts which, if admitted, would not affect the question at issue or the credibility of the witness. If the cross-examiner intends to adduce evidence contrary to the evidence given by the witness, he ought to put to the witness in cross-examination the substance of the evidence which he proposes to adduce, in order to give the witness an opportunity of retracting or explaining. Where a witness has answered a question which only tends to affect his credibility by injuring his character, it is only in a limited number of cases that evidence can be given to contradict his answer. Where he is asked whether he has ever been convicted of any felony or misdemeanour, and denies or refuses to answer, proof may be given of the truth of the facts suggested (28 & 29 Vict. c. 15, s. 6). The same rule is observed where he is asked a question tending to show that he is not impartial. Where a witness has previously made a statement inconsistent with his evidence, proof may be given that he did in fact make it. But before such proof is given the circumstances of the alleged statement, sufficient to designate the particular occasion, must be mentioned to the witness, and he must be asked whether he did or did not make the statement. And if the statement was made in, or has been reduced to, writing, the attention of the witness must, before the writing is used against him, be called to those parts of the writing which are to be used for the purpose of contradicting him (Evidence and Practice on Criminal Trials Act 1865, ss. 4, 5). The credibility of a witness may be impeached by the evidence of persons who swear that they, from their knowledge of the witness, believe him to be unworthy of credit on his oath. These persons may not on their examination in chief give reasons for their belief, but they may be asked their reasons in cross-examination, and their answers cannot be contradicted. When the credit of a witness is so impeached, the party who called the witness may give evidence in reply to show that the witness is worthy of credit. When an accused person offers himself as a witness, he may be asked any question in cross-examination, notwithstanding that it would tend to criminate him as to the offence charged. But he may not be asked, and if he is asked must not be required to answer, any question tending to show that he has committed, or been convicted of, or been charged with, any other offence, or is of bad character, unless:— (i.) the proof that he has committed, or been convicted of, the other offence is admissible evidence to show that he is guilty of the offence with which he is then charged; or, (ii.) he has personally, or by his advocate, asked questions of the witnesses for the prosecution, with a view to establish his own good character, or has given evidence of his good character, or the nature or conduct of the defence is such as to involve imputations on the character of the prosecutor or the witnesses for the prosecution; or, (iii.) he has given evidence against any other person charged with the same offence. Nor may he be asked questions tending to criminate his wife.

Re-examination must be directed exclusively to the explanation of matters referred to in cross-examination, and if new matter is, by the permission of the court, introduced in re-examination, the other side may further cross-examine upon it.

Number of Witnesses and Corroboration.—As a general rule courts may act on the testimony of a single witness even though uncorroborated; or upon duly proved documentary evidence without such testimony at all. But whenever there are circumstances of suspicion, or the testimony of a witness is challenged by cross-examination or otherwise, corroboration is allowed, and in certain cases no verdict can be obtained without it. Thus, on charges of treason, or personation at elections, two witnesses are essential; in cases of perjury, breach of promise or bastardy, one witness will only suffice if corroborated in material particulars; and where proof of an offence rests on the unsworn testimony of children, corroboration is also required. In the above instances, the rules are statutory; but by a rule of practice, though not of strict law, corroboration is also needed in claims to the property of deceased persons, and in criminal cases, of the testimony of accomplices.

Protection of Witnesses.—A witness is privileged from arrest on civil process while he is in attendance on a court of justice, or is on his way to or from the court (*eundo, morando et redeundo*); but the privilege does not exempt from arrest on a criminal charge. And it is a contempt to threaten, bribe, or coerce a witness with intent to influence or prevent his evidence. Moreover, on grounds of public policy, no action will in general lie against a witness in respect of the testimony given by him in court.

DOCUMENTS

Questions of evidence under this head may arise with respect to the execution, contents, supersession, variation or interpretation of documents.

Execution.—As to execution, public or judicial documents are sometimes (*e.g.*, in the case of statutes or letters-patent) judicially noticed on their mere production; in other cases they may require no further authentication than that of appearing in a Government gazette, or of "purporting" to be printed by official printers, or to be certified, signed or sealed by some court or public department. The execution of private documents is proved by evidence of their signature given by the writer, or some person who saw it signed or knows the writing, as explained above; or, if the document is required by law to be attested, by calling the attesting witness, unless it is 30 years old and produced from proper custody, when it proves itself; or by the admission of the party against whom it is tendered; or by comparison, made by experts or other witnesses, of the documents in question with genuine specimens of the writing. (*See* HANDWRITING.)

Contents.—The contents of public or judicial documents may be proved either by ordinary evidence (*i.e.*, production or admission) or, more usually, by secondary evidence, which may consist here of Government printers' copies, Government gazette copies, certified copies (in the case of non-judicial documents such as registers), or office copies (in the case of judicial documents), but not of oral evidence. The contents of private documents must be proved by primary evidence, as above, except where (1) the original is lost or destroyed; or (2) its production is impossible or highly inconvenient, as in the case of registers, tombstones, or documents in a foreign country; or (3) when the original is in the possession of a stranger who refuses, and is not compellable by law, to produce it; or (4) when the original is in the possession of the opponent, who refuses to produce it either after notice to produce, or when such notice is excused, which occurs when the document is itself a notice to the opponent, or the latter is charged, in the same case, with its possession, or has it in court, or has admitted its loss. When, under the above exceptions, secondary evidence of a private document is admissible, such evidence may consist of an examined copy (*i.e.*, one sworn to be true by a witness who has examined it, line by line, with the original, the copies used in proof of public documents not being applicable here); or of oral testimony by witnesses who have read the document; or of entries as to its contents made by deceased persons against their pecuniary interest, or in the discharge of duty; or of presumptive evidence, *e.g.*, proof that parties who had interests under the document had acted in accordance with its tenor.

Supersession.—With regard to the supersession of documents,

the rule is that if a transaction has been reduced to a documentary form, either by requirement of law or agreement of the parties, the terms of the transaction must be proved by production of the document, or an authenticated copy thereof, and not by oral evidence, even though the oral and written terms may be identical, or the oral terms have been acted upon before reduction to writing. The party whose witnesses show that the transaction was reduced to writing must produce, or explain the absence of the instrument; and the opponent, in order to ascertain the fact, may either interpose in chief, or reserve the question for cross-examination, or, if the document be denied, may at once prove its existence. Where, however, the plaintiff can establish a *prima facie* case without disclosing the document, he will not be prejudiced by the defendant proving its existence, for the burden will then be shifted, and if the latter rely on the document he must produce it as part of his own case (with the usual liability as to stamping), even though he has served a notice to produce it on the plaintiff. When the mere existence of a transaction, irrespective of its terms, is in question, this may generally be shown by parol, without production of the document, *e.g.*, the existence of a partnership or official appointment.

Contradiction and Variation.—The rule here provides that when a transaction has been reduced into writing by requirement of law, or agreement of the parties, parol evidence (*i.e.*, oral or written matter extrinsic to the document) is in general inadmissible to contradict, vary, enlarge, or restrict the written terms. The grounds of exclusion commonly given are that where the law requires superior evidence, to admit inferior would be to nullify the law; and that where the parties have deliberately put their agreement into writing, it is conclusively presumed between themselves and those in privity with them that they intended it to be a full and final statement of their intentions, and one which should be placed beyond the reach of future controversy, bad faith, or treacherous memory. The rule, however, is sometimes thought to be based on the "best evidence" principle, though historically it is in fact much older; sometimes on the doctrine of estoppel; and sometimes wholly on the substantive law. It is subject to the following exceptions, in some of which parol evidence is admitted wholly to contradict the document, and in others merely to supplement it, but without contradiction. Thus (1) public documents, *e.g.*, entries in a register of the tonnage of a ship, are in general given no exclusive authority by law as instruments of evidence, and may be contradicted or varied by parol. (2) Extrinsic evidence is in general admissible to show the true nature of a transaction, or the legal relationship of the parties, although such evidence may contradict or modify the instrument. Thus, a sale, absolute on its face, may be proved by parol to be a loan, a conveyance merely a mortgage, an unqualified devise subject to a secret trust, or a receipt in, or indorsed on, a deed, contradicted. Fraud, or mistake may be similarly established, though the document is thereby impeached. (3) Where a contract, not required by law to be in writing, has been reduced thereto, but the court infers that the document was not intended to contain the whole agreement between the parties, proof may be given of any omitted term expressly or impliedly agreed between them at or before the execution of the document, and not inconsistent therewith. The question whether the document was intended to contain the whole agreement may be determined either by the document itself, or by extrinsic circumstances, and may be left to the jury. Moreover, although there exists a contract purporting to be fully expressed in writing, whether required by law to be so or not, proof may be given of a prior or contemporaneous oral agreement or warranty, if it forms part of the consideration for the main contract, and is not inconsistent with the document. The collateral contract must be between the same parties, and not include others as well. Apart, however, from such omitted or collateral terms, unexpressed incidents, if not inconsistent with those expressed, may be annexed to contracts, grants, or wills, either by usage, for here it is presumed that the customs of the particular market or place have been tacitly adopted by the parties, or by law, in which case the incidents annexed will be judicially noticed without resort to evidence, and may in some cases (*e.g.*, in contracts under the Sale of Goods Act 1893, s. 55) be varied or contradicted by parol. (4) Written contracts, if not required by law to be in writing, may at any time before breach, be either rescinded or modified by parol; if required by law to be in writing, they may be wholly rescinded by a parol agreement, even though such agreement may itself be unenforceable, but not partially abandoned or varied thereby. Deeds may be discharged, but not varied, by oral agreement made for valuable consideration; bills and notes may be discharged by writing, or delivery up; and wills may be revoked by later wills, or destruction animo revocandi, or modified by further testamentary instruments.

Interpretation.—When the language of a document is clear and applies without difficulty to the facts of the case, extrinsic evidence is not admissible to affect its interpretation; but when the language is peculiar, or its application to the facts is ambiguous or inaccurate, extrinsic evidence may, subject to the under-mentioned rules, be received to explain it.

Rule i. (surrounding circumstances).—In order to show the identity or extent of the objects referred to in a document, extrinsic evidence (including the knowledge and surrounding circumstances of the writer, his treatment of, and habits of speech concerning, such objects, but not his direct declarations of intention) may be given. The principle is that, as most documents refer to the circumstances under which they were written, the court, in interpreting them, should be placed as nearly as possible in the same situation as the writer; while, as to the degree of certainty required, the maxim *id certum est quod certum reddi potest* applies. Such evidence, however, is not admissible when the ambiguity is merely a grammatical one, or when the language is so vague or imperfect that no reasonable meaning can be attached to it, so that to admit evidence would be, not to interpret the document, but virtually to make a new one. Thus, where A. appointed as his executor "Percival —, of Brighton, the father," evidence that A. had two friends called Percival B., father and son, and both of Brighton, was received, and probate granted to the former. While, where A. left legacies to "Mr. —," and "Lady —," extrinsic evidence to fill the blanks was rejected, the language being wholly defective and uncertain. So, where A., a farmer, sued B. on a contract signed by B. "to take your wool at 16s. a stone," a letter from A. to B.'s agent, before the contract, that he "had sold part of his own clip, but was promised other wool which would go with his own," was received to show that in the contemplation of the parties "your wool" included both clips, and not A.'s clip only.

Rule ii. (primary and secondary meanings, correct and less correct names and descriptions).—When the words of a document in their primary or ordinary sense, are applicable to the facts and not modified by the context, extrinsic evidence cannot be given to show that they were not used in that sense; but when it is clear from the context, or the facts, that such meaning cannot have been intended, extrinsic evidence of the kinds above specified may be given to show that they were used in some secondary or less ordinary sense, provided it is one which the words can properly bear. Rule i. included cases where the words, being of a vague or general character, were equally applicable to a wide or narrow meaning. The present rule deals with words having a proper and also a less proper sense or application. Thus, words of relationship import legitimate relationship; if, therefore, legitimate members exist, evidence cannot in general be given that illegitimates were intended; though if none do or can exist, or if, though some exist, the context may include the latter, the evidence will be receivable. Again, if a given person, known to the testator, accurately fulfils the words in the will, and there is no other claimant, evidence cannot be given that he was not intended; and if one of two claimants fulfils the words and the other not, evidence in favour of the latter will be rejected. So, also, in cases of property, if a subject exists satisfying all the written terms, evidence cannot be given that something more or less extensive was intended. As instances of the foregoing, where A. left property to his "children," having none of his own, but only step-daughters, evidence that they lived with him, adopted

his surname, were known by the neighbours as his children, and were so treated and called by him, was received in their favour; while where A. left property to B's "children," B. having both legitimate and illegitimate issue, evidence that A. treated and promised to provide for them all alike was rejected, and the legitimates alone held entitled.

Rule iii. (incorrect names and descriptions).—When the words of a document apply in part correctly and in part incorrectly to a single subject-matter, extrinsic evidence of the kinds stated in Rule i. may be given to show whether they were intended by the writer to apply to it, or not; and when the words apply partly to one subject and partly to another, but correctly to neither, similar evidence may be given to show which of the two was intended, the maxim *falsa demonstratio non nocet cum de corpore constat* applying. Thus, where a voting paper beginning "I, the undersigned A." was signed "B.," evidence by the town clerk that he gave A.'s paper by mistake to B. who signed it without noticing the mistake, was admitted to explain the patent ambiguity and validate the vote. So, where A. left a legacy to "my dear wife C.," evidence that his wife, from whom he was separated, was called M., but that he had bigamously married C., who was living with him at the dates of his will and death, was received and the legacy given to C.

Rule iv. (equivocations).—Where the words of a document, though intended to apply to one object only, apply equally to more, and it is impossible to gather from the context which was intended, an equivocation arises, and in addition to the evidence admissible above, direct declarations of the writer's intention may be given to solve the ambiguity. An equivocation may arise where the same name or description fits two objects accurately; or one accurately and the other popularly though less accurately, *e.g.*, the same name borne by father and son; or one accurately and the other in a transposed order, or with additional names. There is no equivocation, however, where there are legitimate and illegitimate relations of the same degree, for the case then falls under Rule ii. above; nor where part of a name or description applies to one object and the remainder to another, for the case then falls under Rule iii.

Rule v. (usage, experts, dictionaries).—Where the words of a document have a double meaning, the one common and the other local or peculiar, evidence of the latter is admissible, if the context, or facts, point to such a user by the parties. And the testimony of experts, or a reference to dictionaries, is similarly admissible to explain local, technical or foreign terms.

EFFECT OF EVIDENCE

Weight of Evidence. Presumptions and Estoppels.—The probative weight of evidence, unlike its admissibility, is determined not by arbitrary rules, but by the natural acumen, good sense and experience of the tribunal. Independently of this, however, valuable aid in deciding cases is provided by the rules as to burden of proof, *e.g.*, where the scales are even, the plaintiff or prosecutor, and not the defendant, must lose, since the former will, if the case be a civil one, have failed to establish his case by a preponderance of probability, or, if it be a criminal one, by proof of guilt beyond a reasonable doubt. So, where either party has a rebuttable presumption of law in his favour, he must win, unless his opponent can specifically rebut it.

An estoppel is a rule whereby a party is precluded from denying some state of facts which he has previously asserted. It is usually said to be a rule of evidence, since an action cannot be founded thereon; but as a defence can, and as estoppels must be pleaded and evidence must not, this statement is not wholly satisfactory. Estoppels have been variously treated as conclusive presumptions of law, as solemn admissions, and as conclusive evidence. They are, however, distinguishable from the first in that an estoppel may be waived; from the second as well as from the first, in that it cannot in general be taken advantage of by strangers; and from the third, in that the conclusiveness of evidence may result from mere logical cogency, while, when it results from some rule of law, it operates against strangers as well as parties. Estoppels of all kinds, however, are subject to one general rule, they cannot over-ride the law. Thus, where writing is required by statute, no estoppel will cure the defect; an infant is not estopped by his fraudulent statement that he is of full age; nor is a corporation estopped by acts which are *ultra vires*. Estoppels may arise (1) by record: *e.g.*, judgments or letters-patent; (2) by deed: thus where a party has by deed agreed upon certain facts, neither he, nor those in privity with him, are permitted to deny them. This, however, applies only to actions on the deed, and to recitals or descriptions which are material and intended to bind; (3) by agreement: *e.g.*, a landlord is estopped from denying his title to the premises let, and a tenant from denying the title of his landlord, or the latter's heirs; a bailee is estopped from denying his bailor's authority to make the bailment; and the licensee of a patent from denying the validity of the patent; (4) by representation: the rule here is that when a party has, by his words or conduct, wilfully induced another to believe in certain facts and to alter his position in consequence of such belief, the former is estopped from denying their existence. (*See* TESTIMONY, PSYCHOLOGY OF.)

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THE UNITED STATES

The law of evidence in the United States, even where legislatively codified, is mainly derived from the corresponding branch of English common law. Importations from other legal systems, such as presumptions with respect to survivorship in common disasters, are rare and not of great significance. But the American nation contains some 50 jurisdictional units, State and Federal, each presenting much evidence which is a plain departure from the English system. A late United States treatise on evidence cites about 80,000 decisions, of which only a minority come from England. In recent English digests few cases are listed at the points where evidence is discussed; in corresponding American digests many cases are so listed. Mere numerical comparison is somewhat misleading, because in the United States digesting is highly detailed and more cases are reported than in the older country. Even after full allowance on these points, the multiplicity of American evidential decisions, both absolutely and in comparison with those on other legal topics, indicates that forces tending to complexity may be found in the law itself, or in the manner of administration, or in both.

COMPLICATING FACTORS

Functions of Judge and Jury.—The law of most States largely or completely prevents trial judges from commenting to juries upon the relative weight or credibility of testimony presented by contending parties. While the avowed purpose of the restriction is to keep judges from subduing jurors' independent judgment, an incidental effect is to deprive inexperienced jurymen of guidance by trained minds. It is warmly debated whether the benefits of the rule can outweigh its detriments. This restrictive doctrine has effect among cautious judges, even beyond the jurisdictions which have adopted it. Many cases are reported in which trial judges are charged with having overstepped the deadline; in others, not always reported, judges who lacked original

power to hold juries within reasonable bounds have felt compelled to set verdicts aside as against the weight of the evidence, and grant new trials. Another allied peculiarity, while scarcely so wide-spread, deserves mention. The conventional common law view has long been that the trial judge, and not the jury, should determine disputes of fact upon which admissibility of evidence depends. So, where a culprit objects to the admission of his confession, claiming it to have been involuntary, the judge normally decides whether or not the statement has been improperly extorted. But under a common American view the judge who admits a confession as voluntary may or must submit over again to the jurors the same preliminary question, instructing them to discard the confession unless they too find it to have been voluntarily made. A similar attitude has been taken with respect to the determinations of fact necessarily preliminary to admission of alleged dying declarations. These illustrations relate to the use of evidence against criminal defendants, and certainly this departure from common law conventions is most frequently encountered in that connection. The resulting complication in the handling of evidence gives rise to considerable controversy before both trial and appellate courts.

Questions of Competency and Privilege as to Witnesses.—The United States, like England, has legislated out of existence many old rules respecting incompetency of witnesses which stood upon outworn historical bases partially obscured by subsequent invention of feeble logical justifications for the rules. But the legislation has not been uniform, and some startling vestiges of ancient disabilities remain. There are courts where one spouse is incompetent to testify in the other's favour. In Federal criminal prosecutions Congress has left the principles of competency so obscure that judges are puzzled, and fundamentally inconsistent lines of cases flourish. Many State legislatures have deliberately preserved a fragment of the old incompetency affecting parties and interested persons. The reference here is to the so-called "dead man" statutes, which seek to protect the estates of decedents from trumped-up claims by survivors. As an illustration, the Nebraska statute says "No person having a direct legal interest in the result of any civil action or proceeding, when the adverse party is the representative of the deceased person, shall be permitted to testify to any transaction or conversation had between the deceased person and the witness." Sometimes similar protection is extended to insane persons; sometimes there are express or implied provisions for waiver by the legal representatives of the person protected. If the topics touched upon under the functions of judge and jury indicate a distrust of judges, the present topic indicates a distrust of the jurors' power wisely to discount evidence given against the interests of those whose lips are sealed by death. A few States do not exclude the testimony of survivors, but require this testimony to be corroborated or relax the hearsay rule with respect to declarations by decedents. The "dead man" statutes figure extensively in litigation.

English law recognizes certain classes of privileged communications, as, for example, between husband and wife and between lawyer and client. More than half the jurisdictions in the United States by statute give privilege to penitential confessions made to a priest, clergyman, or minister. This legislation seems sound. Very often privilege has been extended to communications between physician and patient. Many qualified persons vigorously challenge the wisdom of this last privilege, denying that it makes medical consultation more frequent or frank. The ramifications of the physician-patient privilege have distinctly complicated legal proceedings. Occasionally it has harmed the person it was meant to protect; for instance, where an executor lost favourable testimony from the testator's own physician in an action on a life insurance policy, the court holding that the patient alone could remove the seal of privilege.

The privilege against self-incrimination is enforced in the United States, always or almost always under constitutional provisions. There have been elaborate controversies whether the privilege is violated if a prisoner be required to stand up or speak in court for purposes of identification, to put on a coat, cap, or other garment found at the scene of the crime, or to put his foot or shoe in a track left on the ground. Decisions on such points vary and some refined distinctions have been taken. Generally it is not permissible for either the prosecutor or the trial judge to comment adversely upon a culprit's failure to take the stand in his own behalf. The prosecutor often yields to the temptation to break this prohibition. Numbers of cases involving the point are carried to upper courts after convictions. In certain offences, notably those involving many actors, it is desirable to have means for compelling selected offenders to turn State's evidence. With this end in view, statutes frequently provide that a person may be required to testify respecting such offences, but thereafter either his testimony may not be used against him or he shall be immune from prosecution for the acts he is forced to disclose. Conflicts of authority exist as to the constitutionality of such legislation.

Evidence Illegally Obtained by Government Officers.—Authoritative early American decisions held documents and other tangible evidential material none the less admissible because the offering party had obtained them by illegal means. He might be subject to an action for conversion or a prosecution for larceny, but the possibility of such independent proceedings had no bearing upon the immediate problem of admissibility. This rule was generally taken for granted until after the close of the 19th century. As early as 1886, however, the U.S. Supreme Court made a decision destined to cause wide-spread change. In a Federal information for an alleged revenue fraud the U.S. attorney under statutory provisions compelled the defendant to produce a certain material document. A majority of the Supreme Court held the statute unconstitutional as purporting to authorize an unreasonable search and seizure, and also as violating the privilege against self-incrimination; a minority of two justices differed on the search and seizure point, but concurred as to the self-incrimination. The possibilities of this decision were not much developed for nearly 30 years. Then in a criminal prosecution the same court unanimously held that the trial judge had erred by denying before trial the defendant's petition for return of papers seized in his home by a U.S. marshal without a search warrant or other legal justification, and by admitting these papers at the trial. Further developments marched swiftly and steadily. Case after case before the U.S. Supreme Court suggested multitudinous variants of the original situations. In 1928 an important decision held that evidence of a conspiracy which Federal officials obtained by illegally tapping telephone wires was not inadmissible; four of nine justices dissented. The Federal adjudications led to reconsideration of the old rule by the highest courts of practically all the States. Some of these tribunals embraced the new doctrine under the provisions of local Constitutions applicable to the acts of local officials. The output of cases involving illegally seized evidence has been enormous. Public interest has become excited, particularly because enforcement of the acts prohibiting intoxicating liquor is deeply involved. This episode in the struggle between old-time individualism and growing government regulation is the most spectacular recent development of the American law of evidence.

Confessions.—For years claims have been made that police and prosecutors were wringing confessions from prisoners by promises, threats and actual torture. It is difficult to evaluate properly these claims. On the one hand, accused men trying to escape criminal penalties are unreliable witnesses; on the other, the captors have incentive and power to keep more acceptable adverse witnesses from gaining first-hand knowledge of any such illegal actions. But from judicial decision and from admission by some police officers it is indubitable that these improper activities do largely occur. In 1924 the U.S. Supreme Court reversed a murder conviction for admission of an extorted confession. By way of extenuation, police authorities urge that criminals' interests have been so safeguarded as to make convictions almost unobtainable without use of the so-called "third degree." High quarters have suggested that the situation would be bettered by abolishing or modifying the privilege against self-incrimination.

Opinion Evidence.—Many American cases deal with the fundamentally simple rule excluding certain types of opinion evidence. The situation with respect to expert witnesses is not altogether satisfactory. While the English exceptions to the rule

barring hearsay evidence are mainly identical with those recognized by U.S. courts, the younger country has forced one interesting development which has common sense merits, although it adds to the difficulties of administration. The most frequently cited pioneer case comes from the U.S. Supreme Court. In an action on insurance policies covering the life of A., the underwriters claimed that A. was still living, and that a body produced as A. was really B., whom A. had enticed away and killed to carry out the fraud. The underwriters offered evidence that B. had disappeared and that about the time of his disappearance he had declared in letters an intention to go on a long trip with A. The Supreme Court held that the trial judge had erroneously excluded evidence of the contents of these letters. Under what is now in America a recognized exception to the hearsay rule, the usual expressions of mental condition are competent evidence wherever such condition is material to be proved. The opinion says: "The letters in question were competent . . . as evidence that, shortly before the time when other evidence tended to show that he (B.) went away, he had the intention of going, and of going with Hillmon (A.), which made it more probable both that he did go and that he went with Hillmon, than if there had been no proof of such intention." In the foregoing case the inference was forward from a declaration of present state of mind (intention) to the doing of a future act. Why not infer backward from a declaration of another present state of mind (memory) to the doing of a past act or the existence of a past fact? But if the latter inference be allowed, the hearsay rule is practically erased. Some American courts have carried the doctrine of this case to extremes, but the majority are still within reasonably conventional bounds. It has been necessary, however, in making saving differentiations to employ arguments of a complicated psychological nature, scarcely fitted to the rapid progress of court trials.

General Considerations Affecting Evidence in the United States.—To the foregoing brief survey should be added some general considerations. (1) As the American legal profession is undivided into barristers and solicitors, many cases are tried by lawyers comparatively inexpert in the handling of evidence. (2) In America there is too little spontaneous manifestation of the English doctrine allowing relaxation of the rules of proof by mutual consent or court order. (3) The American trial judge usually does not, and perhaps cannot, drive on so tight a rein as the English trial judge. (4) The United States' scale of fees and costs is pitched so low that litigants can afford to take chances with points not worth while in England. (5) Not all American appellate courts insist upon substantial error as a basis of reversal; occasionally dry technicalities are accepted. These factors have caused the habit of arguing and carrying up cases on evidential points.

RATIONALIZING FACTORS

As a result, there is general distrust of the rules of judicial proof. The lay public is not sufficiently informed about defects and debatable points to express more than blanket condemnation. Many in the legal profession display a perfectly comprehensible complacency; familiarity with the mysteries of a great profession breeds tolerance far more often than contempt. But a considerable amount of constructive criticism emanates from both bar and bench. Another significant group for initiating reforms is composed of law teachers. These are critical because they keep up with comparative law. Between 1842 and 1853 Prof. Simon Greenleaf, of the Harvard law school, published the first great American work on evidence. It has gone through 16 editions, has had vast influence, and is constantly cited. Incidentally, it is the basis of Taylor's English treatise. In 1898 Prof. J. B. Thayer, also of Harvard, published his *Preliminary Treatise on Evidence at the Common Law.* This showed that many rules were outworn or misconceived, carefully discriminated between evidence and other branches of the law, and offered recommendations for the former's improvement. Thayer's was a lonely voice, but as a teacher he influenced hundreds of nascent lawyers. After the death of Thayer one of his students, now Dean J. H. Wigmore of the Northwestern university law school, published a comprehensive scientific study in 1904–05. Prof. J. C. Gray said that it was "the greatest law book since Benjamin on *Sales.*" Its effect on American law has been profound. By sharp, thorough analysis and pungent comment, Wigmore has forced even his opponents to reframe their arguments. He has attracted fresh and powerful minds to the field of evidence, and lifted the dead hand of subservience to history merely because it is history.

SPECIFIC IMPROVEMENTS

Some definite seeds of improvement in the American law of evidence are to be found in some already accepted modifications, in the growth of special tribunals, and in the influence of logical experimentation.

Judicial Notice.—No fewer than 13 States have simplified the problem of proving foreign law as a fact by providing that their courts may or shall take judicial notice of the law of some or all foreign jurisdictions. Commentators have praised the Massachusetts act on the point, which was recommended by that State's judicial council: "The courts shall take judicial notice of the law of the United States or of any state, territory or dependency thereof or of a foreign country whenever the same shall be material."

Res Gestae.—The indeterminate doctrine of *res gestae* degenerated into a formless welter at the hands of American courts. Mr. Justice Holmes, faced with the phrase as a ground for admitting certain evidence, is reported to have said: "I prefer to give articulate reasons for my decisions." Commentators have dissected the tangled mass of cases, enlisted the practical aid of judges, and begun to produce at least partial order and comprehensibility. Wigmore extracted a distinct hearsay exception for spontaneous declarations under emotional pressure which is being widely accepted.

Exceptions to the Hearsay Rule.—English law recognizes a group of hearsay exceptions for declarations by deceased persons under conditions of special credibility. A helpful tendency in the United States is expanding these exceptions to cover similar declarations by persons who, although still living, are insane, out of the jurisdiction, or otherwise unavailable as witnesses. Largely through Wigmore's influence, the judges are liberalizing the doctrine of business entries, admitting records covered by this description without demanding meticulous verification. Only key men who can describe the general process of recording are required to be called. This is a boon as it shortens trials and prevents expensive interruption of work in industry. In 1896 Prof. Thayer made a suggestion which caused the Massachusetts legislature to pass the following act: "No declaration of a deceased person shall be excluded as evidence on the ground of its being hearsay if it appears to the satisfaction of the judge to have been made in good faith before the beginning of the suit and upon the personal knowledge of the declarant." Interestingly enough, Thayer derived his idea from a remark by Mellish, L.J., in the famous English will case of *Sugden* v. *Lord St. Leonards.* Massachusetts judges and lawyers have tested this simplification of hearsay exceptions, and are generally satisfied with it. The neighbouring State of Rhode Island adopted the act with slight verbal revision in 1927.

Parol Evidence Rule and Interpretation.—The doctrines forbidding variation of dispositive documents by prior or contemporaneous agreements excluded therefrom, and limiting employment of extrinsic evidence to aid interpretation, are not, strictly speaking, part of the law of evidence. But they are usually treated in connection therewith, and it is proper to note that Prof. Samuel Williston's restatement of the law of contracts for the American Law Institute will cover both these doctrines.

Special Tribunals.—Before such tribunals as workmen's compensation boards, juvenile courts, etc., there is a tendency to relax rules of evidence.

Psychological Studies.—For years psychologists have tried to find surer methods of getting at legally contested facts; the response reaction tests of Prof. Hugo Münsterberg and Dr. W. M. Marston's blood pressure tests for perjury are among their better-known proposals. In the United States a marked amount of

experiment along such lines is now being conducted. This seems to bear more directly upon the weight to be accorded evidence than upon admissibility of evidence under technical legal rules. Yet many of these rules seek justification in the idea that the evidence or witnesses excluded by them fall into classes of low general credibility; and supposed conditions of special credibility are invoked to justify exceptions to such rules. Hence law teachers and psychologists are working in teams at Yale and Columbia universities to ascertain whether these fundamental classifications and sub-classifications should be accepted as sound. This work has barely begun, but such application of scientific method may ultimately lead to important results.

The topic just touched upon indicates a very real difficulty in bettering rules of evidence. Psychology sounds academic and unlawyer-like. Practical criticism by Wigmore, a law teacher, broke down Münsterberg's early proposals. The law teacher in turn is deemed an unworldly adviser by the active American lawyer. Justification for such distrust must be removed, and the feeling itself allayed, if harmonious progress is to be made. The American Law Institute shrewdly provides for participation by every branch of the profession in the composition of its restatements. When the Legal Research Committee of the Commonwealth Fund put a special committee under the chairmanship of Prof. E. M. Morgan to work on problems of evidence, this special committee spent nearly five years upon detailed enquiry into opinions held by hundreds of lawyers and judges. In the end it unanimously recommended five important revisions of evidential rules. Significantly and encouragingly, the States of New York and Rhode Island have already adopted one of the recommendations. On the whole, there is reason to hope that wise persistence will cause steady, if slow, rationalization and improvement of judicial proof in the United States.

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EVIL EYE. The belief that certain persons can injure and even kill with a glance, has been and is still very widely spread. The power was often supposed to be involuntary (*cf.* Deuteronomy xxviii. 54); and a story is told of a Slav who, afflicted with the evil eye, at last blinded himself in order that he might not be the means of injuring his children (Woyciki, *Polish Folklore*, trans. by Lewenstein, p. 25). In Rome the "evil eye" was well recognized and special laws were enacted against injury to crops by incantation, excantation or fascination. The power was styled *βασκανία* by the Greeks and *fascinatio* by the Latins. Children and young animals of all kinds were thought to be specially susceptible. Charms were worn against the evil eye both by man and beast, and were of three classes: (1) those the intention of which was to attract the malignant glance on to themselves; (2) charms hidden in the bosom of the dress; (3) written words from sacred writings. Of these three types the first was most numerous. They were often of a grossly obscene nature. They were also made in the form of frogs, beetles and so on. Spitting was among the Greeks and Romans a most common antidote to the poison of the evil eye. Gestures, too, often intentionally obscene, were regarded as prophylactics on meeting the dreaded individual. The evil eye was believed to have its impulse in envy, and thus it was unlucky to have any of your possessions praised. It was, therefore, necessary to use some protective or prophylactic phrase such as—Unberufen, absit omen, As God will or God bless it.

The powers of the evil eye seem indeed to have been most feared by the prosperous. Its powers are often quoted as almost limitless. The modern Turks and Arabs think that their horses and camels are subject to the evil eye. Among the Neapolitans the *jettatore*, as the owner of the evil eye is called, is so feared that at his approach a street will clear: everybody will rush into doorways or up alleys to avoid the dreaded glance. The evil eye is still much feared for horses in India, China, Turkey, Greece and almost everywhere where horses are found. In India the belief is universal. Modern Egyptian mothers thus account for the sickly appearance of their babies. In Turkey passages from the Koran are painted on the outside of houses to save the inmates, and texts as amulets are worn upon the person, or hung upon camels and horses by Arabs, Abyssinians and other peoples. One of the most striking facts about superstitions in the New World is that the evil eye seems to be foreign to the whole hemisphere. Its absence is often cited as a good example of the occurrence of unexpected human divergences.

See Johannes Christian Frommann, *Tractatus de fascinatione novus et singularis*, etc., etc. (Nuremberg, 1675); F. T. Elworthy, *Evil Eye* (1895); R. C. Maclagan, *Evil Eye in the Western Highlands* (1902); E. Thurston, *Omens and Superstitions of S. India* (1912); Herklotz, *Islam in India* (ed. W. Crooke) (1921); R. E. Enthoven, *Folklore of Bombay* (1924); W. Crooke, *Religion and Folklore of Northern India* (1926).

EVIRATO: *see* CASTRATO.

EVOLUTION, in arithmetic is the operation of finding a root of a number. The Greeks found the square root of a number by a method similar to the one given in elementary arithmetic and algebra books, and this passed on to or was independently developed by the Hindus. The latter gave rules for the cube root. Higher roots attracted the attention of various writers of the 16th century, the method being based upon the expansion of a binomial. (*See* BINOMIAL THEOREM.) The word "root," the Latin *radix*, is due to mediaeval translations from the Arabic, whence came the idea of "extracting the root," and so Recorde (*fl.* 1542) speaks of "pulling out" a root. The symbol for root is $\sqrt{\ }$, as in $\sqrt{2}$. For roots beyond the square root the *index* is written, as in $\sqrt[3]{5}$ and $\sqrt[4]{9}$. The symbol denotes the *principal root*. Every number has n nth roots, only one of which is indicated by the symbol $\sqrt[n]{\ }$. For example, the three cube roots of 1 are 1, $-\frac{1}{2}+\frac{1}{2}\sqrt{-3}$, and $-\frac{1}{2}-\frac{1}{2}\sqrt{-3}$, but the principal cube root is 1.

EVOLUTION, ORGANIC. At a time when the controversy over evolution, after dying down almost to nothing, has suddenly flared up again in certain backward regions and backward circles, it may be as well to state the main problems briefly and concisely before embarking on a detailed discussion.

The first point to realize is that there is really not one problem, but three problems. There is first the problem of the *fact* of evolution: has evolution occurred or has it not? Secondly, there is the problem of the *method* of evolution: if evolution has occurred, what is the machinery by which it works? And thirdly, there is the problem of the *result* of evolution: again granting that evolution has occurred, can we discover any general rules to describe the course it has pursued, or find any main trends in the process?

The third is really the affair of general or philosophical biology and does not especially concern us here. Suffice it to say that there undoubtedly exist certain general evolutionary tendencies, such as that towards increased specialization, with consequent divergence and multiplication of types. Further, that there does

exist a main trend in evolution, which consists in raising the upper level attained by life in regard to various qualities making for greater control over and independence of the environment; this main trend is generally called biological progress.

But the other two problems are of immediate concern, and it is essential to keep them distinct if the issue is to remain clear. Unfortunately, this is precisely what has usually not been done by many anti-evolutionists. They find a weak spot in some widely held theory as to the method of evolution, and at once proceed to state that the whole idea of evolution is false—a procedure only to be explained as the result of weakness of logic or of intellectual conscience.

It is obviously a good deal simpler to be sure that some process exists and is a fact than to understand precisely how it works and what its underlying machinery may be; and we need not deny the fact because we have not discovered the machinery. As an obvious example, we are very far from understanding the physiological and chemical machinery of development, by which for instance a hen arises from an egg; but that does not cause us to deny the fact that hens do develop from eggs.

It is the same with evolution. Although we know a good deal more about the method of evolution than did Darwin or any of his immediate successors, we are still in doubt as to a great many points. But we are not in the least doubt as to the fact of evolution. Among those who have gone into the evidence, that is to say among competent biologists and geologists, there is not a single one who is not convinced that evolution has occurred and is occurring.

The evidence by now is overwhelming. Details will be given in the body of the article. Here it must suffice to enumerate the main lines. There is the evidence from fossils, which is now in many cases so full and detailed as to constitute complete proof in itself. It is however supported by many other lines drawn from different fields. There is the evidence from vestigial ("rudimentary") organs, which are of no direct use to their possessors, but useful in other animals of the same general construction. It is impossible to account for these on any theory of special creation, but their existence is to be expected on the theory of evolution. The facts of embryology (*q.v.*) afford similar evidence; so do the facts concerning the common plan which is found to underlie the structure of whole groups of animals. The facts of geographical distribution (*see* ZOOLOGICAL REGIONS) are easy to explain on evolutionary principles, difficult or impossible on any other view that has so far been put forward. So are the facts concerning variation both in domestic animals and in nature, and especially the total impossibility of drawing any sharp line between individual variations, local races, sub-species and species (*q.v.*); and further the continuity of life through the generations tells in favour of evolution.

Finally there is the pragmatic value of the evolution theory. The biologist in studying living things, finds that the idea of evolution works and helps him to interpret his facts and to discover new facts and principles; while no other theory so far put forward helps him at all. The idea of evolution is as important a biological tool as, for instance, the microscope.

When we come to the method of evolution, matters are very different, and no final conclusion can be reached until a great deal more experimental and observational work has been done. Details of the main rival theories, will be considered later. Here it will be useful to point out that all such theories must fall into one of four categories (or a combination of two or more of these). First we may suppose that the environment has a direct moulding effect upon the race and racial history; this view is the basis of most Lamarckian theories. Secondly, the environment may have no effect, direct or indirect, evolution occurring as the result of changes which take place in the hereditary constitution for reasons inherent in its own nature; evolution would then be predetermined internally. This is the basis of the more extreme theories which go by the name of orthogenesis. Thirdly, the environment may have an indirect effect, by favouring some of the changes which occur in the hereditary constitution, so helping them to be perpetuated, and frowning on others to help their extinction. This is the basis of the theory of Natural Selection. The variations to be selected may arise either completely at random, or only in certain directions; and they may be "spontaneous," due only to the inherent nature of the hereditary constitution, or they may be caused by outer agencies acting on the constitution. They must, however, be sufficiently numerous and varied for the environment to exert a sifting action upon them. Fourthly, the environment may have an indirect effect, but in a very different way—through the organism's endeavouring to adapt itself to its environment, the effort then altering its structure, and the alteration in structure being finally transmitted, in whole or in part, to subsequent generations. This is the basis of the remainder of the Lamarckian theories not covered by our first alternative. Of these theories, the first and the fourth demand the inheritance of acquired characters (*see* LAMARCKISM) as a prerequisite to their working; modern research leads us to believe that neither Lamarckian view is true.

The other two do not need the inheritance of acquired characters to be workable. In the present state of knowledge, it seems probable that the third method, of natural selection, is the main agency of evolution, though determinate variation (theory No. 2) may play some part. The most important problem before the evolutionist to-day is to discover how heritable variations originate, and to what degree they fall short of occurring at random but are limited by the nature of the hereditary constitution in which they occur.

It is often asserted by irresponsible persons that "Darwinism is dead." This is very far from being the case. In so far as Darwinism was a reasoned assertion of the fact of evolution, it is much more firmly grounded to-day than it was in Darwin's own time, and every year brings fresh evidence in its support. Only in regard to the nature of the variations which are to be selected has the theory of evolution by Natural Selection suffered any important modification; in other respects it remains unshaken.

(J. S. H.)

The idea of evolution has penetrated many other departments of thought. Anthropology and ethnology are permeated with it, and so are history and comparative religion. Modern psychology recognizes that the human mind is unintelligible without an evolutionary background. The idea of evolution has re-emphasized our kinship with the animals; it has dethroned man from his position as lord of creation; but in place of the old idea of fixity it has given us the idea of the possible advancement of the human race, and of man as the trustee of future evolutionary progress.

THE THEORY OF EVOLUTION

From the earliest times man must have speculated on the nature and origin of the multitude of living creatures, both plants and animals, which people the surface of the earth. Some have assumed that the diverse forms with their different shapes and sizes, properties and habits, were each specially created, probably to fill a particular place and serve a special purpose; others preferred to consider them as the gradually developed products of nature.

According to modern doctrine, evolution and the diversity we see around us are due to the action in the past of "natural causes," which can be observed still at work in the present. This conception has been applied to the whole cosmos including both living and non-living things; but in this article we are concerned only with the evolution of living organisms.

Although in the 18th and early 19th centuries many naturalists, notably Erasmus Darwin and Lamarck, maintained that the various forms of life have evolved from one another by some process of transformation, it was not till the middle of the last century that Charles Darwin succeeded in establishing the doctrine of organic evolution on a thoroughly scientific basis. This work of Darwin has been one of the greatest triumphs of modern science. It marks an epoch in human thought, for not only has the doctrine dominated ever since all the sciences dealing with living things, but its effect has penetrated to all regions of scientific enquiry. To secure this success every sort of opposition, religious prejudice and intellectual inertia had to be overcome, and not the least resistance was due to the concept of "species" (*q.v.*) held by naturalists themselves.

Species.—This idea of species we owe chiefly to Ray (1628–1705), who first endeavoured to define species as composed of individuals derived from common parents and possessing the same constant well-defined "specific characters." Ray's work was later extended and completed by Linnaeus (1707–78), who founded the modern system of classification and nomenclature. He grouped all known plants and animals into species, genera, families, orders and classes, insisted on the objective reality of species, and introduced the binomial system whereby each was called by a Latin specific name added to that of the genus to which it belonged. Thus man was designated (genus) *Homo* (species) *sapiens*. This was a great practical advance. Organisms could now be more easily described, classified and compared, the floras and faunas of various countries could be contrasted, living could be compared with extinct fossil forms. But the adoption of this system was attended by serious dangers. To Linnaeus and his followers the "species" became the unit of creation; it was assumed to have been separately created at the beginning and to have persisted more or less unchanged ever since. All organisms were supposed to belong to species, clear cut, definable; there could be no transition between them. Thus from a convenient practical classification arose a rigid dogma which for long held a dominant position, especially among systematists concerned with the identification and classification of animals and plants. This dogma was accepted by the world at large, and its effects have not yet entirely worn off even in learned scientific treatises. One of the most important results of Darwin's work has been the destruction once and for all of the foundations on which was built the dogma of the immutability of species, and indeed the belief in the very existence of such definite units in nature.

It is now universally held by competent biologists that all organisms, living or extinct, have arisen from remote common ancestors by a process of gradual change or evolution, and further, that living matter or "life" itself, in all probability arose from non-living matter in the first stages of this evolutionary process. The only doubt which remains concerns the exact steps in the process, and the nature and relative importance of the various factors which have contributed to it.

THE CHEMISTRY OF LIFE

Characteristics of Living Organisms.—If organic evolution has taken place, it must be living matter that has evolved. Let us, therefore, examine what living organisms are composed of, what properties they have in common, how they can be distinguished from non-living matter. An analysis shows that organisms are entirely composed of the ordinary elementary chemical substances found in their inorganic surroundings, but that these elements are built up into highly complex compounds of peculiar molecular structure, and occurring only in living organisms or in their products. These compounds may be grouped in order of complexity into three classes: carbohydrates, fats and proteins. The molecule of a carbohydrate (such as sugar, starch, cellulose, etc.) is formed entirely of the elements carbon, hydrogen and oxygen; likewise the molecule of fat which is, however, more complex in structure. Proteins are the most important of these substances, since their molecules contain nitrogen and sulphur in addition to carbon, hydrogen and oxygen. To these essential elements are added small quantities of phosphorus, iron, potassium, sodium, calcium, magnesium and chlorine. The molecules of a protein are, therefore, very large and may contain many hundreds of atoms in combination, some of which form subordinate groups within them. With every increase in size and complexity, these organic molecules acquire new and often very important properties. For just as the chemical combination of atoms of oxygen and hydrogen into molecules produces a substance, water, with new physico-chemical properties not possessed by either of its constituents, so with every advance in molecular structure will new properties emerge. Many of these new properties displayed by large and complex molecules are of the highest importance in the carrying out of the functions of life.

Living organisms feed, breathe, grow and reproduce. The most characteristic property of living matter is its capacity to undergo perpetual change, and this fundamental process going on in all living things we call metabolism. It involves a perpetual transformation of material and energy. Speaking generally, animals are continually taking in food and oxygen and giving off waste products which are got rid of by excretion. The food consists chiefly of carbohydrate fats and proteins, high compounds in which the energy used in building them up is stored as potential energy which may be freed and transformed into motion or kinetic energy when these substances are again broken down into simpler compounds. This breaking down is brought about by their oxidation or burning by means of the oxygen taken in in respiration. All material entering the organism as food and oxygen eventually leaves as waste products (carbon dioxide, water and urea), except in so far as some is retained for repair and growth. All the energy brought in is balanced by work done in the performance of the animals' various activities, and by heat given off. During the whole process of metabolism, no matter or energy is either produced or destroyed, but merely transformed. One of the most fundamental generalizations of modern biology is that the principles of conservation of matter and the conservation of energy hold good in living organisms as they do in the inorganic world.

What has been said above of metabolism in animals applies also to plants. But whereas in animals the powers of synthesis are restricted to the building up of their substance from organic materials, most plants can form carbohydrates, fats and even proteins from the simplest inorganic compounds. Thus green plants, with the help of chlorophyll, can build up starch from water and atmospheric oxygen by a synthetic process in which the energy of sunlight is absorbed, and can synthesize protein by the addition of simple salts of nitrogen derived from the soil. Many of the lowest plants (Bacteria) can build up proteins without chlorophyll from inorganic compounds, and some can use the free nitrogen of the air. Thus carnivorous animals depend on vegetable feeders, these in turn on plants for nutriment, and ultimately all living matter is derived from the non-living matter of the environment.

Now in the living organism the food does not all pass through merely as fuel; the machinery itself is involved in the process of change. The food serves to build up the complex living substance, part of which is perpetually being broken down again into non-living matter. The highest compounds are unstable, and the complete process of metabolism includes a double process of building up and breaking down. Energy is stored in the first and freed in the second. The organism has at its disposal the excess of energy set free by the oxidation of the food material over that required for the working and upkeep of the machinery. There is thus in living substance a mixture of compounds, some leading up to the highest complexity and others leading down to the waste products, and this mixture of substances undergoing these physico-chemical changes constitutes the living matter known as protoplasm, well named by T. H. Huxley, the physical basis of life. Protoplasm, the essential living substance present in all living organisms and the seat of all their activities, is a viscid colourless substance of granular appearance under the microscope, being apparently formed of minute globules suspended in a more fluid medium. Dead protoplasm can be analysed into a variety of proteins associated with mineral salts. Suspended in the protoplasm may be found granules of food material about to be used up, various products of its own activities, and waste material about to be rejected.

The most characteristic properties of living matter are irritability, growth and reproduction; they all depend on metabolic processes taking place in protoplasm. Like other physico-chemical processes, metabolism is limited by definite conditions. The essential elements, food, oxygen, water, must be present, and it can only take place within a certain range of temperature, not so high as to coagulate or destroy the proteins, or so low as to stop chemical action. Usually the metabolic processes take place with the help of certain proteins known as ferments or enzymes (*q.v.*), which hasten and facilitate chemical action. It has recently been proved that for the carrying out of many processes, special compounds called vitamins (*q.v.*) are necessary.

A living organism may be likened to a whirlpool—new non-

living matter is always being brought in from the outside, caught up and moulded into protoplasm, and passed out again at the periphery as dead matter having yielded the energy necessary for its activities. All the phenomena of life on which these activities are based are strictly determined and limited by external conditions on the one hand, and the properties of the materials taking part on the other. Protoplasm is not one particular chemical compound, but a mixture of substances; some are materials about to be built up, others the products of their decomposition. This life process forms a chain of interdependent actions, every link of which is essential, and the full attributes of life are displayed only by the whole series of substances and their interactions in the process. No single link by itself can be said to be living; no hard-and-fast line can be drawn between the living and the non-living. There is no special living chemical substance, no special vital element differing from dead matter, and no special vital force can be found at work. Every step in the process is determined by that which preceded it and determines that which follows.

That universal property of living organisms known as irritability, or the power of responding to a stimulus, brings them into relation with their environment, and depends on the fact that protoplasm is in a state of unstable equilibrium which can be disturbed by changes in the surrounding conditions. Neither the amount nor the character of the response, *i.e.*, the resulting change in metabolism, is directly related to that of the stimulus, but both are determined by the structure of the mechanism stimulated and the amount of energy stored in it. Thus, just as the pressure of a button may cause a bell to ring or an engine to start, so a given stimulus may cause a plant to grow or an animal to move. But there is an internal environment as well as an external environment, for the various parts of an organism may react on each other. One organ may stimulate another and so regulate its action, as does, for instance, the governor of a steam engine. Thus may arise a series of co-ordinated responses started by a single external stimulus. A special organ for securing this result is seen in the nervous system of animals; but in all organisms the various parts are closely interdependent, and special substances, hormones (*q.v.*), may be secreted by one organ to regulate the action of another. This integration of parts is one of the most striking characteristics of living organisms, and becomes more and more perfected in the higher forms.

A living organism, then, from the point of view of the scientific observer, is a self-regulating, self-repairing, physico-chemical complex mechanism. What, from this point of view, we call "life" is the sum of its physico-chemical processes, forming a continuous interdependent series without break, and without the interference of any mysterious extraneous force. It is true that we are still far from being able to give a complete scientific explanation of all the processes involved, but their analysis is pushed further every day, and there is no good reason to believe they are not all capable of such explanation.

First Steps in Evolution.—Although we are ignorant of the origin of life, we may suggest what may have been the first steps in its evolution. It used to be thought that simple organisms, such as the Bacteria of putrefaction and fermentation moulds, Infusoria and even small worms, arose spontaneously *de novo* in liquids containing dead organic matter (theory of abiogenesis [*q.v.*]). But Pasteur and others in the last century definitely proved that such creatures arise only from living germs or spores already present in the liquids, and that no organisms of any kind will appear and no putrefaction take place in substances in which the germs have been killed and from which new germs have been rigidly excluded. The important principle of biogenesis (*q.v.*) was thus established, according to which all living organisms are derived from pre-existing living organisms without break. It is one of the chief foundation stones of the modern doctrine of organic evolution.

But although this principle of continuity applies to all organisms at the present day, which have a long history behind them and have no doubt departed greatly from the initial stages in the evolution of living matter, there must have been a time when protoplasm first appeared. It must be supposed that long ago, when conditions became favourable, relatively high compounds of various kinds were formed. Many of these would be quite unstable, breaking down almost as soon as formed; others might be stable and merely persist. But still others might tend to reform, to assimilate, as fast as they broke down. Once started on this track such a growing compound or mixture would inevitably tend to perpetuate itself, and might combine with or feed on others less complex than itself. These first steps in the elaboration of living matter probably occurred in the sea, for protoplasm contains the same salts as sea-water and in much the same proportions.

UNITS OF LIFE

Cells.—Protoplasm is necessarily a constituent of every living creature, but the organism is not entirely made up of it, and much of its bulk may be composed of substances about to be built up into protoplasm or of the accumulated dead products of its past activity, such as the woody tissue of a tree, the hard substance of bone, the skeleton of a coral. Only that part of an organism is truly alive which is protoplasmic, and the protoplasm normally exists in the form of "cells." The cell is a small, usually microscopic, mass of protoplasm, consisting of a nucleus and surrounding cell-body. It is generally enclosed in a cell-wall formed of its own secretion. Plants and animals are made up of such cells either singly or in aggregates. Growth is due to the increase in size and multiplication of the cells. They do not grow indefinitely, but each, having reached a certain bulk, divides into two daughter-cells. All the cells composing the body of an individual are thus derived by repeated binary fission from a single original cell. Cells may become differentiated and may acquire parts adapted for performing various functions. Differentiation in multicellular forms is related to the progressive division of labour among the cells, comparable to the division of labour among the individuals of a community, and is accompanied by specialization for the performance of special functions. The body of a multicellular plant or animal is thus an aggregation, not of separate units brought together, but of a multitude of related cells remaining in association and building up its tissues. As a rule the tissue-cells remain in actual protoplasmic continuity by slender connecting bridges; but in animals, certain cells may become free, as, for instance, the white corpuscles of the blood. The activity of an organism is the sum of the activities of its component cells. It is probably to enable oxygen and food to reach all parts, and waste substances to escape, that the protoplasm is thus subdivided into small masses. Moreover, there is interchange of material between nucleus and cell-body, and the relative size of the two must be kept within certain limits. The contents of the nucleus (nucleoplasm) and those of the cell-body (cytoplasm) differ considerably from each other.

Both body and nucleus are necessary for the life of a cell; one cannot live without the other. If a cell is divided into halves, only that with the nucleus will continue to live, grow and reproduce. Among true plants and animals such a cell is the smallest unit of life. But in the Bacteria, doubtfully classified as plants, there is no well-defined nucleus, the chromatin being scattered. Possibly they are the surviving representatives of a primitive stage before the typical cell structure was differentiated.

In the lowest plants, Protophyta, and the lowest animals, Protozoa (*q.v.*), the individual generally consists of a single cell, capable of performing all the functions of life and consequently often provided with highly differentiated cell-organs. Such a unicellular individual may assimilate, grow, reproduce, move and regenerate lost parts. But in the multicellular plants, Metaphyta, and multicellular animals, Metazoa, as differentiation advances, the various cells may become specialized to perform certain functions, and correspondingly unable to carry out others. More especially in animals do cells become so specialized (to form nutritive, nervous, muscular, excretory, skeletal and other tissues) that they can no longer continue to live except in association with each other, supplying each other's wants. They tend to lose the power of reproduction and usually are only capable of giving rise by division to cells like unto themselves.

A unicellular organism does not increase indefinitely in bulk; when it exceeds the size normal for the full-grown individual of

the species, it tends to divide into two. The nucleus divides first, then the cell-body; the resulting two daughter-cells, each with its own nucleus, then separate and grow into adults similar to the original parent. It is the same with the cells of higher organisms. Each multicellular plant or animal starts as a single cell rich in unspecialized protoplasm, which grows and divides repeatedly, and at every division half of the nucleus passes into each daughter-cell. But here, instead of the cells separating, they remain closely associated as parts of a single complex individual. Thus every cell is derived from a pre-existing cell, and every nucleus from a pre-existing nucleus.

Mitosis.—The behaviour of the nucleus and of the chromatin during cell-division is so important with regard to heredity and evolution that it must be described in further detail. It is the nucleus that initiates the division which takes place by a remarkable process known as karyokinesis or mitosis (*see* CYTOLOGY). In the resting stage the chromatin is dispersed within the nuclear membrane in the form of granules or an irregular network. At the start of mitosis the chromatin gathers into coiled threads which break up into definite pieces—the chromosomes. Each chromosome soon splits longitudinally into two equal halves. Meanwhile, from a small mass of denser protoplasm situated close to the nucleus and known as the "central body" or "division centre" (often containing a central granule or centrosome), generally arise delicate radiating fibres (aster). By the division of this body are formed two "division centres" which move apart to the opposite poles of the nucleus, while a central spindle of fibres develops between them. The nuclear membrane having by this time disappeared, the chromosomes become arranged in a ring round the equator of the spindle. The two halves of each chromosome now separate and travel to the opposite poles of the spindle. There they again form coiled threads and break up into granules, the systems of fibres disappear, the nuclear membranes are restored, and thus two new nuclei are reconstituted similar to that of the parent-cell. Division of the cell-body then yields two nucleated daughter-cells. It is very important to notice the continuity of substance during this process. Cytoplasm, nucleoplasm, central bodies and chromatin are all parcelled out to the daughter-cells. Above all, each daughter-nucleus receives the same number of chromosomes, and apparently exactly the same amount of chromatin.

Apart from some exceptional cases, and certain differences in detail, the process of normal cell-division and mitosis is essentially the same in all plants and animals. The same number of chromosomes appear at every division, hence every nucleus in the body of a multicellular organism contains the same number (except the germ-cells as explained below). Moreover, the number of chromosomes may differ widely even among allied forms, but is normally constant within each species.

CONTINUITY AND PERPETUATION

Sexual Reproduction.—If organisms did not reproduce and multiply, they would sooner or later be extinguished, if not by natural, at all events by accidental death. For this purpose they must separate off some portion of their body capable of growing into a new individual. This gives rise to some method of vegetative or asexual reproduction, or to sexual reproduction. We have already seen that unicellular organism can multiply by mere fission into two; similarly in the simpler multicellular plants, such as the fresh-water alga *Vaucheria* or the fungus *Mucor*, every cell is capable of growing into a new plant. But in many forms special reproductive cells (spores) or multicellular bodies (gemmules and buds) are set apart for the purpose, often in vast numbers. Propagation by shoots developed on runners or tubers is common among the higher plants, and a very similar method of bud-formation is widely distributed among animals such as sponges, polyps and sea-squirts. In the Bacteria, indeed, fission and spore-formation seems to be the only method of multiplication; but in all other groups of plants and animals, sexual reproduction occurs, though the asexual method may also be retained.

The typical sexual reproduction of plants and animals takes place by special cells of two kinds set apart and liberated for the purpose, and called the reproductive cells, germ-cells or gametes. Each gamete of one kind gives rise by fusion with a gamete of the other kind in the process of fertilization, to a single cell, the zygote, which grows into a new individual. Usually the two kinds of cell become differentiated along divergent lines adapted to the functions they have to perform. One, the ovum, is quiescent, large, stored with food-material for the nutrition of the developing embryo to which it will give rise. The other, the spermatozoon of animals or spermatozoid of plants, is small, motile, and usually furnished with a head containing the nuclear material, and a vibratile flagellum or whip-like "tail," with the help of which it swims towards and bores its way into the ovum. An individual bearing ova is of the female sex (♀); one bearing spermatozoa is of the male sex (♂). But the terms male and female are often conveniently extended to the gametes themselves. Hermaphrodites give rise to both kinds of germ-cells.

In fertilization one male gamete fuses with one female gamete; and not only do their cell-bodies unite, but their nuclei also combine into one nucleus. Thus the nucleus of the resulting zygote contains chromatin derived from two individuals, since the gametes usually come from different parents; for it is only exceptionally that hermaphrodites are self-fertilizing. Unsuccessful male gametes, which do not reach an ovum, perish; and likewise unfertilized ova die, except in those rare cases where parthenogenesis (*q.v.*) occurs (among lower plants, insects, etc.).

The significance of fertilization is great: on the one hand it provides a stimulus to the ovum for renewed activity and development, on the other it combines two streams of hereditary substance.

The evolutionary history of sex (*q.v.*) is not yet known. Among unicellular forms sexual reproduction may be of a much simpler kind than that described above. For instance the gametes of the two sexes may differ little or not at all from each other, and among unicellular forms two ordinary individuals may act as gametes coming together and fusing to form a zygote. These simpler modes of fertilization may not represent actual stages in the evolution of sex, but give some notion of how sexual reproduction may have developed. Since typical fertilization occurs among both plants and animals it is probably a very ancient process, already fully developed in the common ancestors of all these organisms. It may have originated at a remote time in the history of protoplasm, when it was possibly beneficial for two masses of living material of slightly different constitution to mix and combine their properties.

Among the lowest multicellular plants, the Algae, there are forms in which every cell, or almost every cell can act as a gamete or give rise to gametes, and so share in the making of a new generation. But there is an increasing tendency among higher plants, and especially in animals, to restrict the reproductive function to certain cells, which may be set apart at a very early stage in the embryo and often become localized in special organs or gonads. Thus arises a distinction between germ-cells, destined to give rise to gametes, and body or somatic cells devoted to vegetative functions. On such facts is based Weismann's theory of the continuity of the germ-plasm, the most valuable conclusion of which is that germ-plasm, that substance which is passed on from generation to generation by the gametes, can be traced back through an unbroken lineage of relatively undifferentiated cells to the original zygote, and to a certain limited extent can be said to be independent of the body or soma which harbours it. Whereas the rest of the multicellular organism, the soma, undergoes differentiation and eventually dies, the germ-cells continue for ever giving rise to new generations. Such considerations bring us to the subject of the origin and biological significance of death.

Death.—The question arises whether natural death, as distinct from death due to accident or disease, is an essential and inevitable attribute of life; whether all living creatures necessarily grow old and die. Certainly the living mechanism must wear out, and downward changes must take place in the course of metabolism; but so long as these are sufficiently compensated and repaired they need not lead to death. The Bacteria and unicellular

organisms which can multiply by simple fission may go on doing so indefinitely so long as environmental conditions are favourable. The individual may be said to disappear in the splitting, but it divides into two living individuals—there is no corpse. Such organisms may become weakened and eventually killed by the accumulation of their own waste products; there appears to be no reason, however, why growth and division should ever cease provided the conditions remain favourable, waste products are removed, and a sufficiency of food-material and oxygen is supplied.

Natural death, then, does not necessarily occur among unicellular organisms if the essential mechanism of life, and more especially the nucleus, is continuously or periodically repaired. They are potentially immortal, and the same may be said of the germ-cells of higher forms. Death appears among living organisms when the soma becomes differentiated from the germ-cells. The soma dies, but the germ-cells continue to live and multiply, transmitted from one mortal parent to the next. But why, it may be asked, should the soma die? Even the soma might conceivably go on living for ever provided the conditions were favourable and the wear and tear of life continually repaired. That somatic cells are capable of indefinite growth and multiplication seems proved by recent experiments on their artificial culture. Fragments of animal tissues have been kept alive for countless cell-generations by periodic transplantation to fresh nutritive medium (*see* TISSUE CULTURE) and it is well known that plants can be propagated indefinitely from cuttings. But it is one of the penalties of specialization that organisms in adaptation to particular modes of life tend to acquire a definite, suitable shape and size. However well-regulated they may be, those essential proportions between surface and volume can hardly be so well preserved, that nice co-ordination of parts, that power of repairing waste and injuries, can hardly be so accurately adjusted as to continue working smoothly for ever. To reach the condition of sexual maturity, to preserve the life of the individual long enough to ensure reproduction, is all that is essential for the continuance of the race. And so we find that the length of life of an organism becomes adapted to its needs, and the energies of the individual are exhausted in securing the success in life of the next generation. For instance, many animals in the colder regions live only for one season, leaving behind them their eggs to survive the winter and develop next year. Frequently the male sex dies as soon as fertilization has been accomplished. A definite relation can be traced between the length of life of the individuals of a species, the number of young produced and the care required to bring them up. Thus the longevity of an organism is bound up in evolution with its method and rate of reproduction.

If we have insisted in the foregoing paragraphs that living organisms are the products of a continuous uninterrupted stream of ever-changing and ever-growing substance, that every organism is derived from a pre-existing organism, every cell from a pre-existing cell, every nucleus from a pre-existing nucleus, and indeed, all chromatin from pre-existing chromatin, it is because this principle of continuity is the very foundation rock on which is built the modern doctrine of organic evolution.

As a matter of history it was not this principle which led, in the last century, to the widespread acceptance of the evolutionary interpretation; at that time, indeed, most of the evidence for it had not yet been discovered. Rather was it the cumulative, but indirect, evidence derived from the study of the classification, comparative anatomy, embryology, geographical distribution and palaeontology of animals and plants, as well as from the study of variation and heredity, subjects then first coming into prominence.

THE DARWINIAN THEORY

Darwin.—Previous to Darwin those naturalists who advocated the theory of transformation laid stress sometimes on the cumulative effects of external conditions, sometimes on the action of assumed internal factors, and at other times on the guiding influence of more mysterious perfecting principles. All such speculations failed to convince, being either obviously inadequate, or calling in evolutionary forces of which no scientific explanation could be given and the existence of which could not be proved. Lamarck insisted on the direct effect of environment as the main cause of evolution in plants, but to account for that of animals brought in other factors such as their direct response to new needs and new habits. He conceived that efforts, habits, use and disuse of organs induced changes in the individual which could be inherited by the progeny and so lead to transformation and evolution. But his theories were not worked out in scientific detail, involved many assumptions and some contradictions, and failed to carry conviction (*see* LAMARCKISM).

It was Charles Darwin who, by the patient collection of a vast array of significant facts concerning all sorts of organisms, living and extinct, first clearly showed in his immortal work *The Origin of Species* (1859) how overwhelming is the evidence that evolution has really taken place, and how impossible it is to account for the facts on any other hypothesis. But his great merit is to have made it clear that evolution may be accounted for as the result of "natural causes," which can be seen at work at the present time, can be tested by observation and experiment, and leave no room for any mysterious governing causes or interfering forces in addition.

Darwin and Wallace simultaneously discovered the great principle of natural selection, the keystone to the Darwinian explanation of the method of organic evolution, which may be described in Spencer's phrase: the survival of the fittest in the struggle for existence. It was shown that organisms vary, that these variations may be inherited, that—in competition with others—those which vary in an advantageous direction are most likely to survive and to leave progeny behind them, and that this must inevitably lead to a cumulation of variations and evolutionary change. According to Darwin, then, the chief factors which contribute to the process of evolution are variation, heredity and the struggle for existence. To their combined action he gave the name "natural selection" (*q.v.*) in analogy with the similar process of artificial selection carried out by man on domestic plants and animals. For the breeder, by continually selecting and breeding from those individuals which varied in directions favourable to his purpose and fancy, has been able to transform their characters (bodily and mental) and so bring into being various races differing from each other and from the parent stock even more than do species in nature.

While the validity of the theory of natural selection cannot be denied, its importance and that of the different factors contributing to it in the general process of evolution have been and still are variously estimated. These factors may now be examined in more detail.

VARIATION

Variation from the mean is universal; no two individuals are exactly alike in every detail however closely they may be related. Parents and offspring, brothers and sisters differ from each other, and the differences are called variations. The characters of organisms are all those qualities and properties whereby we can describe them and distinguish them from each other, such as shape, size, colour, mental capacities and so on, and all these are variable. Variation, in fact, affects every sort of character, structural or functional; and occurs at every stage of life. If these variations are measured and arranged in order of size, from the smallest to the largest, it is found that the medium measurements are the most frequent and that measurements became rarer and rarer towards the two extremes. In other words, out of a number of individuals closely related or belonging to the same species, the majority approach the mean, and the more they deviate from the mean the rarer they are (*see* VARIATION, BIOMETRY).

Coming now to the cause of these variations, we find that they are really of two kinds and due to different causes; but to understand the nature of variability we must analyse it further in the light of heredity. When a character of the parent reappears in the offspring it is said to be inherited. There is, of course, a physical basis, a mechanistic aspect of heredity as of the other phenomena of life. The reason why like gives rise to like, why the reproductive cells of, say, a snail, a fly and a fish, all developing under the

same conditions in the same pond, reproduce the same bodily structure, the same functional capacities, the same psychological powers, the same complex individuality as their respective parents, is because they are each composed of the same protoplasm as their parents. Therefore, under approximately similar conditions of environment, they are bound to develop into approximately similar organisms. This special protoplasm, peculiar to the particular organism concerned, is transmitted by the reproductive cells; there is a direct continuity of substance, and only thus can the characters of one generation be made to reappear in the next. Hence the fundamental importance of the principle of continuity insisted upon in previous paragraphs.

We may distinguish, then, two sets of factors contributing to the formation of every organism: on the one hand the substances (germ-plasm) actually transmitted, on the other hand the factors of the environment or conditions under which it develops. The former may be called factors of inheritance. Every organism and every part of it is the result of the interaction of the factors of inheritance, and the conditions or stimuli which influence its metabolism and hence its differentiation, growth, behaviour. Every character is thus of the nature of a response to stimulus, and the characters of an organism are the sum of its past responses. Factors of inheritance are transmitted; characters, however, are not transmitted as such, but are inherited, formed anew in every generation. It is important to realize this distinction. Clearly, if both the conditions and the factors of inheritance remain the same there will be no variation and, consequently, no evolution. Variation, *i.e.*, deviation from the parental form, must be due to some change, either in the factors, or in the conditions, or in both.

It is a matter of common observation that individual organisms are to some extent modified by altering environmental conditions, becoming changed when transferred from one environment to another, by the application of new stimuli, by use and disuse. Plants offer obvious examples of such effects, and often come to vary markedly from each other owing to differences of light, temperature, moisture or the composition of the soil. The same species, even the same individual, may take on a different aspect if cultivated in the garden or grown in the open. Animals are likewise modified and caused to vary in structure or behaviour; but usually to a less extent, especially the more elaborately organized higher forms. For in these the metabolic processes are to a greater extent regulated by the internal environment, so that the effective stimuli are more constant and less easily altered. Yet they are no exceptions to the rule, and there are many examples among animals where conspicuous differences are induced by changes in the environment. This plasticity or modifiability, this power of responding in different ways to stimuli of various kinds, or of varying intensity, is a property of all living organisms and a cause of variation.

Now, Lamarck and the older writers assumed that such acquired modifications can be transmitted in some way from parent to offspring, that they tend to increase from generation to generation by a process of cumulation which leads to the transformation of organisms and to their evolution. Such an assumption is not justified. As Weismann first showed, there is no proof that modifications are transmitted, and no good reason to believe that they are cumulative.

An artificial distinction is often drawn between characters, some of which are said to be "acquired" as the result of the direct action of conditions, and others said to be "innate." But since all characters, as explained above, are the result of the interaction of the transmitted factors of inheritance, with the environmental stimuli encountered, this distinction cannot hold good.

It may be concluded that the reason why two organisms resemble each other is because they start with the same complex of germinal factors of inheritance and develop under the same environmental conditions. Hence, if either the factors or the conditions are altered, variation will result. What may be called the normal bodily and mental structure is that which develops under the usual complex of environmental stimuli. When some deviation occurs and this variation is due to a change in conditions, it may be called a *modification;* when it is due to an alteration in the factors of inheritance it may be called a *mutation.* Thus, although there is only one kind of character, there are two causes of variation. Both may give rise to new characters which may be inherited and reappear in following generations. The mutation will necessarily reappear if the environment remains unchanged, since the factors of inheritance are actually transmitted. So will the modification reappear, although not transmitted, if the conditions which called it forth persist, if the necessary stimuli are present; but it will not reappear if these stimuli are absent. It follows that a new mutation will be inherited in a constant environment, but that the inheritance of a new modification depends on the presence of the necessary conditions. The point of prime importance to notice is that mutations, being due to lasting alterations of the factors of inheritance, will be persistently inherited; and by the addition of new mutations may lead to evolution.

To avoid ambiguities, many authors now use the terminology of Johannsen: the material factor of inheritance is called a *gene;* the word *genotype* is used to signify the whole complex of genes possessed by an organism, and the word *phenotype* to denote the form derived from it, the sum of its characters. The phenotype is moulded by the environment; different environments will give rise to different phenotypes. The more plastic or modifiable the genotype, the greater will be the number of possible phenotypes and the greater the difference between them. Genotypes are transmitted, phenotypes are (may be) reproduced.

HEREDITY

Genetics.—The subject of heredity (*q.v.*) and the details of its mechanism are dealt with in another article, but some account must be given here of the chief results of the modern science of genetics, founded by G. Mendel, in so far as they help us to understand evolution.

In sexual reproduction the specific substance containing the essential factors of inheritance must be transmitted in the germ-cells, and it has now been shown that it is present in their chromosomes, and is carried by the gametes of both sexes, since inheritance is equal from both parents.

If two individuals of a species differing from each other by some contrasting character, say a white-flowered or a red-flowered snapdragon, are crossed, their progeny will have pink flowers unlike those of either of the parents. If, now, two of these pink-flowered "hybrid" or F_1 generation, are interbred, they will produce offspring (F_2 generation) of three kinds, with white, pink and red flowers, and in the proportion of one: two: one respectively. The white-flowered individuals will breed true and continue to breed true if interbred, and similarly the red-flowered individuals; but the pink-flowered will never breed true. If the pink are interbred they will, at every generation, give rise again to the three kinds and in the same proportion. It is concluded that the appearance of the white or the red character in the phenotype is due to the presence in the zygote of either white-determining or red-determining factors transmitted from the parents; and that the appearance of the pink character is due to the presence of both a white- and red-determining factor in the same zygote. Further, it is concluded that the factors in a zygote are in pairs, one received from the paternal and one from the maternal parent, that in the formation of gametes only one kind of each of the pair of contrasting or alternative factors can pass into each gamete, and that, therefore, the factors are *segregated* and so distributed to the individual gametes. The zygote or individual bearing the pair of similar factors is called a homozygote, that bearing the pair of dissimilar factors is called a heterozygote. That the above conclusion is correct may be verified by "back-crossing" a heterozygote with a homozygote, when the resulting offspring will consist of homozygotes and heterozygotes in equal numbers. Frequently the heterozygote resembles one or other of the parents more or less completely; for instance, all the F_1 offspring of a cross between a black and a white (albino) mouse will be black. In such cases that factor of the pair which is expressed in development so as to mask the effect of the other, is said to be dominant, and that factor whose effect is masked or prevented is said to be recessive. A mouse homozygotic with regard to factors determining black-

ness is a pure dominant, one homozygotic with regard to factors producing whiteness is a pure recessive.

The Chromosome Hypothesis.—Cytology (*q.v.*) has revealed the mechanism for the segregation and distribution of these factors or genes. It was stated above that the number of chromosomes is constant in a species and reappears at each divison of the nucleus. There is evidence that the genes are arranged in a linear series, so that at each division, when the chromosomes split longitudinally, every gene is divided and each daughter-chromosome receives a complete set of genes similar to that of the parent-chromosome. However numerous the cell-divisions, therefore, the resulting nuclei remain the same as regards the factors of inheritance contained in them. Now it is clear that when two gametes join in fertilization the zygote so formed would contain double the parental number of chromosomes, were not some device adopted for reducing them. This is brought about in the history of the germ-cells by a "reduction division" of the nucleus in the course of which the chromosomes, instead of splitting into two, combine in pairs and then at division merely separate again to be made up into the two daughter-nuclei. Thus each of the resulting nuclei has only half the usual number of chromosomes found in the ordinary somatic cells. On fertilization this full number is restored. The total inheritance received by an organism is the sum of the factors transmitted to it from its parents by their gametes. The factors or genes are independent units capable of growth and multiplication; are stable, separable, capable of being independently transmitted, segregated in the gametes, and recombined in the zygotes. They preserve their identity and properties when entering or leaving combinations with other genes. They form essential links in the metabolic cycle of the organism, and so influence and direct its development, interacting with environmental conditions in such a way as to give rise to corresponding characters. The genes may reinforce or hinder each other's actions. A single gene may visibly affect all or some of the characters, and the presence of several if not all of the genes may be necessary for the full development of a single organ or part.

It follows that an organism can only exhibit those characters for the development of which it has the necessary genes. The presence of dominant genes may be inferred from its characters; however, since some genes may be recessive, the total factorial equipment of an organism cannot be told from its characters alone, but only by the results of breeding which will bring out the recessive characters in the "recessive" homozygote individuals.

It follows also that any mutational alteration of factors will necessarily be transmitted and perpetuated unaltered, unless some fresh mutation supervenes; and that the factors are not altered, nor their effects necessarily swamped or diluted by intercrossing, however prolonged. Two important conclusions affecting the general theory of organic evolution follow. In the first place it is the character, not the genes, that are directly selected in natural as in artificial selection. The suitable phenotype is successful in the struggle for existence, and the genes are only indirectly selected in so far as they correspond to it. Secondly, the modifiability of an organism is necessarily strictly limited by the potentialities of its complex of genes. It may become modified in various directions, since various environmental conditions may call forth a response, and this may vary in amount according to the strength and duration of the stimulus. Once the maximum response has been reached, however, it cannot go further. Since modifications are not cumulative, it is the mutational variations, due to some alteration in the complex of genes, that are important in enabling evolutionary transformation to take place. By the cumulation of factorial changes the lasting and presumably unlimited alteration of characters can be brought about.

Origin of Mutations.—Evolution may be said to be based on inheritable mutations; hence the supreme importance of ascertaining, if possible, what gives rise to them. They are sometimes stated to arise spontaneously, which is a way of saying that we do not yet know what causes them to appear. It must be confessed that little advance has been made towards the solution of this problem since the time of Darwin. Yet something has been ascertained by careful observation and experiment. Mutations may affect any or all of the characters; they may be dominant or recessive, large or small, even scarcely perceptible; they occur rarely, but apparently more frequently in some species than in others; T. H. Morgan has discerned some 400 in his breeding experiments with the fly *Drosophila,* both in nature and in organisms under experimental conditions. The same sort of mutation may repeatedly recur, and the same sort of mutation, for instance, albinism (the absence of pigment), may occur in different organisms.

All attempts to determine the actual cause of mutational alteration of the genes, or to bring about such alterations artificially, have so far yielded inconclusive results. Tower, experimenting on the Colorado beetle (*Leptinotarsa*), claimed to have brought about true inheritable mutations in colour and pattern by submitting some beetles at a certain stage and for a certain time to extremes of temperature and dryness. Heslop Harrison has caused melanic mutations to appear in moths by feeding the larvae on leaves impregnated with certain salts of manganese. Müller has produced mutations in flies (*Drosophila*) by exposing them to X-rays. But it is to be noticed that in these cases the mutations which appear seem to be such as are already known to occur in nature, that only some of the individuals respond to the treatment and that it is not yet clear that the stimulus applied does more than hasten or facilitate the expression of some factorial difference not primarily due to it.

Mutations may, however, be due to several kinds of factorial changes and may, to some extent, be classified accordingly. For instance, since the genes are very numerous and can be segregated, sorted out and recombined in an almost infinite variety of ways, scarcely any two individuals will have exactly the same combination or factorial make-up. The individuals of a species may differ thus from each other, may be homozygotic for some factors, but heterozygotic for others. Another source of mutation is the irregular distribution of chromosomes in the germ-cells, or their duplication leading to the formation of "diploid" and "polyploid" races with new properties. Since the chromosomes of different existing organisms differ much in shape, size and number, it is clear that there has been variation in these characters in the course of evolution.

But although combinations, reshufflings and duplications of existing genes may give rise to many mutations, they can hardly account for the vast changes which have taken place in organic evolution. In a complete theory the first origin and diversity of these factors must still be accounted for. It must be supposed that new factors have been added and possibly that old ones have dropped out, that new material has entered the stream of germ-plasm, into the cycle of metabolism, and become incorporated as self-propagating ingredients joining in harmonious co-operation with previously formed factors. Presumably this building process is still going on. Mutation, and indeed evolution itself, must be based on the addition to, subtraction from, or alteration in the factors of inheritance. That the factors may be extraordinarily stable seems to be proved by the fact that many organisms have scarcely changed since the deposition of the earliest fossiliferous rocks in remote geological ages. Yet other organisms have changed rapidly and mutations generally turn up even during the short period during which animals and plants have been bred artificially. Since ordinary external stimuli seem to alter the factors but rarely, if at all, it may yet be some day shown that alterations in the genes are due to the inherent instability of certain of the atoms composing them and to the action of certain radiations pervading the environment.

STRUGGLE FOR EXISTENCE

The remorseless, ceaseless struggle for existence, that most essential factor in the process of natural selection, depends on the fact that more organisms are born into the world than can live in it. They tend to increase in geometrical ratio, and their powers of reproduction are often prodigious. A female cod-fish may lay some 9,000,000 eggs a year. The eggs of a tapeworm and other internal parasitic worms may be counted by the million. A single pair of carrion flies (*Musca carnaria*) may produce 20,000 larvae, which will hatch out into flies in about a fortnight, giving rise in turn to some 200,000,000 hungry larvae. No less prolific are

plants. It has been calculated that a single cholera bacillus would give rise to 1,600 trillions of bacilli in a day of free propagation. No doubt, such unrestricted reproduction rarely, if ever, occurs; unfavourable conditions, devouring enemies and competitors are always at hand to keep the numbers down. But all living organisms are striving to increase their numbers, to extend their range, to find new regions for expansion. There is a perpetual competition for space, food and all necessaries of life. So the fauna and flora of any region are made up of a number of diverse species, closely packed and, as it were, exerting mutual pressure. If one increases it must be at the expense of some other. In any given district a balance is soon struck, and an equilibrium established between death-rate and reproduction, in which the average number of individuals of each species remains approximately constant.

How great are the possibilities of increase, and how effective are the natural checks to reproduction, may be seen when the balance is disturbed and some of the checks temporarily removed, as, for instance, owing to a change of climate or the intervention of man. As examples may be mentioned the swarms of lemmings, and of locusts which, occasionally or periodically, sweep over vast regions; also the great epidemics of diseases. Similar expansion of one species at the expense of others is continually going on on a small scale, even in the most stable flora and fauna. The extraordinarily rapid increase of a species, introduced into a new country where it does not meet with the ordinary checks occurring in its native habitat, is seen in the case of the European sparrow in North America, the rabbit in Australia, the Phylloxera insect which almost exterminated the vines of Europe. The spread of water-cress blocking the rivers of New Zealand and of the American water-weed those of Europe, the devastating conquest of vast areas in Australia by the prickly pear, are examples from the plant world.

The intensity of the struggle varies in different seasons, sometimes periodically. In a stable population on the average only two individuals can survive to replace the parents out of the whole number of offspring. As a rule the greatest destruction takes place when the organisms are quite young.

This constant struggle for existence is the primary factor in the process of natural selection whereby adaptation is brought about. The resulting selection is between the variations which are in all possible directions, as already explained; some will be advantageous, some disadvantageous, and others perhaps neutral. The first test every organism has to pass is that of viability, the power to live at all. Just as the intensity of the struggle may be measured by the death-rate, so a variation is advantageous in so far as it lowers this rate; and this gives a measure of its "selection value." Selection acts like a sieve, separating individuals best endowed to survive from others less fortunate. It may be represented equally well as the survival of the fit, or as the elimination of the unfit. In the long run those organisms which vary in the "right" direction will succeed and leave offspring behind them, while the others will be crushed out. In so far as the advantageous variations are due to lasting factorial changes capable of being transmitted and accumulated by the piling up of fresh changes, evolution will continue in the direction of adaptation. Only thus can the adaptation of living organisms be intelligibly explained, and this is the great merit of Darwin's theory of evolution by natural selection which has secured its triumph over rival theories.

It should be clearly understood that the theory does not explain variation, but accepts its existence as affording the material for selection to work on. As Darwin insisted, without variation natural selection can do nothing. What selection alone can do is to pile up individual favourable differences so as to bring about ever-increasing divergencies along various lines of adaptation. And so, step by step, are produced those marvelous adaptations, those wonderfully perfected and complicated organs familiar to all students of plants and animals. Moreover, this affects not only the structure of the parts of individuals, but the relations between individuals which may become mutually adapted to their advantage, as in the case of parent and offspring, and of animal "societies." Further, it may lead to the development of mutual adaptation between different species to the benefit of both, of which striking examples occur among both plants and animals. One may instance the "symbiotic" association of colourless Fungi and green Algae, known as lichens (*q.v.*), or of green flagellates living in the tissues of the common *Hydra*. Perhaps more wonderful still are the mutual adaptations of insects and the flowers they pollinate, a subject to the elucidation of which Darwin contributed so much. Indeed, the intricate interrelationships of the various organisms inhabiting a given area, their influence on each other's abundance and distribution is extraordinarily complex, and forms the chief subject of a special science, ecology (*q.v.*).

If elimination is to be effective in evolution, if it is to bring about adaptation, the death-rate must be selective; *i.e.*, apart from accidental extermination, the successful survivors should in the long run differ from those which fail. It is easy enough to demonstrate this in the case of larger groups differing by conspicuous characters, and even sometimes of "species" or "races" of which we know the history; but it is often very difficult to prove effects of natural selection at work among closely related individuals differing only by small or, it may be, by invisible characters. Rarely can the failures be directly compared with the successes. Nevertheless some attempts have been made to obtain this direct evidence: for instance, Weldon has shown that in the terrestrial mollusc *Clausilia*, extreme variants are eliminated, while those approaching nearer to the mean of the species are preserved; and Tower obtained the same result with the beetle, *Leptinotarsa*. Harrison has given good evidence that, following on the separation of a wood of pines and birches into one half consisting almost entirely of dark pines and the other of silvery birches, of two marked varieties of the moth *Oporabia*, the light variety has been almost eliminated from the pine wood and the dark variety from the birch wood by the bats and birds which feed on them. Of indirect evidence there is overwhelming abundance. One may here again mention the close adaptation of most forms to their environment; the wide-spread occurrence of protective resemblance between organisms and their surroundings whereby many escape the notice of their enemies; or of warning coloration by means of which species advertize their unpalatability; the failure by constant elimination of certain common extreme variants, such as albinos, to establish themselves; the development of immunity to those particular fatal diseases with which a species comes in contact. No one who has studied living organisms in their natural surroundings, especially in the tropics, can doubt the severity of the struggle, the reality of selection. Here may also be mentioned those striking resemblances between species, especially of insects, sometimes closely allied, but often of separate orders, due to mimicry (*q.v.*). No other explanation of these often astounding similarities in appearance of structure and coloration seems possible but that of gradual convergence through the selection of suitable variations.

What, it may be asked, is the effect of selection on succeeding generations, what part is played by elimination and inheritance in evolution? This question has already been partly answered above when it was pointed out that to be effective, selection must be between individuals differing in their factorial endowments. Among individuals homozygotic for the factors determining a given character, selection of variations of that character due to environmental conditions can have no cumulative effect. But natural species are rarely, if ever, so uniform in their factorial inheritance; on the contrary, they differ, as a rule, as regards a considerable number of factors. Selection of individuals in which a given character is best developed, will then rapidly sort out a strain possessing the most favourable assemblage of factors. But, once this strain has been isolated, further selection can do nothing unless some new mutation in the required direction arises.

Continuous and Discontinuous Variation.—Whether variations are "continuous" or "discontinuous," whether variation takes place by a series of small graduated changes or by sudden large steps or jumps, is a question which has given rise to much controversy. A tendency towards discontinuity is shown especially in "meristic" variation. Thus, a cell will either remain single or divide into two, the antenna of an insect may have either four, five or six joints, the number of dorsal vertebrae in a mammal may vary from 12 to 13, or from 13 to 14. But even meristic variation

is not always discontinuous. As already explained most characters vary sufficiently continuously for their measurements to yield an even curve. The controversy has been obscured by the failure to distinguish between such continuity of variation and continuity in the changes of hereditary factors. Phenotypes may be continuous since the incidence and strength of the modifying conditions are due to chance. Mutations may appear discontinuous if the factorial change produces a striking effect, while in other cases they may be of moderate or even of the minutest size. Since the genes appear to be definite units, it is probable that the factorial changes themselves are mostly discontinuous, but the resulting differences are more or less completely masked or smoothed down in the phenotypes by the modifications. No hard-and-fast lines can be drawn between "sports" and small variations. Which of the two is the more important in evolution is a point on which Darwin was somewhat uncertain, but he finally concluded that natural selection dealt chiefly with the smaller. Certainly these are much the more numerous; and it must surely be easier for complex adaptations to be built up by small steps, than by sudden changes likely to dislocate the existing mechanism.

No arbitrary limit can be set to the "selection value" of a character; its value depends on the intensity of the struggle at the moment. The slightest difference in weight between two seeds carried by the wind may decide that one will reach a favourable spot and not the other; the smallest difference between the staying powers of two animals in a flood may enable one to swim to safety and not the other; the smallest inferiority in powers of resistance to disease may cause one man to perish while another recovers. Moreover, a character, useless during the greater part of the life of an organism, may prove of vital importance at a particular time.

THE CASE AGAINST DARWINISM

Objections to the Theory.—Much has been made by the critics of Darwinism of the alleged uselessness of many characters. Since variation is not in itself adaptive, they may be useful, harmless or harmful, and so long as they remain harmless, useless variations may remain. since they have no effect on the death-rate; but so soon as they increase to a harmful extent, they tend to be eliminated. Only favourable variations can be selected and apparent exceptions to this rule may be due to correlation, which plays an important part in evolution. A factor of inheritance may affect several characters and even the whole organism, so that the alteration of one character by selection may lead to correlated changes in other parts.

Many characters have, however, been asserted to be useless which have subsequently been found to be not only useful, but essential. As our knowledge advances, the functions fulfilled by various organs and parts are daily being discovered. Conspicuous examples are the glands of internal secretion, such as the pituitary gland, formerly supposed to be a useless vestigial structure, but now known to be of the greatest importance. No character can be accepted as useless until its presence or absence has been proved to exert no influence on the death-rate.

It has sometimes been urged by detractors of Darwin's theory, that organisms are pre-adapted and that natural selection does no more than allow what has already been developed to persist. In a certain limited sense this is, of course, true. Selection can only take place between existing forms and variations; and many instances may be given in which organisms have been able to spread into new regions, where others have failed, because they happened to be of suitable structure. Selection cannot be prophetic and such cases are due to chance. But they do not diminish the importance of natural selection in building up organisms fitted to live under special conditions, or organs adapted to fulfil special functions, which is what we really mean by adaptation.

Lastly, it is sometimes objected that if selection cannot be prophetic, if evolution is not due to some purposeful force, it is difficult, if not impossible, to account for the development of such complex organs, since the initial stages would be useless. In this connection it should be remembered that organs are rarely, if ever, known to "begin." Entirely new functions are not suddenly developed. A careful study of what we know of their evolution shows that they are evolved by the gradual transformation of, addition to, or subtraction from something already present. The wing of a bird has had no sudden beginning, but has been gradually transformed from the fore-limb of a reptile. An intermediate stage is seen in the extinct *Archaeopteryx* (*q.v.*). The sharp sting of a bee is the transformed ovipostor commonly found in insects. Even such a highly specialized organ as the eye of man may be traced back to the property of response to light distributed over the surface of the body in the lowest animals. No doubt, owing to imperfect knowledge, there are many cases in which the intermediate stages are unknown and difficult to imagine; but it should not be concluded that they have not existed.

OTHER FACTORS IN EVOLUTION

Isolation.—In addition to the three main factors of evolution so far dealt with, variation, heredity and competition, there are, as Darwin pointed out, subsidiary or auxiliary aids to natural selection. Of these isolation is perhaps the most important. As explained above, species are, generally speaking, not composed of individuals of perfectly uniform inheritance, but are assemblages of intercrossing races, differing from each other by some out of the vast number of genes making up their hereditary equipment. Now, sexual reproduction no doubt is the means of affording ever fresh combinations of genes, but it also works towards preserving an average type by continually mixing varying strains. Selection without isolation may lead to evolution in a straight line, but if divergence is to take place, some sort of isolation seems necessary, and the fitting of organisms to new environments, the development of new functions and structures along ever diverging lines of adaptation, is one of the most characteristic and significant features of organic evolution. Isolation is of several kinds: geographical, functional, structural, psychological. The means of dispersal are various; some organisms, such as microscopic animals and plants, spores, and seeds, are distributed passively by the wind, others by water currents, and still others move from place to place by their own efforts. Geographical isolation is due to physical barriers, mountains, deserts, rivers and oceans, separating groups of land animals. Marine organisms may be divided by the uprising of dry land, and the inhabitants of fresh water by the separation of river basins. Further subdivisions are due to organisms adopting different habitats to which they are adapted. Some live in dry, others in damp, places, some in the shade while others prefer the light, and so on. Aquatic forms may be restricted to certain depths, mountain forms to certain heights. Whatever the reason, isolation, sooner or later, leads to divergence from the parent form. Speaking generally, individuals sufficiently alike to be placed in the same species usually have a continuous distribution, closely allied species are usually found in neighbouring regions, especially if they have few means of dispersal, and they are more unlike the further they have strayed from the original centre of distribution.

Each large land area tends to acquire a characteristic flora and fauna, made up partly of indigenous forms evolved within it, and partly of forms which have migrated into it from neighbouring areas. The more efficient the barriers enclosing it and the longer it has been isolated, the more different will be its flora and fauna from those of other areas. The organisms on an island resemble, on the whole, those of the continent from which it has been separated; many of them, however, are generally found to differ somewhat from the continental types. Particularly significant is the fact that in an archipelago, a species may become split up into as many races as there are islands inhabited by it; as has happened, for instance, with the golden oriole (*Icterus*) in the West Indies. In volcanic oceanic islands which have never been connected with a continent, and whose population is derived from rare strays capable of swimming, flying or being conveyed overseas from neighbouring lands, the number of peculiar species is strikingly large, and here again each island of a group may have its own form. A well known instance is that of the local races or species of birds and reptiles in the Galápagos islands. Such

facts, of which many examples might be given, afford unmistakable evidence of the part played by geographical isolation in evolution. Somewhat similar isolation and divergence seem to result from parasitism; for the tendency of the parasite to restrict itself to one host, to which it becomes closely adapted, may lead a parasitic form to split into as many different races as there are kinds of host. Similarly with plants fertilized by insects, the flowers tend to become specialized in various ways to attract certain kinds, while the insects undergo corresponding specialization to obtain nourishment from the flowers.

Many organisms, though closely allied, living in the same locality and coming into close contact, do not interbreed. Their crossing is effectually prevented by variations in structure, habit or temperament. The most important "physiological" barrier is sterility, of which there are several kinds due to different causes. Mere difference of size may prevent interbreeding, or differences in the structure of the copulatory organs, as in many insects; also the attainment of sexual maturity at different times of the year. Variations of the germ-cells themselves lead to what may be called true sterility, of which there are various degrees. Fertilization may be imperfect or not take place at all, probably owing to incompatible differences in the protoplasm, in the number and character of chromosomes, or in the hereditary factors. Even if zygotes are formed they may fail to develop normally, or the offspring, if they reach maturity, may themselves be sterile, as in the mule. Whatever their origin, these various barriers to free and fertile interbreeding favour the preservation of divergent characters.

It may here be pointed out that other results follow on fertilization besides the activation of the zygote and the mingling of genes already mentioned. It is popularly held that close and continued inbreeding leads to harmful results, to loss of fecundity and a weakening of the race; while outbreeding or intercrossing is supposed to have beneficial results, to increase fecundity and general vigour. The almost universal forbidding of the marriage of near-of-kin in human societies is consonant with this belief; and the many devices evolved in nature to facilitate cross-breeding and prevent self-fertilization among hermaphrodite plants and animals point to cross-breeding being advantageous. The question, however, is by no means simple and cannot here be treated in detail (*see* INBREEDING). It may be pointed out that continued close inbreeding due to self-fertilization does occur in many plants and in some animals (especially parasites) in nature, and may be carried on artificially without harmful consequences, provided vigorous individuals are selected for the purpose. One of the results of inbreeding is to reduce heterozygosity and secure homozygosity among the progeny; the opposite follows from cross-breeding. Now, since unfavourable characters are often determined by recessive genes, they are apt to become manifest in the individuals homozygous for them. Hence inbreeding of tainted stocks tends to bring out albinism, deaf-mutism and feeble-mindedness in man; while no such evil results will follow if these particular genes are absent from the inheritance. On the other hand, there is ample evidence that the crossing of individuals or races differing slightly from each other in their inheritance or factorial make up, generally leads to increased vigour in the offspring. This beneficial result, apparently due to some degree of heterozygosity, is secured in nature by the separation of the sexes, and has long been known to breeders.

Great has been the influence of sex on the evolution of organisms. To secure the nourishment, distribution, fertilization and survival of the reproductive cells is the chief function of all creatures; to these ends have been developed that wonderful diversity and elaboration of bodily and mental structure found in living nature.

Sexual Selection.—Another important auxiliary factor in the evolution of animals was called by Darwin sexual selection. The many and often conspicuous differences between the two sexes, other than those of the reproductive organs themselves, are known as secondary sexual characters. They occur among the higher groups of active animals and enable the sexes to find and recognize each other, and to accomplish the act of copulation; as, for instance, the prehensile organs, the specialized organs of sense, the scent organs, the sound-producing organs, the call notes of insects and vertebrates. They also include special organs of attack and defence used by rival males in fighting for the possession of females; and the wonderful developments in structure, coloration and behaviour serving to attract and stimulate the opposite sex. Sexual selection may be considered as a subordinate, special kind of natural selection taking place within the limits of interbreeding groups of animals. It is one of the great triumphs of Darwin to have provided a rational and utilitarian explanation of the evolution of these characters.

AFFINITIES

Evolution and Classification.—It was to a great extent the study of comparative anatomy and embryology pursued with the object of obtaining a trustworthy basis for classification that helped most to the acceptance of the doctrine of evolution. Notwithstanding their great diversity, it was soon observed that organisms form, on the whole, an ascending series increasing in complexity of organization, and further that they fall into great groups or types made up of forms of similar build, but varying much in details and proportions according to their adaptation to different modes of life. These great types do not form a linear series leading from one to the other, and their relationships are better expressed as diverging branches from a common stem. In fact the anatomical resemblances and differences between organisms can only be satisfactorily interpreted as the result of their derivation and transformation from a common ancestor. Phylogeny, or the science dealing with their affinities or "blood-relationships," is the only secure foundation of classification.

Palaeontology, the study of extinct fossil forms, has done much to strengthen this conclusion; likewise embryology, the study of the ontogeny or development of individuals, which has thrown much light on obscure relationships and familiarized naturalists with the notion that small and simple beginnings may give rise to large and complex final products. Classification, then, is an attempt to group organisms according to their natural affinities and to trace out their pedigrees. Similar individuals are grouped into species, species into genera, these into families, orders, classes, phyla, divisions of increasing size and importance. The history of the conception of "species" has been mentioned at the beginning of this article. All sorts of attempts have been made to define species in accordance with modern theories of evolution; but no stricter definition seems practicable than this, that a species is composed of closely allied individuals descended from a common ancestor, which normally interbreed, and are sufficiently alike and sufficiently distinguishable from related forms to be conveniently called by the same name.

Much stress has been laid on sterility between two forms as a test of their specific rank; but although interspecific sterility commonly occurs, perhaps favoured by natural selection to prevent intercrossing, it is by no means universal. Every gradation occurs between absolute sterility and perfect fertility in crosses between well-recognized species, especially among plants. Indeed many botanists claim that inter-specific hybridization is a frequent source of new species.

De Vries tried to define "elementary species" as strains distinguished by a single mutation. But mutations may be of any size from "sports" to scarcely perceptible differences, and most, if not all groups distinguished as species seem to be composed of interbreeding races differing from each other by small factorial differences, which races have sometimes been separated out by careful selection and breeding.

Species living at the present day represent the closely allied individuals at the extremities of the surviving twigs of the phylogenetic tree. If they have become marked off from allied species, it is because the intermediate connecting individuals have died out. Along the branches leading to them and along the main stem, there are no points at which a species can be said to begin or to end. It is only for convenience in description that the name species can be applied to ancestral forms along these lines of gradual evolution. The only "fixed points" in a phylogenetic

system of classification are the points of bifurcation, where one branch diverges from another, and it is here that generic, family and other divisions should be made.

The living species are those which have succeeded in the struggle for existence. The greater the extinction of allied forms the more widely do the survivors become separated from each other. Hence as the phylogenetic tree grows in the course of geological ages it tends to give off ever spreading branches. Rarely, however, is the geological record well enough known to enable us to demonstrate the exact point of origin of a group, and most classifications are but approximations to a correct phylogeny.

Degeneration.—Mere resemblance is not always a sure guide to affinity. Forms which differ widely in the adult state often resemble each other much more closely in young or embryonic stages. By observing their development, affinities can sometimes be discovered which would scarcely be otherwise suspected. For instance, the sea-squirts (Tunicata, *q.v.*) are essentially sedentary animals which have become highly specialized and in some respects degenerate, owing to their peculiar mode of life. The adult lives fixed to the sea-bottom, and is of simple sac-like structure, little resembling an ordinary vertebrate; yet the free-swimming larva has the dorsal central nervous system, gill-slits and notochord characteristic of the vertebrates. The barnacles (Cirripedia) have also taken to an adult fixed life and lost many of the features of the Crustacea (*q.v.*)to which their larval stages show they belong.

Other striking instances of specialization accompanied by degeneration commonly occur among parasites. Since they often absorb their food directly from their hosts, they tend to lose organs of locomotion, special sense organs and even the alimentary canal, and devote themselves to producing enormous numbers of eggs and young to infest new hosts. Frequently they become simplified beyond recognition, and their true affinities are betrayed only in their development.

Degeneration, or the loss of special structures no longer required in the new environment to which an organism may become adapted, is a frequent phenomenon. One of the great merits of the doctrine of evolution by natural selection is that it accounts for this simplification. For both progressive and retrogressive mutations occur; which will be selected depends on the needs of the organism at the time.

Vestigial Organs.—One of the results of change of life-habit or environment is to leave behind, in the course of evolution, parts and organs, once perhaps of vital consequence, but now of little or no use. Numberless such vestigial organs are known amongst plants and animals, and their presence has been considered as affording the strongest evidence for evolution. Unless they become adapted to fulfil some new function, they are apt to diminish and finally disappear, particularly if their presence is in any way harmful. Such vestiges are the splints representing the last trace of the side-digits on the foot of the horse, the small bones embedded in the body-wall of whales and representing the vanishing hind-limb, the vermiform appendix of the intestinal coecum and the hidden little bony tail of man. Flightless birds, like the kiwi (*Apteryx*) of New Zealand, preserve vestigial wings concealed below the feathers.

In the course of evolutionary progress, however, through variation and selection organs are usually transformed and converted to new uses. It is doubtful whether any really useless parts are ever preserved for long unless they are insignificant, and many of the so-called vestigial organs are now known to fulfil important functions. The small pineal organ in our brain is, in a sense, the degenerate remnant of a dorsal eye still fairly well developed in certain living lizards and the lamprey, and there is evidence that it was possessed by most of the primitive fossil fish and land vertebrates; but in ourselves and other mammals, though it has lost its primitive function, it secretes essential substances into the circulation.

Homology, Analogy and Convergence.—Organs converted to new uses become modified and adapted in different ways, along divergent lines of evolution. However different they may become, if they can be traced back to the same origin in a common ancestor they are called homologous. The tracing of homologies is one of the means of determining affinities. For instance, the creeping foot of a mollusc, as seen in the snail, may become an expanded flapping swimming organ in marine pteropods, a jumping organ in the cockle or be converted into prehensile arms in the squid. Our own five-fingered forelimb is homologous with the forelimb of a horse, the swimming paddle of a whale, the wing of a bat or of a bird. In spite of their modifications homologous organs generally show the same essential parts, the same fundamental plan of structure. Intermediate steps between the extremes of specialization may often be found, especially among fossil forms. However much the resemblances may be obscured or lost in the adult, they are generally clearer in the earlier stage of development, in which the common origin of the most diverse organs may be manifest.

But all similar parts are not necessarily homologous, and just as adaptation to different uses leads to divergence, so adaptation to the same function may lead to resemblance. Organs of quite different origin may become so alike by convergence as to deceive the practised eye of the expert. Such specialized parts which cannot be traced back to a common ancestor are called *analogous*. As examples of analogy may be mentioned the wing of a bird and that of a butterfly, our own jaws and those of an insect. Organs may be both analogous and homologous, for example, the wings of the bat, the bird and reptilian pterodactyl are homologous in so far as they are all forelimbs, but analogous in so far as they are organs of flight independently derived from a walking limb. All such cases are powerful evidence in favour of evolution; indeed it is difficult to describe them without assuming their evolutionary origin.

What has been said above of organs is equally true of organisms as a whole. While evolution as a rule leads to divergence, it may by adaptation to similar environments and modes of life, lead, on the contrary, to *convergence* in colour, shape, structure and behaviour. Unrelated forms may thus become deceptively alike. The amphibian *Siphonops*, the lizard *Amphisbaena*, the snake *Typhlops*, all creeping and burrowing forms, have lost their limbs and come to resemble an earthworm. Striking cases of convergence are known among plants; for instance, the independent acquisition of a cactus-like structure by representatives of the Euphorbiaceae, Asclepiadaceae and Compositae in adaptation to dry desert-like conditions.

Recapitulation Theory.—The study of embryology affords not only valuable help in the tracing out of obscure affinities, but also strong evidence in favour of the doctrine of evolution. As pointed out long ago by K. E. von Baer, the embryos of forms belonging to different groups are generally more alike than are the adults. Among vertebrates, for instance, the embryo reptile, bird and mammal possess gill arches like those of a fish at a corresponding stage of development. From such evidence it was rashly concluded that in the course of its development an organism passes through stages approximately representing the series of ancestors which preceded it, and E. Häckel enunciated his famous "Biogenetic Law" that ontogeny recapitulates phylogeny. This was a gross exaggeration, and all that can be maintained is that the ontogeny of an individual may more or less recapitulate the ontogeny of its ancestor. Owing to new conditions and adaptations the course of ontogeny may come to deviate from that of the ancestor at any period from egg to adult; stages may be omitted, larval specializations may be intercalated, new structures developed. The fish, the reptile, the mammal, do not really start from the same point and pass through the same stages; they are fish, reptile and mammal respectively from their beginning. Their ontogenies are similar only in so far as their zygotes contain the same factors and develop under the same conditions.

Apart from differences of environment, the basis of the evolutionary changes seen in a phyletic series lies in the alteration of the factors contained in the continuous stream of germ-plasm, not in the adult organisms derived from it. And here it may be mentioned that this progressive or retrogressive change involves not only the gross structure, but also the intimate chemical composition of the germ-plasm, of the very molecules of which it is made up. There has been a phylogeny of the genes and of their

ingredients, as there has been a phylogeny of the organisms themselves. Consequently protoplasm and its products come to differ along diverging phyletic lines. For instance the red colouring matter of the blood (haemoglobin) differs slightly in different vertebrates; so also starch in various plants and many of the proteins in all organisms. The degree of resemblance may afford some measure of affinity.

Help in tracing relationships has recently been derived from the study of the physico-chemical reactions of the blood and other body-fluids of vertebrates. The "precipitin test" applied to the blood affords evidence, for instance, that man is more nearly allied to the anthropoid apes than to the lower monkeys, and to the latter than to the other Mammalia. Some of the phenomena of interspecific sterility mentioned above are probably related to such divergences in chemical composition.

GEOLOGICAL TESTIMONY

Palaeontological Evidence.—Perhaps the most convincing testimony to the truth of the doctrine of evolution comes from palaeontology (*q.v.*). Incomplete and fragmentary as it is, this geological record shows the actual links in the evolutionary chain, and also the order in which they fit into the series. Speaking generally, as we pass from the recent to older deposits, the fauna and flora appear less and less like those of the present day. The higher and more specialized groups are replaced by lower, more generalized forms, until in the earliest fossiliferous strata only a few of the lowest types remain. The fossil organisms found are, naturally, chiefly those possessing hard skeletons capable of fossilization, and only those individuals which happened to die under conditions favourable for preservation. The record is, therefore, very imperfect and often interrupted by gaps. From the fragments of the earliest-known fossils it is clear that life must have existed long before, since they already show considerable diversity. Already in the pre-Cambrian epoch there are traces of Protozoa, marine Algae and, perhaps, annelid worms. The earliest known vertebrates are the armoured fish of the Silurian, an epoch in which are represented most of the large groups of invertebrates, and in which first appear land plants. Traces of land air-breathing vertebrates occur in the Devonian, but it is not till the Carboniferous that they become common. During the latter epoch flourished spore-bearing ferns and other primitive plants; cycads, ginkoes and conifers dominated in Permian times, to be replaced in the Cretaceous, to a great extent, by the modern flowering plants. During this vast period many great changes occurred in climate and the distribution of land and sea, which must have greatly affected the course of evolution. In a general survey we can watch evolution at work, see its results writ large; many problems about variation, survival, extinction and the like, so difficult to solve when dealing with individuals, seem simplified on such a large scale. Having reached a certain favourable level of organization, a group expands and flourishes; divergent adaptive radiation leads to specialization in various directions. The advantage of such radiation is that more organisms can secure a place in a given region if they adopt different modes of life and of feeding; just as in a human community more individuals can make a living if they take to different trades and occupations. Specialization may secure temporary success, but almost inevitably entails loss of adaptability if the general conditions alter or new competitors enter the field; there follows decline and extinction, and replacement by some other more adaptable form which reaches a higher level of organization. Such has been the fate of most groups as revealed by the palaeontological record.

So we often find scattered over the globe isolated and specialized remnants of a once extensive group betraying their origin by their archaic structure. For example, the arthropod *Peripatus* and a few closely allied genera, in central and south Africa, central and south America, the Malayan and Australian regions; or the lung-fishes (Dipnoi), of world-wide distribution in the fresh waters of Palaeozoic times, now surviving only as *Ceratodus* in Australia, *Protopterus* in central Africa and *Lepidosiren* in south America.

Most remarkable are the number of abortive branches of the phylogenetic tree. Over and over again large and flourishing groups are seen to dwindle quickly to insignificance, or die out altogether. These results of selective elimination are obvious, but the causes which bring it about are by no means so clear. Climatic changes, catastrophes, epidemic diseases may account for a great deal, but overspecialization seems to be the most usual contributory cause. Natural selection can provide only for the needs of the moment; it cannot be prophetic. Once committed to some narrow path of specialization, it may be difficult, if not impossible, for an organism to turn aside. Once an organ has been lost, it can hardly be regained, though it may sometimes be replaced by an analogous structure.

Evolution of the Tetrapods.—A glance at the history of the land vertebrates is very instructive. Derived from some fish-like, aquatic ancestor in pre-Devonian times, they flourished in Carboniferous times as clumsily built Amphibia, and gave rise to several highly specialized forms. But of the whole class, only a few remnants occur at the present day, the salamanders and newts (Urodela), the rare leg-less Apoda and tail-less frogs and toads (Anura), which alone may be considered fairly successful. Already in Permian times they were beginning to feel the competition of the reptiles, more completely terrestrial, agile and highly organized animals, sprung from some unspecialized branch of the amphibian stem. So dominant did these Reptilia become that the Mesozoic age is frequently called the age of reptiles. They displayed an astonishing variety of form and size and became specialized for life on land, in the air and in water. Yet at the end of the Cretaceous they were already on the wane, and of the numerous branches from the reptilian stem only the tortoises, lizards and snakes can be said to have held their own to the present day; scattered Crocodilia still survive in fair number, but the Rhynchocephalia are represented by only a single species, *Sphenodon*, on small islands off New Zealand. The great group of dinosaurs is entirely extinct. The reptilian type gave rise to two classes destined to replace it in almost every sphere. As shown by the beautifully intermediate form *Archaeopteryx* of the Jurassic, the birds arose from some group allied to crocodiles and dinosaurs, and quickly gained the mastery of the air. The mammals, on the other hand, made their appearance in early Triassic times as small humble creatures which did not make much progress till the later Cretaceous and Tertiary ages. Their origin can be traced step by step to the early undifferentiated reptiles known as the Theromorpha. Once the mammalian grade of structure was reached with its many advantages and great adaptability, it soon triumphed over all others and succeeded, not only in establishing itself on dry land, but also invaded the sea and the air. Adaptive radiation gave rise to great divergent modifications of the mammalian type in early Tertiary times, and the Mammalia are at present dominant on land. But this position was not gained without a hard struggle and of the many branches of the mammalian stem, few have lasted to recent times and still fewer are still expanding. The order Primates, to which man belongs, can be traced back, like most of the mammalian orders, to small unspecialized ancestral forms in the Eocene epoch.

Rate of Evolution.—The rate of evolutionary change has varied greatly along the different branches of the phylogenetic tree. Some forms have scarcely altered during long geological periods. The molluscan genus, *Patella*, to which belongs our limpet, dates from the Silurian epoch, a time at which also lived a scorpion differing but little from living species. The brachiopod, *Lingula*, has scarcely changed since the Ordovician. Presumably these persistent types were early well enough adapted to withstand competition in certain suitable environments still occurring at the present day. That evolution has usually taken place by small steps is proved by the very gradual transitions from one form to another as the fossils are traced from stratum to stratum. Wonderful series of graduated forms have been found among trilobites, brachiopods, ammonites and other molluscs, and also among vertebrates. The more complete the record the more gradual the transition. The history of the horse offers a good example. Starting in the basal Eocene from a small generalized ancestral ungulate with four or five digits on each foot and the full complement of short-cusped teeth, the specializations peculiar

to the Equidae can be seen gradually to appear: increase in size, lengthening of the skull, conversion of the biting molar teeth by lengthening of the crown and fusion of the cusps into grinding ridges, reduction of the lateral digits to insignificant vestiges as the feet become adapted to running on hard ground. Even the horse type, however, has not been evolved along a single straight line, and many side-branches were produced which failed to survive.

Other mammalian orders have had a very similar history, and almost always increase in size has been a conspicuous feature of their evolutionary transformation. This has also occurred among plants, and many groups of invertebrates, such as ammonites and arachnids. The large stegocephalian Amphibia, the gigantic dinosaurs among Reptilia, and Titanotheria, Dinocerata and Proboscidea among Mammalia are examples of the same development. This great increase in size doubtless secured temporary success and world-wide expansion; but usually the success has been short-lived and was quickly followed by decline and extinction. From these and similar phenomena it has sometimes been concluded that "trends" may be discerned in evolution leading organisms along some definite line of specialization. If by this is meant that behind ordinary evolutionary processes there is some mysterious force, something other than natural selection of variations, guiding organisms inevitably along some preordained path and guiding them often to destruction, such a view cannot be accepted as a scientific explanation. The dangers of specialization have already been insisted upon; increase in size is a form of specialization, often clearly advantageous in overcoming enemies and other destructive influences.

BEHAVIOUR

Adaptability.—One of the most valuable properties enabling individuals to survive in the struggle for existence is adaptability, that power of responding to different stimuli in different ways. It has been pointed out that the total potentialities of an organism are determined and limited by its inheritance, what particular characters come to be developed depends on the environment, internal and external. The more the assemblage of transmitted factors can respond in various advantageous and suitable directions, the greater the power of accommodation to new or unusual conditions, the greater the adaptability. Thus, a plant so endowed that it will in dry or damp conditions take on a suitable form, will be able to succeed and spread in climates and localities in which it would otherwise fail. The same species of plant, indeed, the same individual if transplanted, will take on a very different form if grown near a mountain-top or in a lowland valley; *Ranunculus* will acquire one appropriate shape if grown in water, another if grown in air. Natural selection can thus build up favourable responses adapted to a variety of needs, and the potentialities of an organism are of primary importance.

One of the most efficient ways of responding advantageously to various needs is by correspondingly modifying "behaviour." Behaviour is response expressed in movements; it is a special kind of accommodation and has developed in association with the power of storing up the impressions of past responses; it enables the organism to "learn" and benefit by "experience." These new powers "emerge" with the elaboration of the sense-organs and of the nervous system. In the long run it is adaptability, and more especially "brain power" which wins in the struggle.

Instinct and Intelligence.—So far nothing has been said about the rôle of mind in evolution. It is a subject which cannot be discussed adequately within the scope of this article (*see* EVOLUTION AND MIND); but something must be said about the evolution of instinct and intelligence (*see* COMPARATIVE PSYCHOLOGY). From the strictly scientific point of view, the whole course of evolution may be represented as an unbroken series of physico-chemical events, each step conditioned by preceding steps. But corresponding to this series is a chain of mental events. To every mental process or event, whether of the most complex or "highest" kind in the mind of man, or of the simplest or "lowest" in the most primitive organism, there corresponds some physico-chemical change. The slightest disturbance in the metabolism of the brain, due to any stimulus whatsoever, will be accompanied by a disturbance in the mental processes. Our sensations, emotions, thoughts—all our mental activities are correlated with changes in our bodies of which our behaviour is the outward and visible expression. Of our own mental processes we have direct knowledge in so far as we become conscious of them; but of the existence of similar mental processes in other organisms we can only infer by observing their structure and behaviour. The gradual elaboration of the sense-organs and nervous system, and behaviour seen in the evolutionary series, more especially of animals, we judge to have been accompanied by a corresponding development of mental powers. The closer these physical characters resemble our own the more like our own we believe their minds to be.

Natural science is not directly concerned with metaphysical explanations or philosophical systems; it does not seek to explain the ultimate cause or purpose of existence, the ultimate nature of things or of knowledge. Nevertheless, when dealing with the scientific description of evolutionary processes, we should endeavour to realize what are the limitations of scientific method, and what is the scope of natural science within which its conclusions may be accepted.

What are commonly distinguished as mind and body are two one-sided incomplete abstractions, made in our own conscious minds and subject to its limitations. These two abstractions represent perhaps two aspects of some whole, more fundamental, reality. Like the two sides of a plane surface, they cannot both be seen at the same time. The mental and physical series of events are not two independent parallel series; so far as we know, one cannot exist without the other; they are indissolubly connected. Neither can one be said to be produced by the other, or be described in the same terms. The mental series cannot be held to interfere with, guide or break into the interconnected chain of physico-chemical events. The two series may perhaps be distinguished as respectively subjective and objective,—the one is felt, the other observed. The question, "What has been the influence of the mind in evolution?" has no scientific meaning, and should rather be asked in some such form as this: "What part has been played in evolution by that complex system of sense-organs, nervous system, etc., to which correspond higher mental processes such as those we know in ourselves?" With such a question natural science can legitimately deal, even though a complete answer cannot yet be given, owing to our very incomplete knowledge of the metabolic processes involved.

The adoption of this position as, at all events, the only practical scientific working hypothesis, entails the conclusion that to every metabolic process in a living organism there corresponds some sort of mental process, that every organism may be said to have some sort of mind be it ever so "low" or rudimentary. And this conclusion is amply justified by the observation of behaviour, whether "instinctive" or "intelligent."

Since the two series are indissolubly correlated, the "laws" of variation and inheritance hold good in mental as in material evolution. This explains how man, by breeding and selecting the requisite mechanism, has altered the behaviour and with it the mental equipment of races of domestic animals.

Tropisms.—An analysis of the behaviour of the lower organisms shows that, to a great extent, it is based on direct responses to external stimuli. Such responses of movement are called tropisms, and distinguished as phototropism, geotropism, hydrotropism, etc., according as the stimulus influencing metabolism is light, gravity, moisture, etc. Thus, owing to more active growth on one side than the other, shoots of plants grow towards and roots away from the light; the former are positively, the latter negatively phototropic. Similarly shoots grow away from, and roots towards, the centre of the earth; here the stimulus is the action of gravity. If light falls on a shoot at an angle to the pull of gravity, the resulting direction of growth will be a compromise between the two tropisms. The same tropistic responses occur with fixed animals, for instance hydroid zoophytes. It is important to realize that the motions of free-moving animals are likewise governed by tropisms. As is shown by the swimming of unicellular Algae or Infusoria, the creeping of a snail, the flight of an

insect, organisms may be positively or negatively phototactic. Thus the behaviour may be made up of various tropistic responses to stimuli. The kind of response evoked depends on the kind of stimulus, and also on the structure and condition of the mechanism stimulated. A well-fed animal will react differently from a starved one, a young animal differently from an old one.

Another important element besides simple tropisms in the behaviour of organisms is known as "differential sensibility," or the reaction to sudden and marked changes in the strength of a stimulus. Leaves may move or flowers open in strong light; a shadow passing across may cause a worm to contract, a fly to escape.

The usual behaviour of lower organisms; their movements when seeking food; their habit of gathering together in dark, warm, or damp places; their sexual instincts; their instincts connected with reproduction, such as the laying of eggs on appropriate substances for the young to feed on, and so forth, can be interpreted as composed of such simple responses. Instinctive behaviour is a chain of interlocked simple responses each one of which acts as a stimulus to the next. An environmental stimulus releases the first and the others inevitably follow to a definite and predictable end, provided the necessary conditions are present.

Tropistic response is, of course, based on the fundamental irritability of protoplasm. It varies in extent and direction, and, like other variations, may be useful, harmful or indifferent. Useful instinctive behaviour may be built up by the natural selection of tropisms of "survival value" into the wonderful instincts displayed, for instance, among social insects (*q.v.*). Such complex chains of reactions will be inherited, for they depend for their appearance on the interaction of certain transmitted factors of inheritance with the conditions present in the normal environment. Among animals, simple responses or tropisms become "reflex actions" owing to the great differentiation of the tissues, and elaboration of the mechanism consisting of sense-organs to receive special stimuli and a nervous system to convey impulses set up by them to muscles which carry out the movements. Sequences of interlocking and co-ordinated reflexes form the basis of the most complicated behaviour; yet another element, "associative memory," enters more especially into its more elaborately differentiated forms. It depends on the fact that the effects of a response may persist as a lasting impression on the organism, in the form of some physico-chemical change which serves as an internal stimulus to modify subsequent responses. The cumulative effects of past responses may thus greatly influence behaviour.

DELIBERATION AND MEMORY

Intelligent Behaviour.—Now instincts are relatively fixed interlocked series of responses to external and internal stimuli, and correspond to a mechanism specialized to respond in a particular direction; once started they proceed to a predestined end. Intelligent behaviour, on the other hand, depends on the fact that although the characters of an organism (including its behaviour responses), are necessarily determined and limited in range by inheritance, yet within that range they are not predetermined in any one direction. Just as a zygote may give rise to as many different kinds of phenotypes as there are varieties of environments capable of moulding its development, so the particular behaviour may vary according to the stimuli received. The cumulated effects of past responses, together with the new stimuli, make up the total of conditions which determine the final response or behaviour. The "choice" between alternative courses of behaviour is the result of the balance struck between these various influences. So intelligent organisms are said to benefit by "experience." Example, precept, tradition, education, are all external stimuli which may influence conduct and leave lasting effects which may act as internal stimuli modifying further behaviour. But, of course, these effects are not transmitted directly, and the stimuli have to be applied anew at every generation if the results are to reappear.

No hard-and-fast line can be drawn between instinctive and intelligent behaviour, and they are usually combined; the rudiments of both seem to occur in the lowest organisms, but it is in the higher animals and more especially in man that intelligence has reached its highest development.

As the sense-organs and nervous system advance in complexity and perfection, new qualities emerge marking new levels in mental development; consciousness is one of these. We cannot tell at which stage in phylogeny, consciousness arose. In the case of our own species we can determine approximately at what stage consciousness begins to manifest itself, as the tissues become differentiated in ontogeny; but, with regard to its evolution, it can only be said that it probably appeared, as we know it in ourselves, when the cerebral hemispheres reached the high state of development seen in man, though the lower organisms may possess it in some simpler stage of development. Very striking in a survey of the evolution of the vertebrates, is the steady increase in the relative size and complexity of the brain, the centre of co-ordination and storage-house of past impressions, as we pass from fish to amphibian, reptile and mammal. This is particularly conspicuous in the Primate series leading up to man. Most of the structural peculiarities of the human body are related to the great development of the brain, in other respects it differs but little from that of our nearest relatives, the anthropoid apes. Man's great capacity for retaining the impressions of past responses, and for bringing them to bear on responses to new stimulations, has led to the wonderful growth of his powers of adaptability to new and varying conditions. The acquisition of stereoscopic vision and the power of fashioning and using implements were important steps in the evolution of modern man. Brain power, not brute force, has secured him his mastery of the world. It is a grave mistake to represent this success in evolution as due merely to individual strength, skill and foresight. The triumph of the human race over the lower organisms, and again of the higher races over the lower, has been brought about through mutual help, co-operation, self-sacrifice and the subordination of the individual.

Patriotism and religion, art, science and literature, have all their survival value and play a useful part in evolution. Morality appears not as an unrelated external force working against a ruthless and unmoral cosmic process, but as a product of evolution and an important influence moulding its development. We may hope and believe that in the long run those civilizations which are founded on justice and liberty, on law and order, on sound morality, will succeed best and last longest.

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(E. S. Go.)

EVOLUTION AND MIND. In current usage the word "evolution" is sometimes restricted in such wise as to render it applicable only to plants and animals, sometimes so extended as to be applicable throughout nature. Closely connected with this difference of use is the place assigned to mind in or in relation to nature. Some of those who advocate the restricted usage urge that evolution is due to the agency of mind; most of those who accept the unrestricted usage interpret mental progress in terms of evolution.

Unrestricted Evolution.—Since the noun here stands for a concept of wide range it needs suitable qualification to indicate its special application. Thus we may discuss cosmic, organic, mental, or social evolution; the evolution of the solar system, of a continent, of scenery; of this or that family of animals or plants; of the atom, the molecule, the crystal. It is clear, therefore, that one must state that which is common to each of these several instances. The noun must have in all cases some comprehensible meaning, though this can only be expressed in comprehensive form. It may take form in a broad generalization. Thus one may say that any set of events or state of affairs, physical or mental, which exemplifies evolution is a passing phase in an orderly sequence and comes into existence under such conditions that its place in the sequence, its relations to precedent and subsequent phases, and its relations to other surrounding events, are interpretable under the accredited method of scientific procedure.

There is, however, difference of opinion as to the distinctive character of the method of procedure in inductive science. Some say that the accredited method in physics is now a discredited method in biology. Each writer should therefore state what he means. That which is here meant may be best expressed in terms of events and relations, on the understanding that things, such as molecules or crystals, and living organisms, such as animals or plants, are, for science, no more and no less than orderly clusters of events in relation. One finds that clusters of events and sets of events are in quantitatively changing relations to each other—relations temporal, spatial, and physical, and those which, in the broadest sense, we speak of as mental. One finds that with change in these relations the course of events changes. Hence one says: Given such and such modes and changes of relatedness, such and such is the course of events.

It is clear that any course of events implies temporal advance. Selecting, then, some set of events as a field of inquiry, one makes three successive snapshot records of three phases in temporal advance. If all three phases are alike there is no evidence of evolution. But if the phases are different, say l, m, and n, we have the kind of evidence on which the unrestricted concept of evolution is based—unrestricted because it is applicable to *any* set of events which is the subject-matter of inquiry. At the phase m the course of events differs in character from that current at the precedent phase l, and from that current at the subsequent phase n. That, however, is only what one observes. In a scientific interpretation of what one observes one seeks an answer to the question: What changing relations are in being during the changing course of events? This subdivides into two: (1) What are the intrinsic relations within the given set of events? (2) What are the extrinsic relations to other events? If answers can be given to these questions the observable passage through the phases l, m and n is scientifically interpreted.

If the snapshots are taken at wide intervals of time, and if the phases l, m and n are markedly different, one may be unable to say what relations, intrinsic and extrinsic, are or were in being during the time-span intervening between the snapshots. This is the chief difficulty that attends the interpretation of the irrecoverable past. The events themselves and their inner and outer relations have to be filled in under more or less probable conjecture.

Where evolution is in progress in like sets of events with like routine of advance, snapshots can be taken at shorter and shorter time-intervals. One must realize that in practice l, m and n symbolize recorded observations, and that difference in symbol denotes difference of character. If there be no difference of character, there is no evidence of evolution. One's aim is to get records at such minimum intervals in next-to-next snapshots as may give evidence of evolutionary change. A further question then arises. Is the difference at minimum interval such as to lead us to infer a seemingly sudden jump from next to next? If so, the new character is said to be "emergent" (*see* EMERGENCE). In some cases there do seem to be critical turning-points—for example, from atom to molecule, or from molecule to crystal unit, or from not-living to living—in the characters of some clusters of events, with new modes of relatedness that swiftly, if not suddenly, appear on the scene of nature.

Evolution and Dissolution.—We now turn to a question of different import. Does every enchained sequence of natural events, in so far as there is observable change, furnish an instance of evolutionary advance? It was one of Herbert Spencer's noteworthy contributions to the discussion of changes in sequential order that he sought to distinguish phases of events as in some sense lower and higher. On this distinction there follows that between passage from lower to higher, for which he reserved the name "evolution" and the passage from higher to lower, which Spencer spoke of as "dissolution." Since both directions in passage occur throughout nature, it is desirable thus to use different words for one and the other, or, at all events, to distinguish between *positive* and *negative* (or *progressive* and *regressive*) evolution. There is, however, difficulty in formulating criteria of higher and lower, especially as applicable to all instances of one or other respectively; for n may be higher or lower than m in complexity, in integral unity, in quality or in value. So long as due provision be made for quality and value, it may be suggested that complexity in the constitution of any l, m or n, and unity of the plan or organization may generally serve to distinguish higher from lower in any context under consideration.

In each specific context some distinction between lower and higher is commonly drawn by those who deal with matters which fall within that context. Progressive advance from lower to higher, or regressive degradation or degeneration in the opposite direction, has often to be reckoned with. And in the light of snapshot evidence the question often arises whether some m has come into existence under positive or under negative evolution. Let m, for example, be an atom of lead. There is evidence of its natural origin in isotope form, by regressive evolution (Spencer's dissolution) of the uranium or the thorium atom. But there is, as yet, no direct evidence of its origin by progressive evolution. If, however, m be a molecule, say of water, there may be evidence of its origin in this instance by progressive evolution, in that instance by the dissolution of some more complex molecule. And if m be an organism, or some phase of its life, or some stage in the development of one of its organs, the present status of m may be on the ascending line of evolutionary progress from lower to higher or the descending line of regressive degeneration.

Biological Evolution.—Under division of labour special departments or branches of scientific inquiry have been demarcated for the prosecution of intensive work and thought. The biologist chooses as his province the field of living organisms under intrinsic and extrinsic relations. He may accept the hypothesis of unrestricted evolution; but he applies the method of scientific procedure within his selected province of inquiry. Evolution is for him a doctrine of descent in affiliated organisms.

In dealing with paleontological records of extinct animals, say of the horse-type, his snapshot evidence of l, m, and n is necessarily widely spaced. Intervening phases must be filled in by inference. Let us suppose the "missing links" are such as may be inferred if a generalization based on the known l, m, n be valid. The subsequent discovery of links heretofore missing adds to the probability of the generalization. The method of procedure is substantially that of interpolating observed points—the closer the better—on a curve of probability. The conditions are different when the biologist deals, in terms of l, m, n, with adults of three successive generations. Even here, however, there is a considerable time-interval between the records of individuals that have reached the requisite stage of development. But when we turn to this individual development, snapshots may be taken at minimum intervals. Hence in embryology one comes to close quarters with next-to-next phases of advance. It then remains to correlate the story of individual development (ontogeny) with that of racial evolution (phylogeny).

Turning now to what one may speak of as linear genetics one brings under observation a short span of a germinal line of advance—or, under gametic union the relational intersection of two such lines—stretching back to more and more primitive organisms. Here, too, the aim is to get next-to-next phases in advance at minimum interval, to be interpreted in terms of relations extrinsic and intrinsic.

Biochemical Evolution.—In the method of treatment here adopted for expository purposes any three phases or stages of evolutionary advance are symbolized by l, m, and n. In all exact and detailed inquiry one's aim is to get recorded steps at minimum time-interval. Then, by combining synthetically a great number of sequent stages, thus analytically distinguished, one may envisage a cinema picture of the advance of events in nature.

If one take snapshot records at very wide intervals, say near the beginning, in the central region, and at the end (so far) of the whole evolutionary process, our l may stand for the atom, our m for the amoeba, our n for man. In the specialized field of biological inquiry, all that lies below the living organism is excluded. But in a specialized branch of biochemical research the aim is to ascertain whether, under laboratory conditions, there can be traced an evolutionary passage from the not-living to the

living. If l be the not-living and n the living, the task of the biochemist (or part of his task) is to find the transitional steps which fall under m. The full sequence has not yet been found. What progress has been made in the seeking cannot here be summarized, since our aim is only to indicate the method of procedure; to emphasize the importance of recording next-to-next snapshots; and to show how, from a wide array of such records, a cinema picture may be constructed.

Mental Evolution.—The biologist and the biochemist tell us what happens when relations of the physical kind are in being. The specific "modes" of relatedness differ at different stages of the onward passage of events in evolutionary progress—atomic, molecular, and organic. Such difference as is in evidence, for example, in the living as contrasted with the not-living, must be duly formulated and loyally accepted. The canon of scientific interpretation runs: Given such and such modes of relatedness; such and such is the course of events.

In mental evolution relations of a different *kind*—relations other than physical or physiological, but none the less natural relations—must receive full consideration, and must be correlated with such physical relations as are judged to be co-present. But just as there are ascending modes of physical and physiological relatedness so are there ascending modes of mental relatedness. When this or that higher mode is in being, the course of events differs from that which is observed when the mode of relatedness has not come into being in evolutionary progress.

That which may be inferred from observation is still interpretable in terms of l, m and n, which now carry two-fold import, both physical and mental. In our own current experience, complex as this is, the aim of psychological analysis is to get as near as one can to next-to-next steps. But, under wide spacing, if l be the life-mind stage of an amoeba, m that of a rabbit, n that of a man, one should not interpret m in terms of n, which is more highly evolved; nor should one interpret m in terms of l—or in these terms *only*—because what gives to m its evolutionary status comprises *more than* is comprised under l. One should take m as one finds it at its own level. Thus one may say (a) in mental and in (b) physical regard (which provides for energy changes): Given such and such mode of relatedness extrinsic or intrinsic; such and such is the course of events in this or that instance of l, m or n. The same method of interpretation is applicable throughout nature. There is no privileged field of natural events wherein its writ does not run.

Restricted Evolution.—It remains briefly to indicate the cardinal claim of those who advocate a restricted use of the word "evolution." This claim is that a concept of *agency*, as efficient cause, is imperatively demanded when one passes the mechanical world of the not-living to the purposive realm of the living. On this all other claims hinge. A further claim—that here in focus—is that only when Life enters into, possesses, organizes and utilizes a physical cluster of events, is there evolution in that sense to which, as they urge, it should be restricted. There is, it is said, nothing in common, between cosmic or physical evolution, so called, and the uplifting activity of Mind disclosed in biological evolution. This may therefore, in elliptical phrase, be spoken of as Creative—more strictly as implying creative activity.

Here the question arises: Is treatment in terms of creative activity—thus restricted to the purposive realm of the living—scientific or metaphysical? The answer turns on definitions. Some so characterize the domain of science as to exclude from its purview the concept of activity as efficient cause. Others urge that it must be included in biology. Opinions differ. That of M. Bergson may here be cited. "La philosophie" he says, "devra donc suivre la science, pour superposer à la vérité scientifique une connaissance d'un autre genre, qu'on pourra appeler métaphysique." In science, he tells us, we are "dealing only with the evolved, which is a result, and not with evolution itself, which is the act by which the result is obtained.

It seems, then, we must take into consideration (1) an observable course of natural events; (2) an interpretation of these events in terms of relations, intrinsic and extrinsic; (3) an explanation of some of these events in terms of agency and act. Fully admitting that under the third heading an important philosophical problem falls for discussion, one may hold that those who impose any restriction of the range of efficient causality must argue their case at the bar of philosophy. In the foregoing sections the field covered by the first and second heading has been selected as the universe of discourse. As we have seen there is, under these headings, ample provision for mental relations in all their ascending modes, and therefore for mental evolution. But it should be realized that for those who use the word "evolution" in the restricted sense, mental evolution implies far more than this. It implies Life or Mind as the efficient cause of the course of events in living creatures. But even if some such philosophical implication be accepted—or preferably one less restricted in scope—the interpretation of all natural events in relational terms must still be the aim of the man of science in his detailed investigations. (*See* ANIMAL BEHAVIOUR; PSYCHOLOGY, COMPARATIVE.) (C. LL. M.)

EVOLUTIONARY ETHICS. There is no warrant for calling animals moral agents, though a few highly endowed types, such as dog and horse, which have become man's partners, may have some glimpse of the practical meaning of responsibility. Cases are known where an animal's natural reaction is inhibited, apparently because of previously established habits, possibly in some cases because ideas are beginning to emerge. But if a truly ethical action implies control in reference to a moral ideal, even those who are inclined to be generous to animals must allow that this is practically man's prerogative. Animals have behaviour, which hardly ever touches the level of conduct; man has always the possibility of conduct, though he often subsides into mere behaviour.

There are among animals many illustrations of what may be called the raw materials of morals. Thus, they are devoted to their offspring, sympathetic to their kindred, affectionate to their mates, self-subordinating in their community, courageous beyond praise. Many a mother animal, such as a stoat, will defend her offspring to the death. A male hornbill will wear himself to a skeleton in foraging for his brooding mate, imprisoned in a hole in a tree. A male baboon in a retreating troup will return in the teeth of danger to rescue a youngster accidentally left behind. Animals may not be ethical, but they are often virtuous. Many animals are faithfully monogamous, as in the case of ravens, eagles, cranes, swans, rhinoceros, oryx antelope, white whale, and orang. When higher animals act in concert, as when beavers cut a canal, or monkeys make a raid, or pelicans combine in fishing, or wolves hunt in a pack in winter, there is some degree of controlled self-subordination, which almost sounds the ethical note; and there are many instances of impulsive mutual aid beyond the bounds of the habituated and the instinctive. No one dreams of calling a plant altruistic because much of its energy is devoted to filling the seeds with nutritive legacy, and one must be restrained in one's appreciation of the instinctive other-regarding activities of ants and bees. Among some ants it is instinctive on the part of a well-fed individual to give food to a hungry beggar of the same species, and though we may agree with those who maintain that conscious kin-sympathy was at work in the racial establishment of that instinct, and that some awareness still remains, we would for our present purpose evade the difficulty by looking for evidence of good feeling among animals that illustrate an intelligent or a predominantly intelligent mode of life. Among mammals, for instance, there are many cases of behaviour that expresses not self-gratification, but devotion to the welfare of others.

For man there is evolutionary interest in these springs of sympathy and courage among animals, for he must have inherited impulses of this type from his pre-human ancestors. Man cannot be a moral Melchisedec, "without descent," and we look among the higher animals for illustrations of the fine strands of kindness, affection, self-subordination, loyalty, courage and control, which were afterwards woven into a distinctively human pattern. Regarding man as a new synthesis, making all things new, we willingly admit that he did not simply carry on and raise to a higher power the kin-sympathy, let us say, of the wolf; for evolution does not proceed in this simple fashion. But our point is

that there must have been definite pre-human strands which were transformed in the new synthesis of man.

The evolutionist question thus becomes: What was there in the early Hominoids to foster further progress in the direction of the raw materials of goodness? An answer cannot as yet be much more than groping. The ancestors of Homo supposedly diverged from a big-brained anthropoid stock of social disposition which had served a long arboreal apprenticeship. About the Miocene time, when the Himalayas were uplifted and the great forests began to shrink, the ancestors of tentative men were forced into a terrestrial environment and were subjected to sifting by predatory competitors from whom they had been previously in some measure isolated by their arboreal habits. Thus we picture the ancestors of men descending to terra firma, with more brains than brawn, with little chance against the large beasts of prey except by outwitting them, and with predispositions towards gentleness which had been engendered in part by the prolonged infancy with its appealing helplessness. Such pre-men, no doubt in obedience to their engrained promptings in favour of mutual aid and sociality, found safety in uniting their families into simple societies. For isolated human families the struggle for existence would be too keen when they ventured beyond the sanctuary of the trees; and thus there probably arose a self-preservative linkage of families, perhaps a million years ago. The fallacy must be avoided of supposing that our ancestors combined their families because they foresaw possible advantages, for this is not the way in which unsophisticated evolution works. They obeyed their social promptings and then discovered, more or less dimly at first, that there was a new strength in their old weakness. The experiments in society-making would give man a firmer foothold in the struggle for existence, and variations in the direction of increased sociality would tend to survive. Precious individuals, such as the pioneer artists and thinkers, would have a chance to survive under the society aegis; permanent products with their useful and educative enregistrations would increase; life would be more secure for adventurous children whose new departures form an important part of the raw materials of evolution, and the growth of tradition would be helped by the increasing care of the aged. Too often, in the things pertaining to man, the evolutionist relapses into creationism, trying to make faculties out of nothing; our point is that we must in our reconstruction make the most of the pre-human strands and of the cradle-influences of early experiments in society-forming.

But here it is necessary to introduce a saving-clause which expresses the divergence of the modern from the Spencerian outlook. As a convinced Lamarckian, Spencer believed that qualities directly induced by new functions and surroundings may be added to the racial repertory by hereditary entailment, and that they may be cumulatively increased by contributions made by individual parents. To many biological evolutionists this possibility appears unproven and even improbable.

MAN, THE NEW SYNTHESIS

The evolution of moral qualities may be divided into epochs. First, there was the pre-human period, marked by the rise and progress of parental affection, kin-sympathy, courage, self-subordination, and other primary virtues. Second, in the early ages of tentative men, hominoid rather than homines, there was a re-definition and re-thrilling of the moral fibres under the influence of the new synthesis or mutation—Man. With reason and language and consciousness of history both past and possible, there must have been a re-tuning of the moral nature. Third, there was the period of primitive societies, still small and simple, when social inter-relations began to have their subjective effect, when social claims began to transcend or to thwart those of the family and the individual, and when the social shield began to shelter variants who would have had difficulty in surviving in the isolated family. The fourth period is especially marked by the growth of the extra-organismal heritage—the moral tradition, the moralising institutions, the morality enregistered in literature and art, and everything in the nature of law. Only in this period did there begin the focussing of moral ideas and the formulation of moral standards. Only now was it possible to have a culture of goodness as a reward in itself. Moral ideals became self-conscious. As social complexities and inter-societary complications increased, a dilemma, previously not more than adumbrated, became poignant,—the dilemma between a social policy, more or less deliberately devised to secure survival, and the moral promptings intrinsic in our natural inheritance or extrinsic in our external heritage. Thus the desirable improvement of the human breed may conflict with our moral sentiments. Contrariwise our strong kin-sympathy may thwart charity organisation and multiply beggars. Moreover, the momentum of the social organisation into which we are born may baulk the realization of both social and individual ethical ideals. New moral problems have evolved with the growth of civilization, and even the individually good man may think too little of the state. Thus we are at present in the early days of an evolving social ethics.

Philosophical critics have exposed the difficulty of giving an account of the evolution of morals in terms of known biological and psychological factors; and that difficulty must be admitted by all who are not easygoing. There is a risk, however, of exaggerating the difficulty by failing to appreciate the subtlety of the evolutionist position. Thus it is not difficult to make game of the Darwinian theory of the evolution of the virtues, if one ignores such points as the following, (*a*) that natural selection includes "reproductive" selection, favouring the more fertile variants, often the better parents, as well as "lethal" selection, which eliminates the relatively unfit to given conditions; (*b*) that the struggle for existence, as Darwin emphasized, includes all the endeavours and reactions that organisms make against environing difficulties and limitations, the well-lined nest of the long-tailed tit, as well as the talons of the eagle; (*c*) that the living creature is not a passive item being sifted in a sieve, but an agent in its own evolution, as James Ward so clearly saw, playing for all it is worth its own hand of hereditary cards; (*d*) that the indispensable sifting, which results in the survival of certain variants on account of certain qualities, is in reference to an established system of Nature, often of extraordinary nicety; (*e*) that a variation not in itself such, in quality or in quantity, that it could be selected by the existing sieves, may be entailed for generations because it is correlated with other variations that have selection-value. There are well-known instances in the realm of organisms of characters which have had a cumulative increase, not because they themselves are of demonstrable utility, but because of a certain "organic momentum," the limit being that they do not prove positively disadvantageous.

In the evolution of morals there has been a continuous sifting of variations in man's sympathy, affection, courage, and control-power, and the sifting process has changed from crude to subtle natural selection, and from rational to social selection, the big fact being that variations in certain directions tend towards not survival merely, but progress. For the animal, progress means greater fullness and freedom of life, marked by increased differentiation and integration, and with an associated emancipation of the mental aspect. For man, granting health and wealth, progress means approximation to an asymptotic ethical ideal, which includes a richer embodiment of the true, the beautiful and the good. Conduct that is controlled towards the ideal is good conduct. Its strands were spun in the animal, they were woven and transmuted in man, they have been sifted by many modes of selection,—natural and sexual, rational and social. The processes of variation and selection are still continuing, and, since retrogressions are easy, it is man's unending task to criticise his sieves and the ideals which form their mesh. It must be allowed by all that these ideals have been influenced not only by man's intrinsic moral nature and extrinsic moral heritage, but by even subtler factors, such as his philosophy and religion. Their validity and sanctity are not prejudiced by an account of their evolution; to anyone with imagination their imperativeness is enhanced by a disclosure of their indispensability in the ascent of man.

But those who seek to form a scientific picture of the evolution

of morals must give to two considerations more attention than they have hitherto received. The first, already referred to, is the necessity of trying to distinguish moral peculiarities that express germinal variations from moral peculiarities that are impressed as nurtural modifications. This is important since the biological facts are, in the writer's judgment, strongly in favour of the hereditary transmission of the former, and against the hereditary transmission of the latter, which may, however, affect the extra-organismal or social heritage. Secondly an inborn variation, say in control-power, sympathy, courage, veracity, may be the subject of selection; yet it may be that the moral quality which is oftenest selected or eliminated is *the degree of susceptibility* to the social heritage as expressed in moral customs and moral institutions of every sort. Thus it becomes urgent to secure the continuance of those factors that have in the past demonstrably bettered the extra-organismal heritage—such homely but supreme influences as the love between man and woman, the happy family, and the social solidarity induced by combination in noble endeavour. A continuance and development of these ameliorative influences, adjusted as need be, must be recognized as the practical side of the evolution of morals.

NATURE AND THE PHILOSOPHERS

But besides the evolution of morals, there arises the question of the ethics of evolution. If man is the present climax of a long process of organic evolution, it is natural to ask whether there is in the evolving system of animate Nature any guidance for his conduct, or any confirmation of his ideals. There has been much difference of opinion on this subject. Thus in a famous essay John Stuart Mill (1874) arraigned Nature for "recklessness," "cruelty," and indiscriminate frustration of man's efforts. To follow Nature, he said, would be "irrational" (Nature being such a wasteful bungler) and "immoral," for "the course of natural phenomena is replete with everything which, when committed by human beings, is most worthy of abhorrence." Somewhat similar was the indictment of Nature in William James's essay, "Is Life worth living?" but his Manichaeism went even deeper. He arraigned Nature for "hideousness," "cruelty," and meaningless weather. "Visible nature is all plasticity and indifference—a moral multiverse, as one might call it, and not a moral universe. To such a harlot we owe no allegiance; with her as a whole we can establish no moral communion." In the pronouncements by these two philosophers there is no appreciation of the actual advancement of life which has been accomplished in organic evolution, no appreciation of the ubiquitous beauty and the almost universal healthfulness, no mention of the parental care, the mutual aid, the kin-sympathy that are so common, no discernment of the rewards of survival and success that have been given to the self-subordinating as generously as to the self-assertive. The fact is that the pictures of Nature drawn by John Stuart Mill and William James are out of perspective and off colour. They do not show a sufficiently intimate acquaintance with Nature as it actually is.

But this cannot be said of Huxley whose famous lecture on "Evolution and Ethics" pictures animate Nature as too much like a vast gladiatorial show, a Hobbesian warfare of each against all, a dismal cockpit, an inexorable struggle for existence, the result of which is merely the survival of the most suitable, not of the best in any sense. "Let us understand, once for all, that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it." It must be granted that Huxley was exposing the error that the survival of the fittest need mean more than the survival of those organisms that are best suited to the particular conditions of their life. The tapeworm is "fit" as well as the golden eagle which it inhabits; and the process of evolution may be retrogressive as well as progressive. Yet, on the whole, we submit, the process of organic evolution had been an integrative advance. It must be granted also that Huxley was making the point that animal life is not in the strict sense ethical, which every clear thinker allows. Yet there is one-sidedness in Huxley's picture, for it is not made clear that "the struggle for existence" is, as Darwin said, a formula covering all the answers-back that organisms make to environing difficulties and limitations, that it includes experiments in co-operation as well as in competition, in parental care as well as in predatory devices, in self-subordination as well as in self-assertion.

But turning from these arraignments we would advance a positive thesis that in the realm of organisms there are great evolutionary movements which correspond in their general trend with some of the best of those expressed in man's concept of progress. Living Nature is all for health; apart from parasites there is practically no disease in wild nature. Beauty is Nature's hall-mark of harmonious vigorous life; ugliness her stigma of dishonour, hardly seen except in those organisms that adopt the parasite's drifting life of ease. Even among animals there is a trend that makes against dull stupidity, so fatal to the giant saurians, and puts a premium on brains. Finally there is survival value among animals in other-regarding as well as in self-regarding endeavours. Good parents, good lovers, good kin do by no means lose their reward. Thus we deliberately advance the thesis that man's pursuit of the beautiful, the true, and the good, though transcending all biology, has its adumbrations in animate nature. *See* ETHICS; EVOLUTION; ANIMAL BEHAVIOUR; ANIMAL SOCIOLOGY.

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EVORA, the capital of an administrative district in the province of Alemtejo, Portugal; 72 m. E. by S. of Lisbon, on the Casa Branca-Evora-Elvas railway. Pop. (1920) 16,148. Evora occupies a fertile valley enclosed by low hills. It is surrounded by ramparts flanked with towers, and is further defended by two forts. Evora is the see of an archbishop, and has several churches, convents and hospitals, barracks, a diocesan school and a museum. A university, founded in 1550, was abolished on the expulsion of the Jesuits in the 18th century. The cathedral, originally a Romanesque building erected 1186–1204, was restored in Gothic style about 1400; its richly decorated chancel was added in 1761. The church of São Francisco (1507–1525) is a good example of the blended Moorish and Gothic architecture known as Manoellian. The art gallery, formerly the archbishop's palace, contains a collection of Portuguese and early Flemish paintings. An ancient tower, and the so-called aqueduct of Sertorius (really dating from *c.* 1550), 9 m. long, have been partly demolished to make room for the market-square, in which one of the largest fairs in Portugal is held at midsummer. Both tower and aqueduct were long believed to have been of Roman origin, but are now known to have been constructed about 1540–1555 in the reign of John III., at the instance of an antiquary named Resende. The aqueduct was probably constructed on the site of the old Roman one. A small Roman temple is usually known as the temple of Diana, a name for which no valid authority exists. Evora is of little commercial importance, except as an agricultural centre, but its neighbourhood is famous for its mules and abounds in cork-woods; there are also mines of iron, copper, and asbestos and marble quarries.

Under its original name of *Ebora*, the city was from 80 to 72 B.C. the headquarters of Sertorius, and it long remained an important Roman military station. It was called *Liberalitas Juliae* on account of certain municipal privileges bestowed on it by Julius Caesar. Its bishopric, founded in the 5th century, was raised to an archbishopric in the 16th. In 712 Evora was conquered by the Moors, who named it *Jabura;* and it was only retaken in 1166. From 1663 to 1665 it was held by the Spaniards. In 1832 Dom Miguel, retreating before Dom Pedro, took refuge in Evora; and here was signed the convention of Evora, by which he was banished. (*See* PORTUGAL.)

ÉVREUX, a town of north-western France, capital of the department of Eure, 67 m. W.N.W. of Paris on the Ouest-État rail-

way to Cherbourg. Pop. (1926) 14,847. It stands on the slopes of the valley of the Iton. Vieil-Évreux (*Mediolanum Aulercorum*) was the capital of the Gallic tribe of the *Aulerci Eburovices* and a flourishing city during the Gallo-Roman period. Its bishopric dates from the 4th century. The first family of the counts of Évreux which is known was descended from an illegitimate son of Richard I., duke of Normandy, and became extinct in the male line with the death of Count William in 1118. The countship passed in right of Agnes, William's sister, wife of Simon de Montfort-l'Amaury (d. 1087) to the house of the lords of Montfort-l'Amaury. Amaury III. of Montfort ceded it in 1200 to King Philip Augustus. Philip the Fair presented it (1307) to his brother Louis, for whose benefit Philip the Long raised the countship of Évreux into a peerage of France (1317). Philip of Évreux, son of Louis, became king of Navarre by his marriage with Jeanne, daughter of Louis the Headstrong (Hutin), and their son Charles the Bad and their grandson Charles the Noble were also kings of Navarre. The latter ceded his countships of Évreux, Champagne and Brie to King Charles VI. (1404). In 1427 the countship of Évreux was bestowed by King Charles VII. on Sir John Stuart of Darnley (*c.* 1365–1429), the commander of his Scottish bodyguard, who in 1423 had received the seigniory of Aubigny and in Feb. 1427–28 was given the right to quarter the royal arms of France for his victories over the English (*see* Lady Elizabeth Cust, *Account of the Stuarts of Aubigny in France, 1422–1672*, 1891). On Stuart's death (before Orléans during an attack on an English convoy) the countship reverted to the crown. It was again temporarily alienated (1569–84) as an appanage for Francis, duke of Anjou, and in 1651 was finally made over to Frédéric Maurice de la Tour d'Auvergne, duke of Bouillon, in exchange for the principality of Sedan.

Évreux is the seat of a bishop. Part of the cathedral nave dates from the 11th century; the west façade is mostly late Renaissance. The elaborate north transept and portal are in the Flamboyant style; the choir is earlier Gothic. The Cardinal-bishop de la Balu built the octagonal central tower and the Lady chapel (15th century), which is remarkable for its stained glass. Two rose windows in the transepts and the carved wooden screens of the side chapels are masterpieces of 16th-century workmanship. The episcopal palace (15th century), adjoins the south side of the cathedral. An interesting 15th century belfry faces the modern town hall. The church of St. Taurin is Romanesque (14th century) and later. At Vieil-Évreux, 3½ m. S.E. of the town, the remains of a Roman theatre, a palace, baths and an aqueduct have been discovered; various finds are in the museum of Évreux. Évreux is the seat of a prefect, a court of assizes, of tribunals of first instance and commerce, a chamber of commerce and a board of trade arbitrators. The making of ticking, metal-founding and scientific glass-making are carried on.

EVZONES, members of rifle units in the Greek army, recruited from mountainous districts, and wearing a picturesque dress with wide skirt and tufted shoes. Their organization corresponds to that of a line infantry regiment. There are three regiments of Evzones in the Greek army.

EWALD, GEORG HEINRICH AUGUST VON (1803–1875), German Orientalist and theologian, was born on Nov. 16, 1803, at Göttingen, where his father was a linen-weaver. Educated at the university of his native town, he was made professor *extraordinarius* in philosophy and lecturer in Old Testament exegesis in 1827, professor *ordinarius* (in 1831) in philosophy, and in 1835 of Oriental languages. Having in 1837, along with six of his colleagues signed a formal protest against the action of King Ernst August (duke of Cumberland) in abolishing the liberal constitution of 1833, which had been granted to the Hanoverians by his predecessor William IV., he was expelled from the university. Early in 1838, however, Ewald received a call to Tübingen, and there for upwards of ten years he held a chair as professor *ordinarius*, first in philosophy and afterwards, from 1841, in theology. To this period belong some of his most important works, and also the commencement of his bitter feud with F. C. Baur and the Tübingen school. In 1847 he returned to Göttingen, the liberal constitution having been restored. But the chief crisis in his life arose out of the political events of 1866. His loyalty to King George (son of Ernst August) would not permit him to take the oath of allegiance to the victorious king of Prussia, and he was therefore placed on the retired list, though with his full salary as pension. The violent tone of some of his printed manifestoes about this time, especially of his *Lob des Königs u. des Volkes*, led to his being deprived of the *venia legendi* (1868) and also to a criminal process, which, however, resulted in his acquittal (May 1869). Then, and on two subsequent occasions, he was returned by the city of Hanover as a member of the North German and German parliaments. In June 1874 he was found guilty of a libel on Prince Bismarck. He died on May 4, 1875.

As a teacher Ewald had a great power of kindling enthusiasm. His *Hebrew Grammar* marked a new era in biblical philology; and as an exegete and biblical critic no less than as a grammarian he has left his abiding mark. His *Geschichte des Volkes Israël*, the result of 30 years' labour, was epoch-making in that branch of research. Taking up the idea of a divine education of the human race, which Lessing and Herder had made so familiar to the modern mind, and firmly believing that to each of the leading nations of antiquity a special task had been assigned, Ewald felt no difficulty about Israel's place in universal history. The history of Israel, according to him, is simply the history of the manner in which the one true religion came into the possession of man. The historical interval between the exodus and the appearance of Christ is treated as dividing itself into the periods of Moses, David and Ezra, and indicated by the successive names by which the chosen people were called—Hebrews, Israelites, Jews.

His chief works are:—*Die Composition der Genesis kritisch untersucht* (1823), an acute and able attempt to account for the use of the two names of God without recourse to the document-hypothesis; *Kritische Grammatik der hebr. Sprache* (1827) which became in 1844 the *Ausführliches Lehrbuch der hebr. Sprache* (8th ed., 1870, Eng. trs. 1836); *Hebr. Sprachlehre für Anfänger* (4th ed., 1874); *Commentarius in Apocalypsin Johannis* (1828); *Abhandlungen zur biblischen u. orientalischen Literatur* (1832); *Grammatica critica linguae Arabicae* (1831–33); *Die poetischen Bücher des alten Bundes* (1835–37); *Die Propheten des alten Bundes* (1840–41, Eng. trs. 1875–81); *Geschichte des Volkes Israël* (1843–59, partial Eng. trs. 1867–74); *Alterthümer Israels* (1848, Eng. trs. 1876); *Die drei ersten Evangelien übersetzt u. erklärt* (1850); *Über das äthiopische Buch Henoch* (1854); *Die Sendschreiben des Apostels Paulus übersetzt u. erklärt* (1857); *Die Johanneischen Schriften übersetzt u. erklärt* (1861–62); *Über das vierte Esrabuch* (1863); *Sieben Sendschreiben des neuen Bundes* (1870); *Das Sendschreiben an die Hebräer u. Jakobos' Rundschreiben* (1870); *Die Lehre der Bibel von Gott* (1871–75); *Jahrbücher der biblischen Wissenschaft* (12 vols., 1849–65).

See T. Witton Davies, *H. Ewald* (1903); T. K. Cheyne, *Founders of Old Testament Criticism* (1893); F. Lichtenberger, *Hist. of German Theology in the 19th Century* (1889); Herzog's *Realency.*

EWALD, JOHANNES (1743–1781), the greatest lyric poet of Denmark, was born at Copenhagen on Nov. 18, 1743, the son of a chaplain. He studied at Schleswig and Copenhagen. At 15 he fell in love with Arense Hulegaard, and in order to distinguish himself enlisted in the Prussian army. After a series of extraordinary adventures in the Seven Years' War, he deserted to the Austrians, where from being drummer he rose to being sergeant. In 1760 he deserted again, returned to Denmark and in 1762 passed his final examination. About the same time Arense married another man, and Ewald never recovered from the disappointment.

On the death of Frederick V., Ewald published in 1766 three *Elegies* over the dead king; one of these is a veritable masterpiece. But his dramatic poem *Adam og Eva* (Adam and Eve), by far the finest imaginative work produced in Denmark up to that time, was rejected by the Society of Arts in 1767 and was not published until 1769. In 1770 Ewald produced *Rolf Krage*, the first original Danish tragedy. During the next ten years he produced one brilliant work after another:—*De brutale Klappers* (The Brutal Clappers, 1771), a tragi-comedy or parody satirizing the dispute then raging between the critics and the manager of the Royal Theatre; *Harlequin Patriot* (1772), a comedy satirizing the passion for political scribbling created by Struensee's introduction of the liberty of the press; *Pebersvendene* (Old Bachelors, 1773), a prose comedy. In 1771 he had already collected some of his lyrical poems under the title of *Adskilligt af Johannes Ewald* (Miscellanies). In 1774 appeared the heroic opera of

Balder's Död (Balder's Death), and in 1779 the finest of his works, the lyrical drama *Fiskerne* (The Fishers), which contains the Danish National Song, "King Christian stood by the high Mast," his most famous lyric. In the two poems last mentioned, however, Ewald passed beyond contemporary taste, and these great works, the pride of Danish literature, were coldly received. In 1775 he founded the Danish Literary Society. But the poet's health had broken; when he was writing *Rolf Krage* he was already consumptive. He embittered his existence by the recklessness of his private life, and finally, through a fall from a horse, he became a complete invalid. His last ten years were full of acute suffering, his family neglected him, and few of his friends showed him any kindness. In 1774 he was placed in the house of an inspector of fisheries at Rungsted, where he fell in love with Anna Hedevig Jacobsen, the daughter of the house. Marriage with her was prevented by his family, who removed him to their own rough keeping near Kronborg. He insisted on returning to Copenhagen in 1777, where he wrote *Fiskerne* with his imagination full of the familiar shore at Hornbaek, near Rungsted. He died on March 17, 1781, recognized at the last as the greatest national poet. Among his papers were found fragments of three dramas, two on old Scandinavian subjects, entitled *Frode* and *Helgo*, and the third a tragedy on the story of *Hamlet*, which he meant to treat in a way wholly distinct from Shakespeare's.

In point of time Ewald preceded all the generations of innovators in European poetry. He was born six years earlier than Goethe and Alfieri, 16 years before Schiller, nine years before André Chénier, and 27 years earlier than Wordsworth, but he did for Denmark what each of these poets did for his own country. Ewald found Danish literature given over to tasteless rhetoric, and without art or vigour. He introduced vivacity of style, freshness and brevity of form, and an imaginative study of nature. He was the first to call the attention of the Scandinavian peoples to the treasuries of their ancient history and mythology, and to suggest the use of these in imaginative writing. His dramas, which had an immense influence on the Danish stage, are now chiefly of antiquarian interest, with the exception of "The Fishers," a work that must always live as a great national poem.

The first collected edition of Ewald's works appeared in 4 vols. (1780–84). The latest edition by K. Brix and V. Kuhr (6 vols., Copenhagen, 1914–24) contains his autobiography, a Danish classic. The best biographies of him are those by C. Molbech (1831), Hammerich (1860) and Andreas Dolleris (1900). *See* also H. Brix, *Johannes Ewald* (1913).

EWART, WILLIAM (1798–1869), English politician, was born in Liverpool on May 1, 1798, and died at Broadleas, near Devizes, on Jan. 23, 1869. Ewart carried through parliament in 1834 a bill for the abolition of hanging in chains, and in 1837 he secured the passage of an act abolishing capital punishment for cattle-stealing and other offences. In 1850 he carried a bill for establishing free libraries supported out of the rates, and in 1864 for legalizing the use of the metric system of weights and measures. He advocated the abolition of capital punishment and on his motion in 1864 a select committee was appointed to consider the subject.

EWE (ā-wā'), a long-headed patrilineal people living in Togo and the Gold Coast, having immigrated from the north-east. They are organized in small kingdoms, the king is elected from among the chiefs and assisted by a council of notables. They have the extended family, holding property in common, and allowing individual ownership of personal possessions. Inheritance passes to the maternal uncle, but different kinds of movable property pass to the paternal uncle and the children. They are husbandmen and animists, and practice divination and the ordeal.

See Spieth, *Die Ewe Stämme* (1906).

EWING, SIR JAMES ALFRED (1855–), Scottish physicist, was born at Dundee on March 27, 1855. He studied at Edinburgh and held successively the following appointments: Professor of mechanical engineering, University of Tokyo (1878–83); professor of engineering, University College, Dundee (1883–90); professor of mechanism and applied mechanics, King's college, Cambridge (1890–1903), director of naval education to the British Admiralty (1903–16); and principal and vice-chancellor of the University of Edinburgh from 1916.

Ewing's work on the magnetic properties of iron, steel and other metals is noteworthy. He modified Weber's theory of induced magnetism, and constructed a magnetic model which behaved in accordance with his theory; he also observed the phenomenon which he named "hysteresis" (*q.v.*, *see* also MAGNETISM). The Royal Society awarded him their Royal medal for this work in 1895. He is the author of a number of papers on thermoelectric properties of metals, on the effects of stress and magnetization on the thermoelectric properties of iron, on the crystalline structure of metals (in conjunction with Rosenhain), and on seismology. He invented an extensometer, a hysteresis tester, a permeability bridge, and other apparatus for magnetic testing.

Ewing was a member of the explosives committee and of the Ordnance Research board; from 1914–1917, he was in charge of the department of the Admiralty dealing with cipher. He is a member of a number of learned societies and has been awarded medals and honorary degrees. In 1911 he was knighted.

Ewing wrote *A Treatise on Earthquake Measurements* (1883), *The Steam Engine and other Heat Engines* (1898), *Magnetic Induction in Iron and other metals* (1892, etc.), *Strength of Materials* (1899, etc.), *Thermodynamics for Engineers* (1920), *The Mechanical Production of Cold* (1921).

EWING, JULIANA HORATIA ORR (1841–1885), English writer of books for children, daughter of the Rev. Alfred Gatty and of Margaret Gatty (*q.v.*), was born at Ecclesfield, Yorkshire, in 1841. One of a large family, she was accustomed to act as nursery story-teller to her brothers and sisters, and her brother Alfred Scott Gatty provided music to accompany her plays. Many of her stories appeared in *Aunt Judy's Magazine*, which her mother started in 1866. In 1867 she married Major Alexander Ewing, the composer of the well-known hymn "Jerusalem the Golden." From this time until her death (May 13, 1885), Mrs. Ewing produced a number of charming children's stories. The best of these are: *The Brownies* (1870), *A Flat-Iron for a Farthing* (1873), *Lob-lie-by the Fire* (1874), *The Story of a Short Life* (1885) and *Jackanapes* (1884), which is a classic. Simple and unaffected in style, and sound and wholesome in matter, with quiet touches of humour and bright sketches of scenery and character, Mrs. Ewing's best stories have never been surpassed in the style of literature to which they belong.

EWING, THOMAS (1789–1871), American lawyer and statesman, was born near the present West Liberty (W.Va.), Dec. 28, 1789. His father, George Ewing, settled at Lancaster, Fairfield county, O., in 1792. Thomas graduated from Ohio university, Athens, O., in 1815, and in Aug. 1816 was admitted to the bar at Lancaster. He was a Whig member of the United States Senate 1831–37, and took a prominent part in the legislative struggle over the United States bank, whose rechartering he favoured. In March 1841 he became secretary of the treasury in President Harrison's cabinet. When, however, after President Tyler's accession, the relations between the president and the Whig party became strained, he retired (Sept. 1841). From March 1849 to July 1850 he was a member of President Taylor's cabinet as the first secretary of the newly established department of the interior. He thoroughly organized the department, and advocated the construction by Government aid of a railroad to the Pacific coast. In 1850–51 he filled the unexpired term of Thomas Corwin in the U.S. Senate, opposing Clay's compromise measures and advocating the abolition of slavery in the district of Columbia. He was a delegate to the Peace congress in 1861, and a loyal supporter of President Lincoln's war policy. He died at Lancaster, O., on Oct. 26, 1871.

EXAMINATIONS. An "examination" is primarily a test of the "capacity" of individuals. The individuals are generally young people or children; their "capacity" is their power to respond to a stimulus provided by the examiner. The character of their responses is measured by the examiner against a standard of achievement usually determined by the type of the examination; when, however, an examination is used to select individuals for a limited number of places it becomes competitive, as in most scholarship and civil service examinations. Success is commonly indicated

by an "award" which serves thereafter as a convenient label, a summary of the "capacity" of the individual. Frequently the "award" carries with it certain rights to further education at the expense of a public or corporate body (scholarship at school or university) to practise teaching or medicine or to enter the State service (civil servant). Sometimes the "award" confers, in addition, membership of a corporate body of practitioners who monopolize certain services or professions (law, medicine, etc.). Hitherto, in England and Europe generally, the methods employed to these ends have been largely founded on written and oral tests in certain specific subjects. The example of the United States of America (*see* that section), however, in which the application of intelligence tests to examinations has been practised on a large scale, cannot be ignored. In fact, it is already in limited use in Great Britain.

HISTORY

The oldest known system of examinations was that used in China for the selection of officers for the public service (*c.* 1115 B.C.). The examinations of western countries originated in the universities of the middle ages. The first universities of Europe consisted of corporations of teachers and of students. The monopolistic tendency of their system of examinations has dominated subsequent developments.

The object of the universities was to teach; and to the three customary classes of gild-members, apprentices, companions and masters, corresponded roughly the *scholar,* the *bachelor* or pupil-teacher, and the *master* or *doctor* (two terms at first equivalent). The universities being under the same religious authority, the permission to teach granted by one university was valid for all. (*See* UNIVERSITIES.)

Bologna.—The earliest university examinations of which a description is available were those in civil and in canon law, held at Bologna during a period subsequent to 1219. The student was admitted without examination as bachelor after from four to six years' study, and after from six to eight years' study became qualified as a candidate for the doctorate. The doctoral examination at Bologna during the 13th to 14th centuries consisted of a private examination which was the real test, and a public ceremonial (*conventus*). On the morning of the examination the candidate was assigned two passages in the civil or canon law, which he retired to his house to study, possibly with the aid of the presenting doctor. Later in the day he gave an exposition of these set passages and was examined by two of the doctors appointed by the college. Other doctors might then put supplementary questions on law arising out of the passages, or might suggest objections to his answers. The fate of the candidate was determined by ballot by a majority vote. The successful candidate, who received the title of licentiate, after payment of a heavy fee and other expenses proceeded to the *conventus.* This public test comprised the delivery of a speech, and the defence of a thesis on some point of law selected by the candidate, against opponents chosen from among the students. Success was followed by the bestowal of a "licence to teach" by the authority of the pope in the name of the Trinity.

Paris.—In Paris a more complicated system had developed by A.D. 1300. In the faculty of arts there were three degrees—the baccalaureate, the licentiateship and the mastership. At a preliminary test or "responsions" the candidate had to dispute in grammar or logic with a master. Certificates of residence and of attendance at courses in certain subjects had to be presented, and the candidate was tested in the contents of his prescribed books. If successful, he was then admitted to maintain a thesis against an opponent, and as bachelor was permitted to give "cursory" lectures. Having reached a prescribed age, and five or six years after his matriculation, a bachelor might take the next examination. This test began with an examination in private by the chancellor and four examiners, a scrutiny of records of study and later a public test before the faculty. The names of successful candidates were sent to the chancellor in batches of eight or more arranged in order of merit. Subsequently the candidate maintained, in public, a thesis on a subject chosen by himself and was submitted to a purely formal public examination. Success was followed by the receipt from the chancellor of the licence to teach in the faculty of arts. Some six months later the licentiate took part in a peculiarly solemn disputation known as his "Vespers," gave a formal inaugural lecture before the faculty and was "incepted" into the mastership.

In the mediaeval examination systems lie the origins of many current university practices: certificates of previous study and good conduct, preparation of set-books, questions on matter not specially prepared, division of the test into various parts, orders of merit, payment of fees, the presentation of a dissertation, and the defence and publication of a thesis. Occasionally the system was abused, yet at its best it probably served its function to test would-be teachers. Written and practical examinations came into use as university teaching broadened in scope.

British Universities.—At Oxford (*q.v.*), in the middle ages, examinations were apparently confined to "disputations." Laud (1636–38) introduced definite examinations for M.A. and B.A., but it is doubtful how far they were enforced. In the 18th century "the studies fell into an abject state." Important reforms were introduced in 1800 when, by statute, distinctions were first awarded to the ablest candidates for the bachelor's degree. In 1830, in addition to the pass examinations, honours examinations were set up; the successful candidates were more rigorously tested and were divided into four classes. By the statutes of 1849 and 1859 an intermediate "Moderations" examination was instituted between the preliminary examination called "Responsions" or "Smalls" and the final examination. Long before the 19th century the B.A. had become the recognized culmination of a long course of study, and in 1807 the examination for M.A. was abolished. A holder of the B.A. degree now proceeds to the M.A. degree on the payment of fees. Respersions have now been superseded by the School certificate which a candidate passes before entrance. At Cambridge development followed similar lines and there, also, the M.A. is a mere formality. During the 18th century the "reputation of Cambridge" was established "as a School of Mathematical Science," but the standard of the final honours examination, the "tripos," did not become generally high till 1840. The preliminary examination, the Previous, or "Little-go," now superseded by the School certificate, leads directly to the triposes or to the numerous special subjects necessary for a pass degree (B.A.), from which a candidate must choose three principal and three subsidiary. Nearly all the triposes have been divided into two parts, of which the second is not always obligatory to obtain a degree. British degree examinations were thus developed by the universities and were normally open only to members of the universities in residence. In 1858 the University of London, where examinations had been hitherto confined to students in affiliated colleges, threw open its examinations to all comers who could produce a nominal certificate of good conduct, and the university became an examining body pure and simple. Candidates wrote answers to printed questions at examination centres in London, elsewhere in the British Isles and also in the British empire. Candidates for a bachelor's degree took three examinations (matriculation, intermediate and final) and proceeded to higher degrees by subsequent examination. In 1900 the university became hybrid and added to the former system of "external" examinations a parallel system of "internal" examinations for members of constituent colleges of the university. Women were recognized as eligible for examination at London in 1878, at Cambridge in 1881, at Oxford in 1884. They are now eligible for degrees at all the universities. When, in 1880, the Federal University of Victoria was formed, the examinations were confined to internal students and the practice has been followed in the case of the newer foundations of Manchester, Liverpool, Leeds (formerly constituent colleges of Victoria university), as well as those of more recent foundation.

In Scottish universities the B.A. has become extinct, and the M.A., awarded on the results of examinations, is the first degree in the faculty of arts. Formerly the M.A. was taken in many subjects, now the final examination can be taken in honours in one or two.

In Trinity college, Dublin, degrees were also obtainable by external students; but on the foundation of the Royal University of Ireland in 1880, the earlier London model was followed of making the university a purely examining body. In 1908 the R.U.I. was replaced by the National University of Ireland and by Queen's university, Belfast. To-day all examinations in Irish universities are closed to external students, except that at Dublin university (as the former Trinity college is now called); exemption from the regulations may be given in very exceptional cases.

Since the growth of university studies, the number of examinations in British and Irish universities has greatly multiplied, and the calendars and regulations now form bulky documents which prescribe the conditions under which degrees can be obtained. The most important new degree is the doctorate of philosophy (Ph.D.) which is awarded on a thesis on any academic subject approved by the faculty concerned.

French Universities.—In France the *baccalauréat,* which has also become a school-leaving certificate (*see* below) is the entrance to the university. It leads to the *licence* in arts, science or law. A point to note in the French examinations, especially the higher ones, is that in many cases the subjects are now often taken separately. Thus the *licence* in arts or science is granted to the student obtaining four subjects selected by him out of a large number, which he can, if he prefers, take one at a time. The *doctorat* in arts requires the presentation of these two theses, which often involve years of strenuous work. If these are accepted, they are followed by a public *soutenance* (maintenance) of his thesis by the candidate. The possession of the *doctorat* is an indispensable qualification for full professorship.

In science a candidate for the doctorate submits two theses, or else one thesis and undergoes an oral examination; in law, a thesis and two oral examinations are required. In medicine there is no *licence,* but six examinations are to be passed, and a thesis submitted. A special *doctorat d'Université,* awarded on a thesis and an oral examination, has been instituted for foreign students of graduate standing, and *diplômes d'études supérieures* are awarded on subjects such as philosophy, history, etc., and generally taken by persons intending to enter the teaching profession.

German Universities.—Students enter the university by passing the "Abiturienten" examination (also known as *reifere Prüfung*) at the age of eighteen. For his doctor's examination the student has to present a thesis. If this is accepted, he has to submit to a public oral examination on his principal subject (*Hauptfach*) and on two or more collateral subjects (*Nebenfächer*). He may then give outside lectures in the university, as a *Privatdozent.* But to become a full university professor, he must have a more advanced thesis (*Habilitationsschrift*) accepted, and give two specimen lectures, but these latter proceedings have become largely a formality.

In university examinations, most of the other European countries follow closely the lines of the French or German model.

PROFESSIONAL EXAMINATIONS

Teaching.—*Great Britain.* Elementary teachers pass examinations in knowledge and teaching proficiency, hitherto conducted by the Board of Education, but now being transferred to the universities. Teachers, however, who follow a four years' course in a university take the teaching diplomas of the university concerned. There is no official compulsion for teachers in secondary schools to be trained, but an increasing number of graduates are taking university courses of training, especially women. In fact, in girls' schools, training is rapidly becoming a sine qua non.

France. Elementary teachers have to pass a State examination for entrance into a training college as well as a leaving examination at the end of the year; the latter includes a test in teaching proficiency. Teachers in the higher classes of secondary State schools (Lycées) have to pass an examination called the *agrégation,* comprising a severe written and oral test. Ordinary teachers in the schools need only have the *licence* or *diplôme d'études supérieures.*

Germany. Elementary teachers have to pass the ordinary State examinations, academic and professional. Secondary teachers are obliged to attend a university for three years. The Ph.D. is optional, but they must take the State examination and become full teachers only after two years' probation.

Law and Medicine.—(*See* LEGAL EDUCATION; MEDICAL EDUCATION.)

Other Professions.—A complicated system of professional examination by professional bodies was largely developed in Great Britain during the 19th century. Many of these bodies even conducted the preliminary entrance examinations, but fortunately, in many cases, they have adopted in their place certain accredited examinations like the "locals" of the universities or the examinations of the College of Preceptors. The following are some of the more important subjects (the professional body concerned being given in brackets): Accountancy [Institute of Chartered Accountants and Society of Accountants and Auditors]; actuarial work [Institute of Actuaries]; music [Royal Academy of Music, Royal College of Music, Trinity College of Music, Royal College of Organists, and the Incorporated Society of Musicians]; pharmacy [Pharmaceutical Society]; plumbing [the Plumbers' Company]; surveying [Surveyors' Institution]; veterinary medicine [Royal College of Veterinary Surgeons]; technical subjects, *e.g.,* cotton-spinning, dyeing, motor manufacture [City and Guilds of London Institute]; architecture [Royal Institute of British Architects]; engineering [Institutions of Civil Engineers, of Mechanical Engineers, and of Electrical Engineers]; commercial subjects, shorthand [the Society of Arts and London Chamber of Commerce]. (*See* COMMERCIAL EDUCATION.)

SCHOOL-LEAVING EXAMINATIONS

Great Britain.—A somewhat similar multiplicity of examinations formerly prevailed in the sphere of secondary education. Pupils, even those of ten years of age, were subjected to examination. All such intermediate examinations, with the exception of the junior locals taken mainly by private schools, have been abolished as far as the universities are concerned, and since 1917, the secondary school examination council has been steadily engaged in a continuous audit of school examinations, in the way of standardizing the papers set by the different universities, co-ordinating methods of marking, etc. State-recognized examinations are now confined to the school-leaving certificate (a higher standard in which, under certain conditions, qualifies for the matriculation or entrance to the university), and the higher school certificate, taken in a more limited number of subjects. The former is generally taken at the age of 16 or 17; the latter at the age of 18 or 19. (For further details *see* below.) In Wales, Scotland, Northern Ireland, and the Irish Free State, similar examinations are to be found.

France.—In France the *baccalauréat,* after the reform of 1902 (*see* EDUCATION: *France*) consisted of four different sections: Classical; Latin-Modern Languages; Latin-Science; Modern Languages-Science. However, since the recent reforms of M. Bérard, slightly modified by M. Herriot, it has been reduced to two—classical or modern. The examination is divided, as before, into two parts, and the second deals mainly either with philosophy or with science, including mathematics. It is taken a year later than the first part. Each part further consists of two sections, a written and an oral one, and the pupil's school record is taken into account in the final award in each case.

Germany.—In Germany (of which Prussia may be taken as the best example) the school-leaving examination which also, as we have seen, qualifies for entrance to the university, is the *Abiturienten* examination. It varies in subject according to the type of school to which it applies, whether it is fully classical, half classical or modern. In German education a point to note is that the teachers themselves take part in the examination (a very desirable factor). The usual age at which the examination is taken is 17 to 18. There is also a *Mittlere-reife-prüfung,* taken at the age of 16, which gains admission to certain professions; pupils in the first grade schools mentioned above are automatically awarded the certificate on being promoted to the *Ober-secunda* class, of which the normal age is 16.

Leaving examinations in other European countries largely resemble those of either France or Germany.

ELEMENTARY EXAMINATIONS

For many years examinations of all the pupils in each public elementary school in Great Britain were conducted by the Government inspectors. The system lasted from 1862 till 1895 and was known as "payment by results" (*see* ELEMENTARY EDUCATION). The principal reason for its abolition was the cramping effect it had alike on teachers and taught. Central schools, so far, have had no leaving examination, though one has been proposed by the commission on the education of the adolescent.

In France there is an elementary leaving certificate with written and oral tests called the *certificat d'études primaires*, generally supposed to be passed at the age of 12, but often taken earlier. There is a leaving certificate for the higher primary school, which also serves for entrance into the training colleges.

COMPETITIVE EXAMINATIONS

In Great Britain, competitive examinations may vary from County Council scholarships awarded at the age of 11 to scholarships at the public schools, or at the universities. They are also used for entrance to all grades of the civil service—from sorters in the post office to first-class clerks in the Foreign Office. The award depends, not on reaching a certain standard of attainment, but on the number of scholarships or posts open to candidates. The first competitive examination was instituted in 1885 for entrance to Woolwich academy and the system was generally adopted for the civil service in 1870, in order to do away with the widespread abuses connected with the nomination of unfit persons. The same principle was adopted after the World War when a large number of temporarily employed ex-soldiers were allowed to qualify for permanent service by passing certain specific examinations, though in this case the posts were not limited in number. Formerly the colleges at Oxford and Cambridge had each their own separate examinations for scholarships. This method has now been superseded by groups of colleges holding a joint examination, candidates indicating beforehand, in order of preference, the college they would choose if successful. It is probably true to add that Oxford Scholarships are awarded on promise as well as on performance, while Cambridge Scholarships are mainly given on performance, though promise is not entirely excluded from the aftermath. Oxford, like Paris, prizes rather the artistic presentation of facts than their mere reproduction as such; Cambridge attaches more importance to the abundance and accuracy of the facts, their presentation being a secondary matter. The one puts a premium on art; the other on science.

METHODS OF EXAMINATION

Examinations on traditional lines are usually carried out in the case of the most advanced work by a thesis only; in the other grades by means of (1) written papers; (2) oral tests; (3) practical tests; (4) a combination of two or more of these.

Thesis.—A thesis or dissertation is usually required only for the higher degrees of universities; it normally embodies the results of research into some branch of knowledge and is usually looked over by two or more specialists, whilst it is generally necessary to undergo a public examination in addition to the thesis submitted.

Oral Tests.—An oral examination provides the opportunity to test the individual as regards the range of his knowledge, and makes it possible to test many important qualities, such as readiness of wit, presence of mind, common sense, which are not so easily tested by written papers. One useful extension of the oral examination is practised by the headmaster of secondary schools when interviewing candidates who have been qualified by a written examination for admission into a secondary school, to decide whether they are suitable for admission into his school. The interview is also used on a still larger scale by some local authorities who examine orally candidates for senior or technical scholarships. Similarly, candidates who are successful at competitive examinations for entrance into some of the public services, notably the navy, are subjected to an oral examination to determine whether their personality justifies their entry.

Practical Tests.—Oral tests sometimes shade off into practical tests, as in testing foreign languages orally. Such tests are, in fact, designed to test predominantly the manipulative skill of the candidate, whether it be in science, craft-work, medicine or some skilled trade or profession. A doctor or surgeon, for instance, must show that he is familiar with the practical side of his calling, an engineer or plumber must show that he has already attained sufficient skill to be allowed to be certified as capable of following his trade.

Written Tests.—In written examinations the candidates attend for several sessions of one and a half to three hours' duration, and answer printed papers of questions under a prescribed rubric. The number of questions on a paper may vary from a very large number to one or two according to the type of examination. The answers required may consist of a symbol or single word, or a single essay of considerable length, as in the case of a university honours candidate.

Simple Written Examinations.—The simplest form of examination question involves merely a single mental operation and an answer which is right or wrong, *e.g.*, What is twice two? Answer: Four. The children ultimately to be examined are taught an algebraic operation such as: if $a=3$, $b=2$, $c=0$, then $ab=6$, $3c=0$, etc. They work through sets of examples on the operation until they are familiar with it under its various guises. They reach a stage when they can be said to know the operation and are ready for examination. The examiner prepares the examination paper by selecting a large number, say 40, of the simplest form of questions each involving this operation. He tries his question out on a group of children similar in character to those to be examined, and grades his 40 questions in order of difficulty until he is justified in the expectation that only one or two candidates will fail to answer the easiest question and that only one or two candidates will succeed in answering the hardest question. He then sets this examination paper to the group of candidates and is able to produce an order of merit showing the relative ability of these candidates to perform the algebraic operation tested.

A simple examination paper of this character has the merit of objectivity. The questions are simple, can only be correctly answered in one way, are graded in difficulty by an objective preliminary test. The only variable characteristics which affect the result of the examination, apart from the difference in ability to do the algebraic operation, are the temperament and nerves of the candidates. Some pupils are not good examination subjects. Another element of uncertainty is introduced when examiner and teacher are not the same person, for even if the ground is common the teacher may have stressed some points more than others. Again, the moment more difficult questions are introduced into an examination paper a further element of chance is introduced; this is the chance that the form of the question will affect some candidates differently from others; for two questions of equal difficulty but of different forms will be answered with different success by some, at least, of the examinees.

When the subject of examination is English, the element of chance assumes greater importance. Children's knowledge of words and phrases, their ability to understand a short passage of connected prose is conditioned by many other influences than school. Hence children are very liable to suffer even in the simplest form of examination in English by the fact that they do not "know" a word or phrase, not having met beforehand with it, in the question paper. The examiner, even by the most exhaustive preliminary trials, cannot provide against such a possibility and the element of chance affects the scores made by some candidates.

Complex Examination Papers.—Examination papers increase in complexity whenever two or more mental operations are tested. In arithmetic a paper of 20 questions might test 20 processes; or ten questions in an English paper might test facility in the use and comprehension of language in ten different ways. In history, geography, science, etc., where the examiner is required to set a paper covering a prescribed syllabus, the test samples the candidates' acquaintance with the facts specified in the syllabus, and the first test of the quality of the examination paper refers to the goodness of his sampling. In such papers the element of

chance tends to be concentrated upon the average candidate; the very best and the very worst candidates are definitely determined, for they are familiar or unfamiliar with the material put before them in the paper of questions, but the candidates of a little more than average ability may score below the average by a chance unfamiliarity with one question. In much the same fashion the candidates may be concentrated towards the average by the fact that they will have covered the different portions of a syllabus with different degrees of industry, and the chance that the examiner has emphasized different aspects of the subject in a different way from some of the candidates, tends to mass the candidates together in a large group where the scores are about half the maximum. The concentration of the incidence of luck upon the average candidates is one of the reasons why it is inexpedient to pay too much attention to the candidates who score 50%; in the neighbourhood of "half marks" there is a very high probability that a difference of five or six marks between the scores of candidates represents the luck of the examination and nothing else.

The Use of Intelligence Tests in Examinations.—It would be impossible for methods of examination to remain unaffected by the recent development of mental tests. It was not long before mental tests themselves extended their boundaries beyond their native realm of intelligence, and invaded the province of school studies. The technique which had served to test general intelligence was carried over to the testing of academic attainments. This procedure gave rise to standardized scholastic tests. Just as intelligence tests were made to form a scale of mental ages, so were scholastic tests made to form a scale of educational ages. When the scholastic tests were not standardized, when they were not intended to be used over and over again like an electric torch, but were intended to be used once only, like a lucifer match, then they became known (in the United States) as "new type tests."

Ignoring, therefore, the distinction in purpose and in content between these three classes of new tests, and regarding them purely from the point of view of method, we find that a new style of examination has come into being, a style which stands in marked contrast with the old traditional type. And in connection therewith a large body of doctrine has been developed, and a large variety of statistical methods devised, all bearing upon the validity of tests. Prof. F. Y. Edgeworth, writing in 1890, long before the new methods were heard of, gives the following as a fundamental postulate: "The true or standard mark of any piece of work is the average of the marks given by a large number of competent examiners equally proficient in the subject and instructed as to the character and purpose of the examination." This postulate, of vital importance to the old examiner, is of no use at all to the new. For it assumes that judgments vary, and the new examiner regards judgments that vary as invalid. The marking, in fact, should be objective, in the sense that different examiners would inevitably give the same mark to the same examination product. This is possible only when the contents examined on have been so analysed that each question contains only one element, the answer to which must be either definitely right or definitely wrong. It thus carries one mark or no mark at all. Thus the essential difference between the old examination and the new lies in the analysis of the subject-matter into markable elements. The new examiner analyses before the examination, the old examiner after the examination. The new examiner's analysis is complete and definite: it admits of no variation or extension on the part of the marker. The old examiner has a complex product, such as an essay, to mark, and either does not analyse it at all and judges by general impression, or analyses it into such vague factors as style, ideas, logical arrangement and so forth. It thus happens that the main superficial difference between the old examination and the new is that the former requires a small number of long answers, and the latter a large number of short answers.

The new examiner lays great stress on "reliability"—a technical term which means the degree to which the order of merit secured by one application of a series of tests agrees with the order secured by a second application of the same series. The agreement is measured by the mathematical method of correlation. Tests which give a low coefficient of reliability are discredited and rejected. The new examiner, therefore, tests his tests before applying them. He "tries them out" on children who are not genuine examinees.

A subsidiary characteristic of the new testing is that it occasionally probes a lower stratum of knowledge than is reached by the ordinary examination question. It does this through the "limited option" test. Here is an example: "The author of *The Scarlet Letter* is [Hawthorne, Poe, Stevenson, Kipling]." The testee has to underline the right author. He need not recall the author's name, he need only recognize it; and recognition is much easier than definite recall.

The new school tries to keep steadily in view the purpose for which an examination is designed, and modifies the questions according as the purpose is diagnostic, prognostic, selective or evaluative. It is maintained that though an examination may serve more than one purpose, it can only serve one purpose well.

How far has the new examination influenced the old? In England, slightly; in America, profoundly. In the United States the new type of tests has in certain instances superseded the traditional examination. European countries have shown a much more critical attitude towards them. On one side of the Atlantic the new testing is almost universal; on the other side it is sporadic and experimental. The rivalry between the two systems lies not so much in practice as in principles. What the ultimate issue of the contest will be no man can at present tell: much experiment and research must yet take place before a final adjustment is reached. In the meantime it seems fairly clear that each system has its points of weakness and its points of strength. The main merit of the new system is that it succeeds as far as seems possible in eliminating the element of chance; its main defect is that it fails to test—directly at any rate—constructive and creative ability. This is a grave defect, a defect from which the traditional examination is singularly free. But the freedom is secured at the expense of objectivity: the examination result is more liable to suffer from the vagaries of personal judgment.

Since the merits of one system are the defects of the other, it seems reasonable to regard the two as complementary. It is not improbable that both will, in the course of time, be brought within one scheme, yielding a final estimate of ability which would be of higher value than either of the constituent estimates. However that may be, the scientific precision of the new system cannot be ignored. It is a significant fact that no thesis embodying the results of psychological or educational research would be accepted by any university unless those results had been measured by the new methods. (*See* also below, under *United States.*)

Mental tests for examination purposes are actually used by 21 local authorities. An enquiry by the Psychological Society shows that three-quarters of those who answered the questionnaire were making use of them mainly as providing an additional criterion to the orthodox tests, or in adjudicating on borderline cases. They were also found of special value in reducing the disabilities of pupils from small rural schools.

THE TREND OF MODERN EXAMINATIONS IN SCHOOLS

The more old-fashioned examinations were predominantly an audit of fact. Certain specific facts, data or formulae had to be mastered, and the pupil was examined on these. But for many years we have been moving in the direction of testing capacity as well as mere knowledge, and not merely capacity for dealing with specific subjects, say English or arithmetic, but also general ability as such. Here, no doubt, the more advanced of our examiners, especially those dealing with younger children, have been influenced by the modern psychological theory that each individual possesses a certain degree of general ability, and that this is capable of being measured and tested.

At the same time, the unsuitability of numerous examinations for pupils under 16 has been recognized, so that to-day out of the multiplicity of examinations with which the schools were formerly burdened, there are now only three definite types of

school examinations recognized by public authorities in England, each of which possesses a clear aim and perspective: (1) A competitive admission examination for children of 11, success in which procures admission, sometimes with pecuniary privileges, to secondary or central schools. (2) A general school examination for children of 16 or 17, success in which indicates that the pupil has profited reasonably well by a course of four or five years in a recognized school, or, in the case of having attained a higher prescribed standard, has qualified for entrance into the university (matriculation). (3) A higher school examination in a fewer number of subjects, combined in courses open to pupils who have passed matriculation, and taken normally two years after the latter.

The competitive admission examinations are conducted by the local education authorities, each for the children in its area, for admission into its own higher schools, whether as "scholars" or "free-placers." The school examinations are conducted by a university authority, and have no territorial limitation. By a historical accident since the general school examination has grown from the matriculation examinations of the several universities, the first, or general school examination is complicated by the specific requirements for university entrance and is not entirely a general examination.

Competitive Admission Examinations.—The competitive admission examination aims at filling a small number of school-places from a large group of children of a definite age. It usually comprises papers in English and arithmetic treated quite generally. The fact that success is limited to the best few of the competitors means that the element of chance affects but slightly the composition of the final list of successful candidates.

General School Examination.—The general school examination suffers from limitations due to its university origin. Rightly enough the matriculation examination prescribed papers and a syllabus which the particular university considered would secure students prepared to profit by the courses which the university provided. With the increase in the number and scope of university facilities the matriculation examination was widened and made more general. At the same time the "local" examinations of Oxford and Cambridge, and the similar examinations of London, provided tests of a more general character suited in some fashion to the work done in the secondary schools and suited further to furnishing candidates (who fulfilled certain more rigorous regulations) with a qualification that could be accepted for matriculation. The schools were not compelled to submit candidates for any of these examinations. In combination the whole was an "omnibus" attempt at providing matriculation certificates and school-leaving certificates. Subsequently, it became obligatory for the schools to present for the general school examination, which was developed from the "locals," the whole of the members of a form, in order that the general school certificate might be a school-leaving certificate, and the general school examination became an integral part of the education system of the country. It was laid down that the certificate examination should be such that an average scholar who had steadily pursued the regulation course in an approved secondary school should pass. This probably meant that half the candidates should obtain certificates. Obviously, the percentage who should pass should be fixed by the central controlling authority, yet it is doubtful whether 50% is not much too low a proportion. Either the schools are not satisfactory when only half their pupils can be certified as satisfactory products, or the certificate examination is too severe a test.

The general school examination purports to be a general test of average pupils of an average secondary school. Stress is laid naturally upon English and arithmetic as the two general subjects of examination. In addition to these two subjects others are prescribed and by a slow process of release from the university traditions the examination is being widened so that subjects which are taught in an approved school may count equally with each other in the examination. Freedom is being gradually achieved. The domination of Latin, the presumed absolute necessity of mathematics, the limitation of science to physics and chemistry, have gradually been abrogated and the claims of girls to different treatment from boys are receiving recognition. There is a notable movement, made especially in the interests of girls, to secure the recognition of the arts and crafts as adequate alternatives to the more definitely academic subjects of examination. From the earlier position when the examination controlled the teaching in the schools, gradual progress is being made towards the ideal that the examination shall mirror the school curricula, though we are still far from the ideal that each school should be examined on its own curriculum. The examination papers have changed; the number of examination subjects have been notably increased and the character of the papers has been altered. Formerly the paper in any subject aimed at discovering whether candidates were fitted to pursue their studies further in that subject; now the paper rather aims at finding evidence that the candidate has reasonably profited by an approved course of study in school of that subject, and advocates are not lacking of the opinion that the "pass-mark" in each subject should be such that 70% or, even 80%, of the candidates should pass. It is held to be a fault of a school-leaving examination system that out of 100 children who have been reasonably assiduous in their study of a subject, not more than 50 to 55 can pass the examination therein. Little by little the general school examination is becoming really general and the examination papers are gradually approximating to general tests of ability in specific media of thought. No longer does the examination paper test for a minimum quantum of information; it now attempts to discover general ability to think and act within the realms of knowledge of a small number of subjects in which the candidates have acquired reasonable facility in school.

Coincident with, and contributing to this development, considerable improvement has taken place in the technique of examining. Syllabuses have become less detailed and freedom has been given the schools to submit their own syllabuses for approval and subsequent examination. The examination papers themselves are now regarded as the most potent factor in the system, and the composition of the paper, the character of question used, the balance of the whole paper in relation to the average teaching in an average school, each receive careful attention. Boards of moderators revise and approve the papers suggested by one or two examiners. But it is still doubtful whether, in spite of material difficulties, more scope should be given to testing the pupils orally, and whether the teachers should not be directly represented on the body of examiners.

The Higher School Examination.—This examination marks the final stage in specialization at school. It has been greatly improved from its original form, but further elasticity is needed. Some people think it should take the place of the matriculation and serve as entrance to the university, thus liberating the school-leaving certificate from any connection with that examination. This would, however, involve grave difficulties. The whole nature of the examination would probably have to be modified and consideration would still have to be taken of the fact that for many candidates who are not going to the university, it serves first and foremost as a final test of their school studies. It is worth noting that State scholarships are awarded on the results of this examination; they are, therefore, indirectly of the nature of a competitive examination.

Much of the improvement in the technique of examining is due to the work of the secondary school examinations council. In the traditional English manner, inspectors of the Board of Education conduct enquiries into the way in which school examinations are conducted, and pass on from one team of examiners to another, and from one authority to another, the best methods of examining which they discover. Almost equally potent for good has been the action of the Civil Service Commissioners in adjusting their tests to favour modern methods of teaching. There is no definite attempt to train examiners who drift into examining by accident, learn their methods by experience, and only rarely pay any attention to the principles which are at the basis of all sound testing; consequently, there is room for yet further improvement.

The Public Schools Common Examination.—It is worth

noting here that entrance to the public schools (*q.v.*) from the preparatory schools (*q.v.*) is obtained by passing the so-called common entrance, which has replaced the separate entrance examinations formerly held by each individual school. It has lately come in for a severe criticism. It is alleged to lead to an undue study of Latin in young boys to the detriment of subjects like history, geography and the mother tongue while the papers in these latter subjects directly encourage the mere acquisition of a jejune and desiccated information, being in fact rather an audit of memory work than a test of capacity. Further, owing to the limited number of places available in the schools, the examination is tending to become really competitive and so necessitates cramming. Various substitutes have been proposed—recommendations by the preparatory heads, interviews, increase of public schools, or of schools directly attached to them, the last of which, apart from possible evils of inbreeding, seems possible. Mention may also be made here of the examinations of all Colleges of Preceptors taken by the private schools (*q.v.*).

EXAMINATION SCORES

The main aim of an examination is to place a set of candidates in a relative order of merit. It has a prescribed range, between a zero which marks ability below the minimum which the examination is designed to test, and a maximum which marks an ability greater than the examination papers can legitimately assess. Between these limits the examiner used to award marks, now he scores points. The precise system of scoring should be suitable to the purpose of the examination; a system of symbols $\alpha+$, α, $\alpha-$; $\beta+$, β, $\beta-$, etc., serves for some examinations, notably at Oxford, but it is usual to score by numbers with 0 as the zero limit and 100 as the maximum. It is desirable when an examination is repeated annually that the pass-level shall be constant throughout the series. When the numbers of candidates are small on each occasion, the constancy of the pass-level must be maintained by the examiner and it is usual to fix 40% or 50% as the pass-level, and to leave the examiner the task of ensuring that the pass-level for successive years represents the same level of ability. This is an onerous task and calls for a measure of ripe experience and sound judgment, coupled with a somewhat rare ability in setting suitable examination papers. When the candidates at each examination run into thousands, a more objective method may be substituted for the subjective judgment of the examiner. The pass-level may be fixed at such a point on the scale that X% always pass. X may be fixed at 50 or 60, or even 85, to suit the purposes of the examination.

Scores are arranged so that candidates are spread between 0 and 100 in such a fashion that if x candidates score a% then x candidates, an equal number, also score $(100-a)$% and that about 40% of the candidates score between 41% and 59%. A curve of distribution of the candidates then resembles the lines of a broad-brimmed cocked hat. Such a distribution happens readily in arithmetic, but to ensure it in English and kindred subjects needs more careful examining. The form in which the spread of the marks finally falls depends upon the examination paper and the schedule of marks prepared by the examiner, and is, therefore, largely within his control.

When an examination includes many papers, it is usual to record passes on the single papers with some form of allowance for candidates who do exceptionally well on one or more papers and just miss passing on others. This requires that the several examiners shall so arrange that their pass-marks measure similar degrees of ability. Subjectively, this is difficult, objectively (should time allow) this equality between different papers may be determined by the regulation that the pass-mark per paper shall be that mark which will secure that Y% of the candidates who took the paper shall pass.

In competitive examinations, where there are several papers, the scores are usually added together, with or without allowances for exceptional ability displayed on one or more papers. In certain cases candidates have to score a certain number of marks, so to say, "below the line," as in some civil service examinations, before they are credited with any marks at all. When the papers are marked by α, β, etc., final positions are determined either by the number of αs or by the general impressions of the candidates' work.

Borderline Cases.—In close relation to the treatment of examination scores lies the necessary consideration of those candidates who nearly or only just succeed; these candidates are frequently designated as borderline candidates. In most examinations borderline candidates receive special attention, careful consideration being given to their work as a whole and systematic allowances made on principles prescribed by previous experience. The method of scoring differences facilitates the consideration of borderline cases.

Closely allied with the consideration of borderline cases is the necessity in competitive admission examinations of young pupils (say boys and girls of 11 +) of giving them an age allowance. Usually the age allowance is determined by rule of thumb methods which secure that the numbers of successes shall be evenly distributed in each month of the age group.

Finally, in such examinations some definite allowance is made for the teacher's judgment on the relative merits of the candidates whom he submits. In these and other specially appropriate ways, means are taken to secure fair treatment to all candidates.

The Organization and Conduct of Examinations.—The organization of examinations so that each candidate shall be treated in precisely the same way as every other candidate, increases in complexity with the number of candidates examined. The greatest precautions are taken to ensure the secrecy of the examination papers before and during the examination, and to isolate the individual candidates in the examination room. Both the seating arrangements and the supervision should be adequate to remove all temptation of copying. The hygienic conditions and the time of year and day should be such as to reduce the strain to a minimum. The examination time-table should tend to minimize the effects of mental fatigue.

Marking the Scripts.—The chief examiner usually sets the papers of questions and marks some of the scripts; the assistant examiners mark scripts. The preliminary stages in marking are usually occupied with the determination of a schedule of marks. All markers read a sample batch of scripts and then meet to discuss what the particular batch of candidates have done with the particular paper. The chief examiner has provided a provisional schedule of marking, and this schedule is modified in the light of the experience gained from reading the samples of scripts. The marking thus tends to be objective and to become merely a grading of the candidates against each other. The markers in conference determine upon a revised schedule of marks which is strictly followed thereafter; they disperse and, later, supply the chief examiner with samples of their marking. Markers, being human and being required to work under pressure against a time limit, inevitably err; many of their vagaries occur in mechanical matters such as totalling marks. The marking of simple questions is merely a matter of eyesight. When the questions are more complex, or are of the kind which require essay-type answers, marking becomes more difficult; human judgment in these cases does not always act consistently, and inconsistencies of marking are inevitable. It is a function of the chief examiner to standardize the work of several examiners engaged on the same paper.

The Pass-mark.—In competitive examinations there is no pass-mark, the number of awards is predetermined. In university and professional qualifying examinations, where marking is by figures and not impressions, a pass-mark is fixed to separate those who pass from those who fail. In some cases the pass-mark is 50% of the maximum, in others it may be 30% or 70%. Reference has already been made to the unavoidable incidence of chance in the relationship between the candidates and the questions. There is also an inevitable incidence of chance in the relationship between the candidates and the markers. In both these cases the incidence of chance tends to be concentrated upon the candidates of average ability, so that of any set of candidates the markers may decide on the relative merits of the best fourth and of the worst fourth with comparative certainty, but their decisions concerning the middle half are much affected by luck.

Consequently, the pass-mark should always occur in such a position as to leave the middle half definitely as "passes" or "failures"; this means that the examination papers should be either so difficult, or so easy, that the "pass-mark" falls on the slope of the cocked-hat curve which shows the spread of the marks. If the curve is a symmetrical cocked hat, the pass-mark should not be 50%, but less than 40% or more than 60%. If the pass-mark is 50%, then the curve should be a "skewed" cocked hat. In other words the relation between the difficulty of the examination papers and the pass-mark should be such that the borderline candidates are few in number.

The fixation of the pass-mark is the business of the examining authority. It is urged that the pass-mark for a practical examination should be higher since candidates either can or cannot perform the manipulative operations tested. Such a contention implies that the test is a first-class sample of all the manipulative operations which might be tested. In the examination for teachers' certificates the pass-mark is very low, for most of the candidates have been specially selected and specially trained and, on these counts, are theoretically qualified for a certificate, and the examination result is merely a confirmation of the goodness of the previous selection and the training. It may reasonably be urged that the general school examination should be conducted similarly. Secondary scholars tend to be specially selected; they are specially trained or taught in approved schools by registered teachers on an approved curriculum, so that the examination should be so arranged and the pass-mark should be so low that a large majority of these scholars should pass the examination at the conclusion of their course. So liberal a view of the situation runs counter to the university tradition so definitely that it is only by slow degrees that the general school examination system is being reformed. It is, of course, handicapped, as we have seen, by the two somewhat incompatible examinations, matriculation and leaving-school certificate being linked together, yet to divide them is difficult on the score of expense and of duplication of examinations, which is bad alike for pupil and teacher.

Checking the Scores.—A system of checking the scores is inevitable. Mechanical inaccuracies are readily discovered; inconsistent marking may be detected. A staff of experienced checkers is required and their efforts must be concentrated upon the scripts of candidates on or near the borderline.

PROS AND CONS OF EXAMINATIONS

Against examinations, mainly of the orthodox or traditional type, the following are some of the objections formulated. Most of them apply both to competitive and pass examinations. In the case of the former they are certainly more difficult to answer, but till we have found some other means of selection than competition, most of the defects inherent in such examinations must exist, though some are partially neutralized by the addition of an interview.

(1) They destroy natural interests and concentrate the pupil's attention on the subjects of the examination to the exclusion of all others. They need not necessarily do this in the case of pass examinations at least, if the papers are carefully graded and pupils take them in their stride. (2) They are apt to furnish the pupils too exclusively with ready-made opinions. This is a large subject and raises the whole question of the rival claims of originality and tradition in education. (3) There is an inevitable tendency for examinations to increase in difficulty. If the ordinary moderators cannot prevent this, the tendency could be checked by a periodical overhaul of the examination. (4) The questions are frequently unfair. The presence of actual teachers on the Board of Examiners would minimize this and also the previous objections (1), (2) and (3). (5) Difficulty of maintaining a standard of assessment between different examiners. This danger has been and is increasingly successfully dealt with. (6) There is too much stress laid on written work, insufficient or insignificant importance attached to the oral test. This could be met by extending the oral test or interview to all cases that mattered, such as borderland cases. (7) The practice of making a candidate who has failed in one subject take the whole examination over again has little logical justification. This anomaly has been rectified in some cases, but the whole matter needs serious reconsideration. In France, for instance, in the *licence* the system of taking the examination piecemeal (*see* above) is now the rule. (8) Examinations impose too great a strain on growing pupils, especially girls. This can be largely met by readjustment of the examination on lines suggested in (1), etc. (9) Public examinations are unnecessary. Teachers are sufficiently capable of examining and assessing their own children. The co-operation of the teacher is most desirable, but certificates, to have public validity, need a public guarantee.

On the other hand, a large number of people believe, rightly or wrongly, in the stimulus provided by an examination at the close of, or at least at a definite stage in, the pupil's career. They are strongly convinced of the value of such an examination in inducing the pupils to round off and codify their stock of knowledge, and in enabling them to mobilize and use it at short notice. Again, when the oral test or interview is employed, a more or less "all round" view of the pupil is possible. Paper work deals rather with actual performance, an oral test or interview especially helps to discover promise.

Moreover, no one seriously contests the necessity of examinations for professional people, however much the examination may be capable of improvement. Criticism mainly centres round school examinations, yet the average business man, while desirous of having a headmaster's recommendation, is also anxious to have an independent estimate of the pupil's ability from another authority. Moreover, the State, the local authority and the parents also have their rights in the matter. Full justice will be done to the teacher, if, as has been suggested, he is given a position on the board of examiners.

Examinations, whether pass or competitive, cannot in the public interest be abolished till something has been found to take their place. They act as the machinery for sifting out the different kinds and degrees of capacity of the nation. In fact, it is in the further improvement of the machinery, much as it has been improved in the past, that the principal hope lies, whether it be an extended use of intelligence tests for young children, a preliminary selection for various callings by psychological tests, or a greater flexibility in the examinations for older pupils, leading possibly in the long run to some half-way house towards the American method of "accrediting" in the way of giving credit for certain subjects to the pupil on his certificate, and taking the word of the duly recognized school that adequate time has been devoted to them, while in the sphere of the universities, a degree may be obtainable by a less rigid course of study either in the way of a larger choice of subjects, or combinations of them, than at present is allowed in most British universities.

(C. Br.; P. B. B.)

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EXAMINATIONS IN UNITED STATES

Examinations in the schools and universities of the United States have developed in much the same way as in European educational systems. They have not been as numerous as in Britain, and there are fewer examinations conducted by outside or extramural examiners. Very early many universities began to admit students without examination, provided that they had graduated from an accredited high school, and this is now the common policy of most State universities. Many universities, however, still insist upon examinations. In addition to examinations conducted by the

schools themselves, there are those given by many special examining boards, such as State, city and county boards of examiners for certifying teachers, the College Entrance board and Civil Service commissions.

The three methods of examination have usually been the written examination, the oral examination and more rarely the practical test. The last two are not very common, and the oral examination usually consists of random questions put by the examiners, who then register a total impression of the candidate. The written examination, therefore, is the most important method. Until recently this has consisted of written answers in the essay form to more or less general questions set by the examiner. The value attached to each question is subjectively determined by the examiner, and his scoring of the answers is based upon the general opinion of their worth. This subjectivity of the usual examination has been severely criticized by many educators. The same paper scored by many teachers will receive marks scattered all the way from very low to very high. The same examiner will mark differently at different times.

During the period of criticism of the old-type examination, the standard educational test and the intelligence test were being developed. In this connection there grew up a technique of constructing questions, evaluating them and standardizing the total test. The construction of an examination in a school subject for nation-wide use (generally called a standardized educational test) is now quite a technical matter. The effect of this was immediately felt in the ordinary examination and there is now the so-called new-type or objective examination, which calls for a specific response to an item, this response being made by underlining, checking or writing a word or at most a phrase. In an old-type examination the candidate might, for example, be asked to write an essay in answer to the question, "Describe the secretion of gastric juice." In the new-type examination (examples taken from D. G. Paterson, *Preparation and Use of New-Type Examinations*, Yonkers 1925) his knowledge about gastric juice would be tested by his response to short items, sometimes containing both true and false information, sometimes incomplete. Such statements may take several forms, as will be illustrated by examples from different subjects:

Analogy: Gastric juice is to the stomach as (saliva, adrenin, *tears*, bile) is to the lachrymal glands.

Completion: The part of a circle included between two—and an—is called a sector.

Recognition: Planets move around the sun in orbits that are circular, *elliptical*, hyperbolic, cylindrical.

True-False: The chief crop in Ohio is tobacco.

There are many different varieties and combinations of such forms, and those quoted above must be considered only as samples. These new-type examinations are now being widely used in all types of schools.

B. D. Wood describes such examinations at the university level and C. Russell shows in detail how school-teachers can construct such examinations in all subjects in the elementary school. He goes further and suggests how they may be used as effective teaching devices. None of these authorities advises the absolute abandonment of the old-type essay examination, but all of them believe it to be insufficient for the accurate examination of the pupil. All of them emphasize the necessity for a careful construction of the new-type examination, and they maintain that it can be made to measure the pupil's ability to reason. They deny that it merely tests the memory of the pupil.

These new-type examinations are now being used by such examining bodies as the College Entrance Examination board and the board of examiners of the New York city board of education, and by many civil service commissions, both State and municipal. In *Public Personnel Studies*, a journal issued by the Bureau of Public Personnel Administration, Institute for Government Research at Washington, suggested examinations for a great many civil service positions have been published. Almost all of these examinations are of the new type.

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(R. Pi.)

EXARCH, a title that has been conferred at different periods on certain chief officers or governors, both in secular and ecclesiastical matters. Of these, the most important were the exarchs of Ravenna (*q.v.*). In the ecclesiastical organization the exarch of a *diocese* (the word being here used of the political division) was in the 4th and 5th centuries the same as primate. This dignity was intermediate between the patriarchal and the metropolitan, the name patriarch being restricted after A.D. 451 to the chief bishops of the most important cities (*see* PATRIARCH). The title of Exarch was also formerly given in the Eastern Church to a general or superior over several monasteries, and to certain ecclesiastics deputed by the patriarch of Constantinople to collect the tribute payable by the Church to the Turkish government. In the modern Greek Church an exarch is a deputy, or legate *a latere*, of the patriarch, whose office it is to visit the clergy and churches in the provinces allotted to him.

EXCAMBION, in Scots law, the exchange (q.v.) of one heritable subject for another [from Lat. *cambire*, possibly from Gr. *κάμπτειν*, to bend]. The modern Scottish excambion may consist in the exchange of any heritable subjects whatever, *e.g.* a patronage or, what often occurs, a portion of a glebe for servitude. Writing is not, by the law of Scotland, essential to an excambion. Power to excamb was applied to an entailed estate by the Rutherford Act of 1848, and the necessary consents of heirs were regulated by the Entail (Scotland) act of 1882.

EXCAVATION. In civil engineering such as dock, harbour, canal, rail and road operations, the excavation of all manner of soil and the frequent construction of dams with the spoil, is of great importance. It is a special branch of engineering, and has been developed rapidly since the construction of the Manchester and Panama ship canals, in both of which the steam power shovel was extensively used. Even in the erection of big buildings, excavations have to be made for the foundations and basements; and though this task is not comparable in magnitude with some of the others, it may be of interest to quote the result of investigations made by the United States bureau of public roads, which gives the average cost of unskilled labour for excavating one cu.yd. of soil as $0·586, and that for rock as $1·61, when the average rate of pay was 23·9 cents per hour. It is further asserted

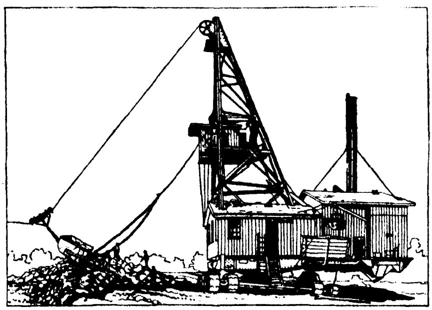
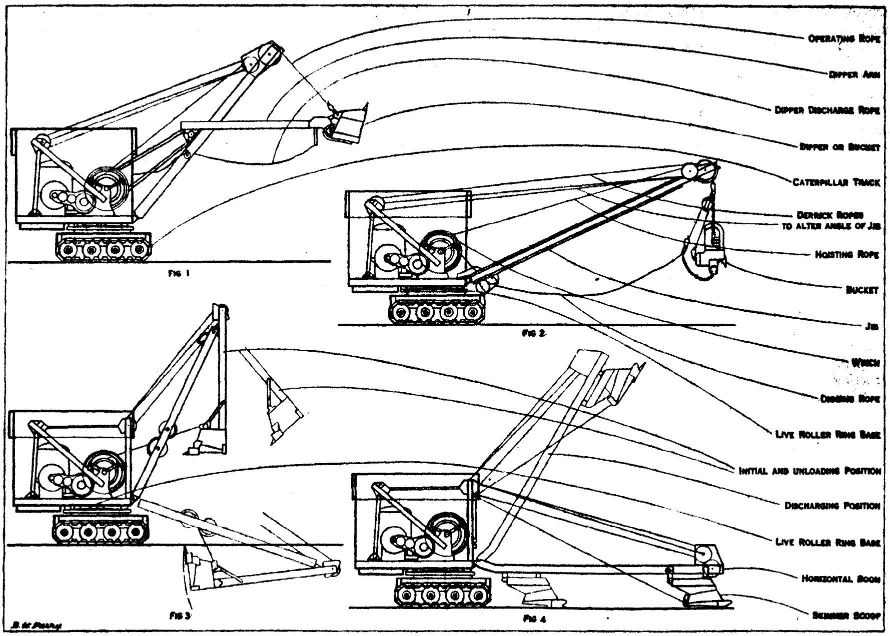


FIG. 1.—6-YARD DRAG BUCKET OPERATED FROM TOWER AT WORK ENLARGING A LEVEE IN THE LOWER YAZOO DISTRICT, MISSISSIPPI

by competent authorities that the cost of excavation for buildings ranges from 30 to 40% of the total cost of the foundation work.

The Crane Navvy, or Power Shovel.—This is principally employed in open-face mining and quarrying, in stripping overburden, in excavating clay and chalk, and also for general contracting work. A view of the machine with the dipper and arm in relation to the jib, is shown in Fig. 1. The bucket or dipper makes an upward cut and is therefore suitable for working against relatively steep faces. The contents are discharged from a hinged door at the back of the bucket, and the depth of cut is regulated by racking the bucket arm in and out at the point where it engages with the jib arm or boom. Electrically-operated machines hav-



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FIGS. 1 TO 4.—TYPES OF MODERN EXCAVATORS

Fig. 1. Section of crane navvy or power shovel on caterpillar track. Fig. 2. Dragline excavator, used principally for excavation of docks. The dragline and crane navvy may, in certain sizes, be converted from one type to the other. Fig. 3. Skimmer scoop. Fig. 4. Skimmer scoop used as trenching machine

ing a dipper capacity of 10 to 12 cu.yd. are in operation in the brown coal fields at Victoria, Australia, and similar machines are at work in tin mines in Nigeria. The largest power shovel has a dipper capacity of 15 cu.yd., and it is fitted on crawler tracks or caterpillar wheels. The skimmer scoops (figs. 3 and 4) are special purpose machines, somewhat on the lines of the crane navvy. They have a low-lying horizontal boom upon which the cutting scoop runs, and are suitable for removing shallow overburden, ripping up the surface of roads, and similar work where a shallow horizontal cut is desired.

The Drag-line Excavator.—This machine is most generally adopted to-day as a general purpose excavator. It is capable of digging to a considerable depth beneath its own level, and, as the digging stresses are taken by ropes, its jib can be made lighter and longer than that of the crane navvy; also it can be set at the most convenient angle for working. When the excavator is in operation one rope raises and lowers the bucket to and from the digging position, while the second rope drags the bucket over the ground, filling it during the process. By manipulating the two ropes in correct relation to each other, the filled bucket can be raised, lowered, or brought into a vertical position at the point where the soil is to be discharged. By revolving the machine on its wheel base the required dumping point can be reached; this may be a retaining bank, a train of vehicles, or a previously made cutting. As a general purpose excavator, the drag-line (fig. 2) stands in a class by itself. It is used for the excavation of docks, railway cuttings, canals, ditches; of sand and gravel from dry and flooded pits; and also for foundation and general excavation work. Drag-lines require a level path, and cannot dig such hard material as the shovel. This machine was invented in America and is manufactured by many builders there.

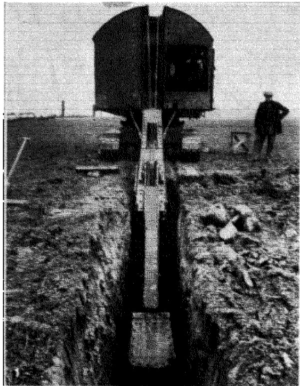
The drag-line excavator and crane navvy are closely related to one another, and, in all ranges of size, are capable of being converted from one type to another. They take the general form shown in the illustrations (figs. 1 and 2). The engines, gear, winches and control levers are contained in a cabin; the jib is hinged on the revolving frame. The machine is capable of being revolved upon its tracks by means of the roller-ring base shown. Such excavators travel mostly under their own power, and the adoption of caterpillar wheels enables them to negotiate difficult paths; sometimes they are mounted on rail tracks. Steam engines, internal combustion engines, or electric motors, are adopted as power units. The Diesel engine and Diesel-driven electric sets have also given good results on the larger sizes. Quite a variety of special-purpose machines, combining the elements of the above, have been developed (figs. 3 and 4), *e.g.*, the *slack line cableway* excavator, digging over big distances within a defined area, and an amphibious type of the *barge* or *ladder* dredger. The crane-and-grab combination is also used on medium soils.

Slack Line Cableway Excavator.—A typical plant consists of a rope track set at an incline. One terminal of this track is a movable anchorage near ground level, and the other is a relatively tall mast or tower suitably guyed and strengthened. The height of this tower is governed by the length of span, which may be from 800 to 1,000 feet. The digging bucket runs to and fro along the track, travelling in one direction by gravity, and being hauled back by a second rope which transmits the power for both digging and conveying. The bucket is lowered to digging position by slackening the track line, thus enabling the hauling rope to draw the bucket into the ground. With the bucket filled and the

BY COURTESY OF THE OSGOOD COMPANY

TYPES OF AMERICAN EXCAVATORS AT WORK

1. **Gasoline shovel used for heavy work, shown removing old pavement on city streets, where traffic delay must be avoided. In this type speed and economy are essential factors**
2. **Large buckshoe excavator operating between gas and water mains in a city street. Perfect control of machine ensures safety to pipe lines**
3. **Air shovel or pneumatic excavator working in tunnel for new subway, New York city. Pipe line at lower left brings high pressure air supply from compressor at surface. Girders overhead support temporary roadway**
4. **Gasoline shovel used for logging a road in the State of Washington. The machine rests on the log roadway**
5. **Large clamshell excavator handling rock near Tulsa, Oklahoma. The halves of scoop dig into loosened rock, closing by power device (top)**
6. **Steam shovel used in excavating building sites. Caterpillar treads allow the machine to move readily to any part of the area to be excavated**
7. **Gasoline shovel for housing or city development work. Where any large area is to be excavated, railway is generally used for removing earth, stones, etc.**
8. **Railroad type steam shovel mounted on continuous treads. The machine has a $3\frac{1}{2}$ yd. dipper; two scoopfuls fill a car. This type of machine was used in building the Panama Canal**



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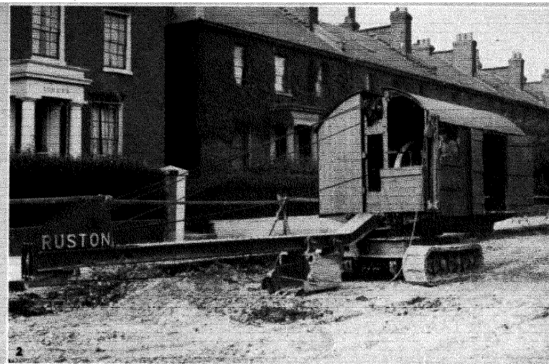

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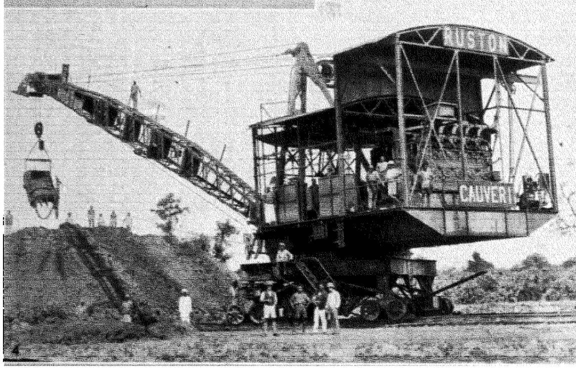

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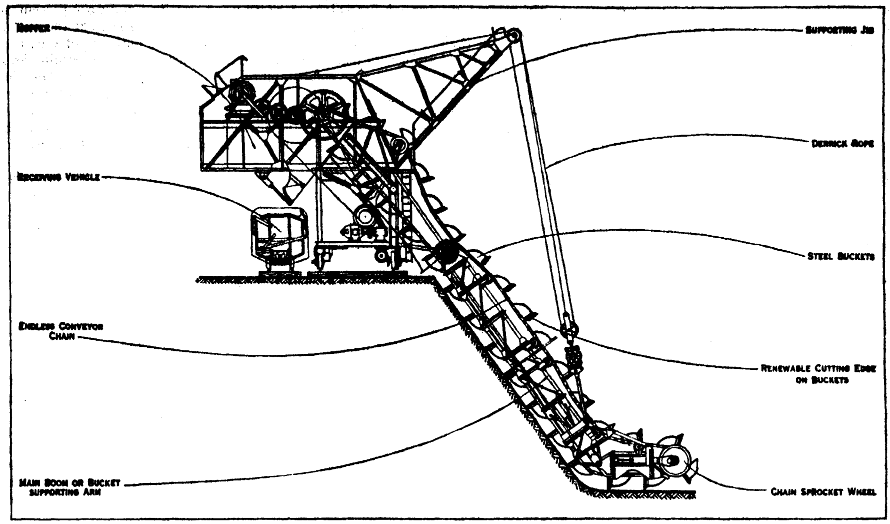
EXCAVATING MACHINES OF ENGLISH MANUFACTURE IN OPERATION

1. View of petrol (gasoline) excavator with special arm, working as back trencher, to dig a deep, narrow line for housing drains. 2. Petrol (gasoline) machine (*see* fig. 1), for the excavation of old road surfaces under repair. A special arm is used in this work, consisting of a channel beam along which scoop is moved. 3. Caterpillar shovel (*see* figs. 1 and 2), fitted with derrick for general excavating. Scoop in this type digs toward the machine. 4. Large oil-electric dragline scoop, used where coal and water are unobtainable. In rear of housing is Diesel oil engine, driving electric generator. Scoop and derrick are operated by current passing through motors in front of housing. 5. Small petrol (gasoline) driven excavator, shovel type, for foundation work. The machine, controlled by one man, turns in a complete circle



BY COURTESY OF "V.D.I."
SECTION OF BUCKET OR LADDER DREDGER, SHOWING THE SERIES OF RUNNING STEEL BUCKETS WITH CUTTING EDGES FOR EXCAVATION

track again made taut, the hauling rope conveys the load to the discharge point. All operations are effected by a power-driven winch having two winding drums to which the track and the digging ropes are led after passing over sheaves at the head of the tower terminal. A modification of the slack-line cableway excavator is the *power or drag-scraper,* whose bucket travels backwards and forwards over the surface of the ground, and, when loaded, automatically sets itself free from the digging position. One method of discharge is to provide a ramp, at the home terminal, up which the bucket rides to a tripping engagement, which enables the material to be discharged.

The Bucket or Ladder Dredger.—This, a modification of the well known barge dredger, runs on a rail track, an example of which is shown (fig. 5). Here a series of continuously running steel buckets with cutting edges are employed; these engage with the soil and convey it to the receiving hopper, which is at a height suitable for discharging material into vehicles. The main boom, or bucket-supporting arm, is composed of two parts, and the working angle can be adjusted up to 45° from the horizontal. These dredgers are suitable for removing shallow overburden, cleaning up marginal banks, and also for excavating areas. The *crane-and-grab combination* may either be a self-contained machine—which type is well known—or it can be adapted to work from the jib of a drag line excavator, in which case one winch drum is used for operating the digging and hoisting rope, and the other for operating the rope for opening the grab to release the load after it has been slewed into the delivery position.

AMERICAN TYPES

Revolving Shovels.—These are standardized (1928) and are built in three size buckets—½ to 1½ cu.yd. for small car, truck and wagon loading; 2½ to 4½ cu.yd. (heavily constructed) for quarry work; and 5 to 12 cu.yd. for overcasting overburden in "strip" or surface mining or for very large iron ore and quarry operations. All three sizes are full-revolving and most are mounted on crawling traction. They are capable of digging very hard material and prepare their own path as they dig ahead of themselves and above the surface on which they rest.

Tower Excavators consist of a head and a tail tower, a bucket being loaded and pulled along on the ground toward the head tower by a drag line. Attached to the rear of the bucket is a trolley sliding on a track cable which is raised slightly when filling and dumping the bucket and raised high to allow the bucket to travel back by air to the digging point. They give a greater horizontal displacement of the "spoil" or excavated material than any other machine. (G. F. Z.; G. B. M.)

EXCELLENCY, a title or predicate of honour. The earliest records of its use are associated with the Frank and Lombard kings; *e.g.*, Anastasius Bibliothecarius (d. *c.* 886) in his life of Pope Honorius refers to Charlemagne as "his excellency" (*ejus excellentia*); and during the middle ages it was freely applied to or assumed by emperors, kings and sovereign princes generally, though rather as a rhetorical flourish than as a part of their formal style. Its use is well illustrated in the various charters in the Red Book of the exchequer, where the addresses to the king vary between "your excellency," "your dignity" (*vestra dignitas*), "your sublimity" (*vestra sublimitas*) and the like, according to the taste and inventiveness of the writers. Du Cange also gives examples of the style *excellentia* being applied to the pope and even to a bishop. With the gradual stereotyping of titles of honour that of "excellency" was superseded in the case of sovereigns of the highest rank, about the beginning of the 15th century. Dukes and counts of the empire and the Italian reigning princes continued, however, to be "excellencies" for a while longer. In 1593 the bestowal of the title of *excellence* by Henry IV. of France on the duc de Nevers, his ambassador at Rome, set a precedent that was universally followed from the time of the treaty of Westphalia (1648). This, together with the reservation in 1640 of the title "eminence" (*q.v.*) to the cardinals, led the Italian princes to adopt the style of "highness" (*altezza*) instead of "excellency." In France, from 1654 onwards the title of *excellence* was given to all high officials, and this example was followed in Germany in the 18th century.

The subsequent fate of the title varies greatly in different countries. In the British Empire it is borne by the viceroy of India and all governors of colonies and ambassadors. In the United States it is part of the official style of the governors of States, but not of that of the president; though diplomatic usage varies in this respect, some States (*e.g.*, France) conceding to him the style

of "excellency," others (*e.g.*, Belgium) refusing it. The custom of other republics differs: in France the president is addressed as *excellence* by courtesy; in Switzerland the title is omitted; in the South American republics it is part of the official style (Pradier-Fodéré, *Cours de droit diplom.*, i. 89). In Spain the title of *excelencia* properly belonged to the grandees and to those who had the right to be covered in the royal presence, but it was extended also to high officials, viceroys, ministers, captains-general, lieutenants-general, ambassadors and knights of the Golden Fleece. In Austria the title *Exzellenz* belonged properly to privy councillors. It was, however, extended by custom to all the higher military commands from lieutenant-field-marshal upwards. Ministers, even when not privy councillors, are styled *Exzellenz*. In Germany the title was borne by the imperial chancellor, the principal secretaries of State, ministers and *Oberpräsidenten* in Prussia, by generals from the rank of lieutenant-general upwards, by the chief court officials, and it was also sometimes bestowed as a title of honour in cases where it was not attached to the office held by its recipient. In Russia the title was very common, being borne by all officers from major-general upwards and by all officials above the rank of acting privy councillor. Officers and officials of the highest rank had the title of "high excellency." Finally, in Italy, the title *eccelenza*, which had come to be used in the republics of Venice and Genoa as the usual form of address to nobles, has become as meaningless as the English title "esquire" or the address "sir," the usual form of address to any stranger.

In the diplomatic service the title of excellency is technically reserved to ambassadors, but in addressing envoys also this form is commonly used by courtesy. (W. A. P.)

EXCELSIOR SPRINGS, a city of Clay county, Missouri, U.S.A., 25m. N.E. of Kansas City, at an altitude of 939 feet. It is on Federal highway 69, and is served by the Chicago, Milwaukee, St. Paul and Pacific and the Wabash railways. The population in 1920 was 4,165 (90% native white). There are over 20 medicinal springs, which supply five different kinds of mineral water, and the city is an all-year health resort. It was founded about 1881 and incorporated in 1886. A city-manager form of government has been in operation since 1922.

EXCESS PROFITS DUTY OR TAX, a tax on the excess of the actual profit of an accounting period over a standard of profit.

THE UNITED KINGDOM

Following the outbreak of the World War in 1914 it was apparent, from the movement of the monthly index numbers of the wholesale prices of commodities, that profits of businesses, especially of those concerns whose products would immediately be in increased demand, would move upwards at a rate even greater than that shown by the index number. The results shown by accounts of trading concerns embracing part of the War period more than confirmed this anticipation. So the excess profits duty was born. It was imposed by Part 3 of the Finance (No. 2) Act 1915, which passed into law on Dec. 23 of that year.

The excess profits duty was a duty, where a chargeable profit existed, on the profit of businesses carried on in the United Kingdom or carried on elsewhere by persons ordinarily resident in the United Kingdom. Agriculture, professions and employments were exempt. The duty was imposed upon the profit of a business concern as an entity, and not by reference to the profit or income of individuals as such. A chargeable amount of profit was the excess of the actual profit of an accounting period over a standard of profit increased by certain free allowances. An accounting period was in general the period for which the accounts of the business were made up. Profit was determined, subject to certain modifications, on the principles which determined profits under the Income Tax Acts.

Standard of Profit.—The standard of profit was represented in the normal case of a business which had been carried on for some years prior to the outbreak of war by either: (a) a profits standard, or (b) a percentage standard. A profits standard was normally the average profit of any two of the three years to the end of the last accounting period ended before the outbreak of war. A percentage standard was normally a statutory percentage on the amount of capital employed in the business at the end of the last accounting period ended before the outbreak of war. Provision was made for the increase of percentages in certain cases.

To preserve comparability provision was made for a reduction or increase of the profit of the accounting period, by reference to a statutory percentage upon the additional or reduced amount of capital employed in the accounting period as compared with the capital employed during the period or at the date to which the standard related.

Capital as computed for the purpose of the duty represented the proprietors' trading capital, and borrowed money was, therefore, excluded from the computation of capital. In general, capital of a business consisted of money; assets acquired by purchase at the price paid, subject to any deductions for wear and tear or replacement; debts due to the business and assets not acquired by purchase taken at their value when they became assets of the business. Accumulated profits employed in the business were treated as capital; any capital (the income of which was not taken into account in computing profits for the purposes of duty) and any borrowed money or debts were to be deducted in computing the capital.

Special provisions affording relief from the full weight of the duty were introduced as from Jan. 1, 1917 in the case of small businesses.

A percentage—equal to the percentage rate of duty in force for the period concerned—of any deficiency of profit of a business below the standard in any accounting period was set off against the amount of duty applicable to an excess of profit over the standard in another period. The rate of duties varied between 40% and 80% of the excess profits chargeable.

Munitions Levy.—The Munitions Levy was imposed by the Munitions of War Act 1915. It applied only to certain concerns engaged in the manufacture of munitions which the minister of munitions "controlled" under the provisions of that Act.

The Act limited the profits to a retainable amount, ascertained in accordance with the statute and rules made thereunder. Any excess of net profits of the establishment over such retainable amount was payable to the exchequer as a munitions levy.

Controlled establishments liable to the munitions levy were also liable to the general excess profits duty but their total liability was limited to the higher of the two charges. From Dec. 31, 1916, the rate of excess profits duty became, practically without exception, the heavier charge. The munitions levy was therefore terminated at that date.

Repeal of the Duty and Special Reliefs.—Excess profits duty was abolished by the Finance Act 1921.

Where a taxpayer had been required to pay an amount of duty in excess of his aggregate net excess profits over the whole period for which the duty was in force, provision was made that the excess should be remitted or repaid.

Part of the productivity of the duty was due to the continuous rise of the price level. To take care of any heavy losses arising from a heavy fall in prices, after the duty was repealed, complex provisions were contained in the Finance Act 1921, granting three reliefs in connection with trading stocks, two of which were alternative to one another.

The net amount of duty collected and retained in the British Exchequer from the inception to the end of the tax was approximately £1,280,000. (W. H. C.)

UNITED STATES

Although during the Civil War the State of Georgia had adopted (1863) a tax on business profits in excess of 8% on the capital stock, at rates varying from 5% to 25% according to the amount of such excess profits, the first Federal excess profits tax was adopted in the Act of March 3, 1917, for the purpose of creating a "special preparedness fund." After the United States entered the World War, this tax, at higher rates and in more complex form, was continued in the Acts of Oct. 3, 1917, Feb. 24, 1919, and Nov. 23, 1921. In all these Acts, the American tax was aimed primarily at "supernormal profits," *i.e.*, profits in excess of normal profits, rather than "war profits," *i.e.*, profits in excess of pre-war

profits, which served as the basis of the British excess profits duty. The decision to base the tax chiefly on supernormal profits was made deliberately by the framers of the law on the ground that an exemption based upon invested capital was simpler, better designed to serve as the basis of a permanent tax, and more equitable in that it prevented taxpayers from escaping the tax merely because they had been unusually prosperous before the World War. Under the American tax, a business which had been unusually profitable before the war and merely maintained during the war the former rate of profits, was still subject to a heavy excess-profits tax. However, minor recognition of the war-profits idea was incorporated in the Act of Oct. 3, 1917; and for the one year 1918 a dual or alternative tax was imposed, the taxpayer in effect paying an 80% war profits tax or an excess profits tax at progressive rates of 30% and 65%, whichever tax was larger. During the years 1919–21 only the excess profits tax was retained.

The 1917 tax applied to all trades and businesses, including professions and occupations, but beginning with 1918 the tax was confined to corporations, excluding the so-called "personal-service corporations." The normal exemption or "excess-profits credit" consisted of a specific exemption of $3,000 plus 8% of the invested capital. Income in excess of this credit but not in excess of 20% of the invested capital was taxed (after 1918) at the rate of 20%, and the remaining income, if any, at the rate of 40%. The upper rate for the year 1917 was 60% and for 1918, 65%. Under the Act of Oct. 3, 1917, the specific exemption to individuals and partnerships was $6,000, but only $3,000 to corporations.

Judged by the standard of productivity—the most important quality of a war tax—the excess profits tax was conspicuously successful during the World War. The approximate yield of the tax was as shown below:

Excess Profits Tax Returned for Calendar Year

1917—Individuals, etc.	$ 101,249,781	
Partnerships	103,887,984	
Corporations	1,638,747,740	
Total		$1,843,885,505
1918—Corporations only		2,505,565,939
1919 " "		1,431,805,690
1920 " "		988,726,351
1921 " "		335,131,811

The figures for 1918 represent possibly the largest annual amount ever produced in one country by a single tax. During the years 1917–19 the excess-profits tax produced more than 25% of the total ordinary receipts. But despite the high rates, the tax was collected without crippling industry, owing to the high level of profits and to the protective effect of the normal exemption, the relief provisions, and the large degree of administrative discretion authorized in the law.

In accordance with the promises of both political parties, the tax was repealed, after stubborn opposition, as from Dec. 31, 1921. The termination of the tax gave rise to no special problems such as arose in Great Britain, because under the American tax the liability of the taxpayer for any one year was not dependent in any important way upon his income for other years. The repeal of the tax was due mainly to the sharp decline in its productivity under peace conditions; its discrimination in favour of over-capitalized concerns and against conservatively financed corporations; the general belief that it was passed on, loaded with additions, to the general body of consumers; its capricious inequalities; and its great complexity. The complexity of the tax, which, in the words of one secretary of the Treasury, threatened to cause an administrative breakdown, is illustrated by the fact that the tax liability for the year 1918 of some of the large corporate consolidations had not been finally determined at the close of the year 1927. Upon the repeal of the excess profits tax, the income tax rate applicable to corporations was raised from 10% to 12½%, and since that time the corporation rate has been markedly higher than the standard normal rate applicable to individuals. (In the Revenue Act of 1928, the corporation rate is 12%, while the highest normal rate for individuals is 5%.) There seems to be a general belief in the United States that "the theory of the excess profits tax is sound," but owing to its complexities and administrative difficulties there has been, since its repeal, no noteworthy movement for its reintroduction.

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EXCHANGE: *see* Trade, Primitive.

EXCHANGE, FOREIGN. Foreign exchange, as its name implies, relates to the purchase and sale of foreign moneys. The subject includes the interpretation and significance of "rates of exchange," the operation of the foreign exchange market, and, on the more theoretical side, the reasons why a particular currency is bought or sold, and all the factors accounting for its supply and demand. These last form part of the general science of economics, and also react upon the more practical questions of trade, investment and interest rates.

A rate of exchange between two countries is the price of one country's currency expressed in terms of the other's. From this it would seem that there are two alternative ways of expressing the rate, *e.g.*, £1=$4.866, or $1=49¼ pence. By custom, only one of these ways is adopted. Thus, in New York, all rates except sterling are quoted in cents per unit of foreign currency. In London, most rates are quoted in foreign currency per pound sterling, but the Lisbon, Eastern and most South American rates are quoted in pence per unit of foreign currency. To cite a few examples, Paris would be quoted, say, frs. 121, Rome lire 92, but Bombay at 1s.6d. (per rupee) and Brazil at 7d. (per milreis). As regards British Empire rates, Canada is quoted in dollars per pound sterling, and the Australian and New Zealand quotations express the price in London of £100 in Australia or New Zealand. The South African exchange is quoted both ways, *i.e.*, "on London," or money in London; or "on South Africa," *i.e.*, money in South Africa.

The next point to consider is what it means when a rate goes up or down. Confining this analysis to London, a sharp distinction must be made between the "foreign currency" rates and the "penny" rates. In the first instance, a rise in the rate, say from $4.86 to $4.87, or from frs. 120 to frs. 121, means that the price of the foreign currency has cheapened, or that, in the jargon of the market, the rate has moved "in favour of" England and "against" America or France. In the second instance, a rise in the rate, say from 1s.6d. to 1s. 6$\frac{1}{16}$d. for the rupee, obviously means exactly the reverse. The test of a "favourable" or "unfavourable" movement is whether the country's currency has risen or fallen in price.

It will probably be simplest to abandon for the moment further consideration of the technicalities of rates and to consider the immediate causes of their rise or fall. For this purpose, it will be easiest to consider two countries alone, such as England and America, though it must be remembered that in practice the rate between two given countries is affected by developments elsewhere in the world.

Foreign Exchange: Supply and Demand.—A rise in the dollar rate in London means that dollars have become cheaper and pounds dearer, while a fall means the reverse. There can be only one cause of such a rise, namely, that more people wish to buy pounds in exchange for dollars than wish to buy dollars in exchange for pounds; so the next thing to see is who wishes to buy pounds or dollars at all. The answer is clear. The pound alone is legal tender in England, and the dollar alone is legal tender in the United States. Everyone who has goods to buy, money to invest, debts to pay or money to lend in England must buy pounds, and everyone who wishes to do any of these things in the United States must buy dollars. The Liverpool importer of cotton from the United States must buy dollars. The London buyer of "American rails" must buy dollars. The British Government, when paying interest or sinking fund on the war debt, must buy

dollars. The London stock-broker who sells British war loan on behalf of an American client must buy dollars, for he has to pay the proceeds to his client in dollars. The British fire insurance company which has to meet an American claim must buy dollars. Conversely, the American exporter of goods to Japan or the Fiji Islands, who sends them in a British ship, must buy sterling, so as to pay his freight. The American importer of Manchester goods, or even of French lace sold to him by a London merchant, must buy sterling. The American who insures himself with a British company must buy sterling every time he pays his premium. The American tourist in England must buy sterling to pay his hotel bill. The American trader who sends his bills to London for acceptance must buy sterling to pay his commission to the London accepting house. The American buyer of British stocks and shares must buy sterling so as to pay for them. The American railroad company with British shareholders on its register must buy sterling so as to pay their dividends.

These examples can be multiplied indefinitely, but can be summarized more conveniently in the following table:—

Sterling is needed to pay for:	Dollars are needed to pay for:
A. *Trade*	
All goods (British or foreign in origin) shipped from Great Britain to U.S.A.	American goods shipped from U.S.A. to Great Britain.
The American use of British ships.	The British use of American ships, and payments by British captains in U.S. ports.
American premiums to British insurance companies.	American claims on British insurance companies.
American commissions paid to British banks, merchants, etc., for services rendered.	Commissions (if any) due in America, as per contra.
B. *Investment*	
American purchases of British stocks and shares.	British purchases of American stocks and shares.
British sales of American stocks and shares.	American sales of British stocks and shares.
American loans to Great Britain.	British loans (if any) to America.
Repayment of loans made in past by Great Britain to U.S.A.	Repayment of loans made by America to Great Britain.
C. *Interest*	
Interest due on British loans to America.	Interest due on American loans to Great Britain.
Dividends due to British holders of American stocks.	Dividends due to American holders of British stocks.

The next point is to see how these various traders, investors, etc., acquire in practice the sterling or dollars that they need. The basic, though least common, means of making payment is in gold. By English law, one gold sovereign contains 123·274 grains of gold, eleven-twelfths fine; and by American law, one dollar contains 25·8 grains of gold, nine-tenths fine. The Bank of England in London engages to buy all gold offered to it at 77s.9d. per ounce, eleven-twelfths fine, while the Treasury in Washington will also buy gold at the appropriate rate. Also gold is legal tender in both countries. Hence anyone in America owing money in England can pay by tendering the weight of gold corresponding to the sum he owes at the above legal rates.

Gold Points.—This is of importance, as it is by these rules that the "par of exchange," or gold equivalent of the pound and dollar, is established at $4.866=£1. In practice, payments in gold are comparatively rare. For one thing, certain countries prohibit the export of gold, and even in England small shipments are checked by the fact that the Bank of England will not sell gold in less quantities than 400 ounces. Also, payment in gold is a costly business. It has to be properly packed, shipped and insured against loss, and while it is on the ocean it is earning no interest. By the time an English debtor has paid in gold, he must deduct about 2½ cents, representing the cost to him per pound's worth of gold shipped, from the dollar equivalent of $4.866 to £1, and so will only get about $4.841 for his pound. Conversely, the American shipper to England will also have to pay about 2½ cents per pound, so that to the dollar cost to him of $4.866 for his pound's worth of gold he must add about 2½ cents, making the total cost about $4.891. These rates of approximately $4.841 and $4.891 are called the "lower" and "upper gold points." It is not at first easy to see why in one case the cost is deducted, and in the other it is added. The best way to look at it is to remember that the result is always adverse to the shipper. The Englishman wants cheap dollars, but only gets $4.841 for his pound. The American wants cheap pounds, but has to pay $4.891 for each. This also explains why gold shipments are comparatively rare. In the vast majority of cases, the Englishman can buy more than $4.841 with his pound, and the American can buy his pound for less than $4.891. They do this as a rule through the medium of their banker, and so long as the rate of exchange remains between the gold points, they do not ship gold.

Methods of Making Foreign Payments.—Now to return to the table of supply and demand. Goods, as a rule, are bought and paid for with some form of bill of exchange (*q.v.*). The bill is drawn in sterling or dollars by agreement between buyer and seller. Thus, the English buyer of American cotton might be drawn on in sterling, while the American buyer of Manchester goods might be drawn on in dollars. In a large number of cases the buyer might have a credit opened for him by his banker (*see* BILL OF EXCHANGE), and the seller would then draw his bill on the bank. In many other cases payment would be made by a cheque drawn by the buyer on his bank—just as if he were paying for his coals or his joint of meat—and sent direct to the seller. In a few cases the buyer might send actual currency notes, either pounds or dollars. Again, dividends on bearer stock are payable by the medium of coupons. These may be regarded as cheques to bearer drawn on the bank responsible for the service of the stock, and so come under the heading of bills of exchange. In many general cases the remitter of funds will buy, from his own bank, a draft drawn on a bank in the country to which he is remitting, and send this to the man to whom he owes the money.

There is thus in constant circulation a huge mass of paper, bills, drafts, cheques, drawn in various currencies upon various individuals and banks, and it is the function of the foreign exchange market to provide a means for dealing with this mass. Until the present century, this was largely done direct. A large proportion of international trade was financed by bills drawn on London, the buyer, wherever he might be, getting a London house to accept on his behalf (*see* BILL OF EXCHANGE). Again, bills of all currencies and descriptions were either sold in the London market or sent to London for collection, with the result that London finance houses were continually in receipt of bills of all kinds. They, therefore, held the famous bi-weekly market "on change," in the Royal Exchange, and every house which had bills drawn in any currency to buy or sell would attend and get the best prices it could. These prices, of course, became the rates of exchange of the day.

The need for speed, and the development of the telephone, have put an end to dealings "on 'change," and the market now operates in different fashion. The best way to understand it is to revert to the relations between the trader and his bank. One or two examples may conveniently be cited. (For explanation of terms, *see* BILL OF EXCHANGE.)

The Banks' Function.—The first is the simple one of an American selling cotton to an English merchant in Liverpool. The American draws on the Englishman in sterling at sight (D/P), and hands the bill and the documents to his New York bank for collection. The New York bank forwards these to the London bank which acts as its agent, and the London bank presents the bill to the Liverpool buyer, gets his acceptance and payment of the bill, then surrenders the documents. The cash so paid, it credits to the New York bank's account with it, and advises the New York bank, which promptly credits the seller's account with the dollar equivalent of the sterling sum. The important thing to note is that the New York bank's sterling balance in London has been increased.

The second example is that of a London investor receiving a

dollar cheque drawn on a New York bank from a Wall street stock-broker who has sold stock in New York on behalf of his London client. The London investor either hands this cheque to his London bank for collection or else sells it to his London bank outright (save for the contingent liability attaching to his endorsement). Whichever he does, the London bank forwards the cheque to its New York agent for collection, and the New York agent presents it, receives payment and credits the London bank's account with it with the proceeds. It then advises the London bank accordingly. If the London investor sold the cheque to his bank, he would be credited with the sterling equivalent there and then. If he handed it to the bank for collection, he would wait for his money until the London bank had been credited with it in New York. In either case, the London bank's dollar balance in New York has been increased.

In many instances, where a debtor has to meet a claim (including a bill of exchange) expressed or drawn in a foreign currency, he buys a draft for the amount from his bank, drawn on his bank's account with its agent in the country concerned. Thus a London importer could meet a dollar bill drawn on him by a dollar draft drawn by his London bank on its New York agent. When an English traveller returned from New York hands dollar notes into his bank, the bank either keeps them against the needs of other customers who may be going to America, or else posts them to its New York agent for the credit of its dollar account.

One more difficult example may be cited. A German buys cotton from America, the terms of the deal being that the seller can draw in sterling on a London credit opened on behalf of the buyer. The buyer asks his German bank to arrange with its London agent to open the credit, and informs the seller accordingly. The American seller then draws his bill on the London agent of the German bank, and either discounts it at his New York bank or tells his New York bank to collect it. In either case the New York bank forwards it to its own London agent, who presents it to the London agent of the German bank for acceptance, and in due course for payment. In this case there is a decrease in the sterling balance in London of the German bank and an increase in the sterling balance in London of the New York bank.

These examples show the foundation of modern foreign exchange dealings. This consists of the balances held by the banks of one country with the banks who act as their agents in foreign countries, such as the sterling balance in London of the New York bank, and the dollar balance in New York of the London bank.

Frequent mention has been made of the "equivalent rate," but before this can be explained, the operation of the foreign exchange market must be described. It will be realized that every one of the examples cited above ends in an increase or decrease in the balance held by one bank in one country with its agent in another. Were there a complete equilibrium every day in the supply and demand table previously given, these increases and decreases would obviously cancel out. As equilibrium never exists, some banks are always finding that their foreign balances are growing too big, while others find that they are becoming depleted. They then have to buy and sell foreign currencies between themselves, and this is the modern foreign exchange market.

The London Foreign Exchange Market.—Every bank in London has a "dealer" whose job is to watch the size of his foreign balances and to buy or sell foreign exchange accordingly. There are also brokers in London who act as intermediaries between the dealers. One set of brokers will specialize in dollars, another in francs, and so on, so that a dealer wishing to buy and sell dollars knows that there are two or three special brokers whom alone he need approach. Each morning the broker rings up the various bank dealers and quotes the rate; thus for dollars he might call "5 to 5¼," meaning $4.85 to $4.85¼ to the pound. One dealer might want to buy $10,000 to replenish his New York balance, and as he wants them as cheaply as he can get them, he might say he will "take at 5½." Another dealer, with a surplus of dollars, may want to sell, but only "at 5⅛." Then the broker tries to "get a fit," and in the middle of it some more buyers and sellers may come in at varying rates. If the broker has many buyers, he will call the rate "4⅞ to 5⅛," and so shake off some buyers and tempt out fresh sellers, for "4⅞ to 5⅛" means, of course, dearer dollars than "5 to 5¼." So the day goes on, and every time the broker gets a buyer and seller to agree, he drops out at once, leaving them to put the transfer of dollars through between them. The only other thing he has to do is to collect his commission. The important thing is that normally he neither buys nor sells himself; and the "double quotation" is not a buying and selling quotation such as is made by a stock-jobber, but is made in that way for its psychological effect in tempting buyers and sellers to agree.

The actual transfer of dollars is made by cables from the buying and selling banks in London to their agents in New York. By custom, two days after the deal, the one London bank pays the other London bank in sterling for the dollars, while the seller's dollar account in New York is debited and the buyer's credited, the dollars being paid over by the one New York agent to the other.

Rates of Exchange.—The rates at which these deals go through are called "cable rates," for the orders to the foreign agents for their execution are sent by cable. They cannot go beyond the gold points, for bankers would then find it cheaper to correct the size of their balances by an import or export of gold, bought in the one country and sold in the other. They are the rates published in the newspapers, and they are the basic rates for all exchange transactions and remittances made by banks for their customers, *i.e.*, for the "equivalent rates" mentioned above. Some of these can now be described.

(1) *Cheque rate* is the rate at which a bank will buy foreign currency cheques from its customers. If cable rate for dollars is $4.85, cheque rate would be slightly higher, say $4.85⅛—*i.e.*, the bank would insist on buying at a cheaper price or rate than the cable rate of the day. The reasons for this are (*a*) that the bank may want a small margin as an insurance against the risk of the cheque being a bad one; and (*b*) the bank pays sterling for the cheque at once, but does not receive the dollars until the cheque reaches New York and is presented for payment. Meanwhile, the bank is out of its money. When a dollar cheque is not sold, but is handed to the London bank for collection, the customer has to wait for his money until the cheque reaches New York and is paid. He gets his sterling at the cable rate ruling on the day the cheque is paid, less the charge made by his bank for collection.

(2) *Sight rate* is the rate at which a bank will buy foreign currency bills payable at sight. This is governed by the same considerations as the cheque rate.

(3) *Long rate* is the rate at which a bank will buy foreign bills payable some definite period after sight (*see* BILL OF EXCHANGE). Here the bank is out of its money until such time as the bill matures, and the calculation of the rate is best illustrated by an example. Say the bill is for $100, has 90 days to run and the discount rate in America is 4% per annum; then the buyer of the bill only gets $100 at the end of 90 days, which at 4% is the equivalent of $99.01 on the spot. If cable rate on the day of the purchase is $4.85, the sterling equivalent of $100 in three months is not £100÷4.85, but £99.01÷4.85, or £20.8s.3d., for $100 in three months is only worth $99.01 on the spot. The long rate can now be found by setting £20.8s.3d. against the original $100, and by simple division it comes out at about $4.89¾. This roundabout way of calculation has been used to show exactly how and why the long rate is reached. The simpler and more usual method is to calculate directly from the cable rate, the equivalent interest being added thereto, as dollars in three months are cheaper than dollars on the spot. Were an American banker buying a three months' sterling bill, he would deduct the equivalent interest from the cable rate, making "long sterling" $4.80¼. This is because it is sterling that is cheaper, not dollars.

(4) *Forward rates* are the basis of a special market, which was built up to meet the difficulties arising from wild exchange fluctuations prevalent from 1919–26. Just as a cotton spinner can buy or sell "futures," *i.e.*, cotton for delivery on some fixed future date, so can a trader buy or sell foreign exchange from or to his bank for delivery one or two or three months ahead, at the forward rate of the day on which he buys or sells. Once he has

bought, say, forward francs at frs. 120 to the pound, he need not worry if, before he gets delivery and has to pay, the rate goes to 60 or 240. Forward exchange has proved a very real protection to traders against exchange vagaries.

When a bank dealer is notified of a large sale (or purchase) of forward francs by his bank to a customer, he at once buys (or sells) in the market in equal quantities of spot francs. Then he is safe for the day against any big adverse jump in the spot rate, which would, of course, carry the forward rate with it. Just before the close of the day's business, he adjusts his open forward positions. To do this, he buys (or sells) such net amount of forward francs as he has over after taking into account all his bank's sales to and purchases from its customers, and at the same time "undoes" all his "guard" purchases and sales of spot francs by a net sale (or purchase) of spot francs at the closing cable rate of the day. He has thus balanced his forward book for the day.

Forward rates are always quoted in so-many centimes or cents above or below spot. If dealers are buying forward dollars, the forward rate may be a cent or so below spot, and vice versa. The reasons why a forward rate is sometimes above and at other times below the spot rate will be considered later. For the moment, all that need be done is to emphasize the fact that the considerations are totally different from those that govern long rate.

The Theory of the Foreign Exchanges.—It is now time to turn to more theoretical considerations. Why is it that there is a demand for sterling or francs or dollars? The answer is contained in four main rules. (1) Goods naturally flow to the market where prices are highest. (2) Investors turn to the market where they can get the highest and safest return on their money. (3) Bankers and financiers deposit their surplus funds in the centre where, granted adequate safety, they can obtain the highest interest. (4) If a country is losing gold, and/or finds trade and the stock exchange reaching a speculative height, and/or credit becoming "shaky," bankers in that country tend to raise interest rates.

Purchasing Power Parity.—Rule (1) may be regarded as the basis of Professor Cassel's famous "purchasing power parity" theory. This is that if the shipment of gold is forbidden, so that the rates of exchange can move beyond the gold points, the rate of exchange between two countries is determined largely by the internal purchasing power of each country's currency. Thus in 1913, at par, £1=$4.866 and British and American internal prices each stood at 100 (*see* INDEX NUMBERS). For the year 1920, British prices averaged 290 and American prices 230, in round figures. According to the theory, it took £2.9 in 1920 to buy the same as £1 in 1913, and $2.3 to buy the same in 1920 as $1 in 1913. Hence the 1920 parity would not be £1=$4.866, but £2.9=$4.866×$2.3, or £1=$3.86. This theoretical rate of $3.86 Professor Cassel called the "purchasing power parity."

So long as the actual rate was at that point, the British purchaser would find British and American goods equally cheap, but if it moved, say to $3.96, American goods would be the cheaper, for he could then get more than a pound's worth of dollars for his pound. So he would buy American goods, and his banker would have to supply him with dollars out of his New York balance, so that he could pay for them. So his bank's dealer would start buying dollars, and force the rate lower till it reached $3.86, the point of equilibrium, when a pound would buy a pound's worth of dollars and no more. If the actual rate went, say to $3.76, the position would be reversed and Americans would start buying British goods.

The theory holds in a different form when gold shipments are legal and the exchange is kept within the gold points. The Englishman and American alike buy in the cheapest market, and the country where prices are the higher begins to import goods. Purchase of exchange to pay for them drives the rates down to the gold point, gold flows out and the loss of gold forces bankers to contract credit, call in loans and so make traders throw their stocks of goods on the market. This forces down prices at home to the point where home goods become cheaper than foreign, and so restores equilibrium. In the former case the rate is forced to conform to the purchasing power parity, but where the gold standard obtains, it is the purchasing power parity that is forced to conform to the rate.

The following table, dealing with England and the United States, illustrates the approximate character of the theory:—

Date.	Purchasing power parity.	Actual rate of exchange.
April		
1920	$3.78	$3.93
1921	4.10	3.93
1922	4.74	4.42
1923	5.00	4.66
1924	4.57	4.35
1925	4.90	4.79
1926	5.21	4.86

All than can be said is that the two move up and down together; in practice they rarely coincide. Of course, purchasing power parity can never be calculated exactly.

Rule (2), relating to stocks and shares, works out in a similar fashion. It is permissible to connect with this the high level of New York stock prices in the autumn of 1927, and the flow of American money to Europe for investment, which was one of the causes of the European exchanges being forced down to the gold point, so that gold was lost to Europe.

Exchanges, Discounts, Rates and Gold Shipments.—Rules (3) and (4) have been proved over and over again. A banker can obtain interest on his balances with his foreign agents at rates governed by the general level of interest rates in each country, and so, where interest rates rule high, he will let his balances grow, and even add to them by exchange purchases on his own account. For example, he may buy spot exchange and sell forward exchange, and by so doing he will have foreign currency at his command for a definite period. Incidentally, this will make forward exchange cheaper than spot exchange, *i.e.*, if London was buying spot francs and selling forward francs, the forward rate for francs would be above spot. The relative level of interest rates thus partly decides whether the forward rate is above or below spot. It follows from these rules that a rise in interest rates always checks an efflux of gold due to foreign exchanges reaching the gold point. A striking case of this occurred in London in the autumn of 1925. Many American bankers knew in 1924 that England was going back to gold, when the pound would be worth $4.866; so they bought pounds at $4.5, $4.6 and $4.7, knowing they could eventually re-sell at $4.866. When these hopes were realized in April 1925, interest rates in London were high, so they left their money in London. In the early autumn of 1925 interest rates in London were lowered, and American bankers found their money could earn more at home. So back it came, and London lost millions in gold to New York. It was only when London rates were raised again that the loss of gold ceased.

In the autumn of 1927 London was again slightly above New York, and this time it was New York that lost gold. As a matter of fact, the three first rules united in making the exchanges unfavourable to the United States.

In short, adverse exchanges are a sign of (*a*) too high internal commodity and stock prices, and (*b*) too low internal interest rates. They lead to a loss of gold, and in self-protection bankers have to take steps which automatically correct these adverse factors. Equilibrium may take time to reach, but in the long run it is restored.

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(N. E. C.)

EXCHANGE MARRIAGE. As workers and potential wives and mothers, all women are valuable to the community of which they are members. For this reason, amongst many primitive peoples a man can only get a mate by compensating the group from which he takes her. This compensation can be in the form of goods or service or of another woman. Though sometimes a woman has much freedom in choosing a husband, where marriageable women are scarce (owing to polygyny or, to restrictive marriage prohibitions) she is more or less at the disposal of her guardian, generally her father or maternal uncle or brother, who may use her as a means of procuring a wife for himself by exchanging her for another man's sister or daughter. In Australia and New Guinea and parts of the Pacific this is the most widely recognized way of arranging marriages. Commonly two men will marry each other's sisters (almost always real, not "classificatory"). If a man has several sisters, he has generally the right to dispose of all of them and so can obtain an equal number of wives; but if there are several of each sex in a family every brother in age order has a right to one sister, though, in Australia, a man will sometimes deprive his sons by exchanging a daughter for a wife for himself. In the island of Erromanga (West Pacific), where there is local exogamy (*see* EXOGAMY), the transaction concerns districts not families. If a man of district A wishes to marry a girl of district B, a girl of his own district, not necessarily his own sister, must be set aside for a return match, and both girls must be approved by the district chiefs.

In other parts of the world marriage by exchange is substituted for "marriage by purchase." If a man is too poor to collect the necessary "bride-price" for a wife, he may seek out another similarly circumstanced and effect an exchange of sisters. This is done to-day in many parts of India, by the Fellahîn of Palestine and by less cultured peoples. Even where "marriage by purchase" is general we may see another form of exchange in the custom, found in East Africa and elsewhere, of regarding the wealth obtained by the marriage of a woman as belonging by right to her brother, wherewith he may obtain a bride.

Among some tribes who normally practise exchange marriage, part of the ceremony consists in what appears to be the paying of a bride-price, which would be superfluous, if the exchange of women were for economic reasons. It is often the case with so-called "marriage by purchase," however, that the woman is not "bought" from her people, but that the exchange of gifts which takes place is of purely sociological not economic significance and has as its object the ceremonial uniting of the groups of bride and bridegroom. In Erromanga, when, after a marriage between two districts, a return marriage is made, part of the "bride-price" paid consists of the very goods which changed hands during the first marriage. Thus in some places the exchange of women may have originated for a similar reason.

In Australia, and among many tribes in India, exchange marriage is definitely associated with the marriage of cross-cousins (*see* COUSIN MARRIAGE). If two men exchange sisters, and if sons and daughters result from each union, then it would be natural for the boy cousins again to marry each other's sisters. This would result in a marriage between people who were doubly cross-cousins and, if persisted in from one generation to another, would create a permanent bond between the two branches.

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EXCHEQUER. An English name for an accounting department, used of private as well as of public institutions, but more commonly of the government office receiving and having the care of the public revenues. (Lat. *Scaccarium,* a chess-board or, derivatively, a counting table and, from that, an accounting department.)

As the name of a Government department, we cannot say whether "Exchequer" is older than the 12th century. The Treasury, with which it was in practice joined, dates from before the Conquest and those officers of the Exchequer who were drawn from the Treasury staff can be traced back to Domesday. The word came quite early to be applied to the two jointly, the "lower" Exchequer, or "Receipt," closely connected with the permanent Treasury, being an office for the receipt and payment of money, while the "upper" Exchequer (the *scaccarium* proper) was a court sitting twice a year to regulate accounts and closely related to the Curia Regis, and is thus probably on the Norman pattern. The lower Exchequer was conditioned in its development by the use of tallies (*see* TALLY); the upper, as its name implies, was based on the use of the abacus, or counting-board, for reckoning, such a contrivance being almost universal before the introduction of Arabic numerals, which did not become common in England till the 16th century. Our earliest information about the Exchequer itself, apart from that afforded by the pipe rolls, rests on a treatise (*Dialogus de Scaccario*) written in the latter part of the reign of Henry II. by Richard, bishop of London and treasurer of England. His father, Nigel, bishop of Ely, had been treasurer to Henry I., and nephew of that king's great financial minister, Roger, bishop of Salisbury. Nigel is said to have reconstituted the Exchequer after the troubles of Stephen's reign upon a model inherited from his uncle.

The Angevin Exchequer.—The sessions seem at first to have been confined to the actual times when the court sat at the "chess-board," round which were grouped the "barons," officials and accountants. At the head of this table were the great officers of State; except the treasurer, who sat on the right with the Exchequer clerks below him: on the left was the calculator, and at the bottom appeared the officials whose accounts were to be audited. Of the officers of State, the justiciar was normally the president, in the king's absence; the chancellor was responsible, as keeper of the seal, for all writs and summonses; the two chamberlains, lay colleagues of the treasurer, shared with him the duty of receiving money and keeping the records and other contents of the Treasury; the marshal, a subordinate of the constable, was responsible for the custody of prisoners and of the accountants' vouchers. The treasurer charged accountants with their debts and dictated the great roll of accounts ("pipe roll"), which was written by his scribe, the chancellor's scribe copying from this a duplicate (the "chancellor's roll"). The calculator worked out the sums on the Exchequer table (*abacus*) by means of counters. Other subordinates were the *Magister Scriptorii* and the chancellor's clerk (later chancellor of the Exchequer) who settled the form of all writs and summonses, charged the sheriff with all fines and amercements, and acted as a check on the treasurer in the composition of the pipe roll.

In the lower Exchequer (the "Receipt"), the staff was divided between the treasurer and chamberlains, the clerical members being under the former, the lay under the latter. The money brought in by the royal accountants was counted by the "four tellers," weighed by the "pesour" (a knight) and assayed by the "melter," receipts being recorded by means of wooden tallies cut and split by the tally cutter, one half going to the payer while the other was retained at the Exchequer to prevent fraud. Record of moneys issued was mainly secured by filing the warrants for payment (writs under the great seal) as they were honoured. Early in Henry II.'s reign written records of the tallies (rudimentary receipt rolls) began to be kept in addition to the originals; issue rolls were also used later for money paid out, but the old tally and warrant system continued throughout the history of the department. At the Receipt the treasurer was represented by a clerk (later clerk of the pells), and each of the chamberlains by a knight (later the "chamberlains of the receipt"); these three had joint control of the Treasury. In both upper and lower Exchequers were ushers.

The business of the ancient Exchequer was mainly financial, though some judicial business connected with the accounts was also done. The principal accountants were the sheriffs, who were bound, as the king's chief financial agents in each county, to give an account of their stewardship twice a year, the state of their accounts being "viewed" at Easter, when they made their first "profer," and audited on the pipe roll at Michaelmas. The fixed revenue consisted of the farms of the king's demesne lands within

the counties and of certain boroughs which paid annual sums as the price of their liberties. Danegeld, though regarded as fixed revenue, was infrequently levied after Henry II.'s accession, but there were rents of assarts and purprestures, mining and other royalties. The casual revenue consisted of the feudal incidents (escheats, wardships and marriages), of the profits of justice (amercements, and goods of felons and outlaws) and of fines or payments made by the king's subjects to secure grants of land, wardships and marriages, and of immunities, and to hasten (or sometimes to delay) justice. Besides these there were the revenues arising from aids and scutages of the king's military tenants, tallages of the Crown lands, customs of ports and special "gifts," or general assessments made on particular occasions. For the collection of all these the sheriff was primarily responsible, though in some cases debtors and accountants dealt directly with the Exchequer and were bound to make their appearance in person on the day when the Sheriff accounted.

The farms of demesne lands were originally for the most part paid in kind (though payments in assayed silver are found in Domesday Book), but at some date, possibly in the administration of Roger of Salisbury, the inconvenience of the earlier arrangement led to payment in cash. The rapid deterioration of a small silver coinage gave rise to attempts at maintaining the value of cash payments, first by a scale reduction for wear, then by substitution of payment by weight for payment "by tale," and finally by the reduction of payments of most farms of the shire to their pure silver value by means of an assay. The casual revenue was still paid by tale, and for the determination of its amount it was necessary for the Exchequer to receive copies of all grants made in the Chancery on which rents were reserved or fines payable: these were known first as *contrabrevia* and later as *originalia*. The profits of justice were notified by the delivery of similar "estreats" from the justices' records from an early date; and, while for certain minor casualties the oath of the sheriff was at first perhaps the only security, later they were frequently determined by means of inquisitions. Exchequer business might be transacted anywhere in England; the original meetings were at Winchester, later they took place at Westminster as a rule but occasionally, even in the 14th century, elsewhere.

Developments in the 13th and 14th Centuries.—The Angevin "course" remained the ideal of the Exchequer for six centuries: and its lineaments were never completely effaced, though the vast increase of business soon meant that the machinery had to be stretched if it was not to break down. Great officers of State ceased to attend personally: even under Henry II. we gather that all, except the treasurer and chancellor, had deputies: and under Henry III. the chancellor was represented by his clerk who became "chancellor of the Exchequer." On the other hand new officials emerge, notably the four permanent official barons and the king's and lord treasurer's remembrancers. Two "memoranda rolls" of these remembrancers survive for John's reign and show that the Exchequer already sat regularly except during vacations, that memoranda were made of business reserved for attention at subsequent sittings, and that this business had begun to be arranged systematically. During the 13th century their functions, originally very similar, became gradually differentiated, the memoranda rolls developed so that they formed a complete record of a large part of the Exchequer business, and by the Ordinance of 1323–26 the remembrancers' precise duties were defined. Henceforward the king's remembrancer was more particularly concerned with the casual, the treasurer's with the fixed revenue: the former put all debts in charge, while the latter saw to their recovery, when they had found their way on to the great roll. Hence the preliminary stages of each account, the receiving and registering of the king's writs to the treasurer and barons and the drawing up of all particulars of account, lay with the king's remembrancer, and he retained the corresponding vouchers, a collection which, though much diminished, is still one of exceptional size, diversity and interest. The treasurer's remembrancer exacted the "remanets" of such accounts as had been enrolled, as well as reserved rents and fixed revenue, and so became closely connected with the clerk of the pipe. Before the end of the century these three offices had separated into different departments.

Judicial Procedure at the Exchequer.—We must turn aside here to mention a 13th century development at the Exchequer which was only indirectly concerned with accounting. By about 1250 convenience had led to the establishment of something like separate machinery, and definitely separate records for legal cases which arose out of accounts and which, in the earliest times, we find among the ordinary memoranda. In the case of Jewish affairs we have a curious mixed arrangement by which, though receipts from Jewish sources passed through the ordinary machinery of the lower Exchequer, there was apparently no recognized organization for audit. In these circumstances a special *Scaccarium Judaeorum*, whose records are known to us as the Jewish plea rolls, dealt with most of the financial business, other than that of actual receipt, and at the same time acted as a court for the trial of all cases, both Crown and civil, in which Jews or Jewish business were concerned. The point of contact with the Exchequer was that, all Jews and their property being at the absolute disposal of the Crown, no case arising from their business was without a potential interest for the royal financial administration. Parallel to this was the organization of a department of pleas which, while it had nothing to do with financial business covered by the ordinary machinery of the memoranda roll, and nothing with normal "pleas of the crown," relieved pressure by taking cognizance of the increasing bulk of disputes arising out of the conduct of the royal accounting together with all cases affecting Exchequer officials. The *Scaccarium Judaeorum* ended with the expulsion of the Jews in 1290, but the Exchequer of Pleas, though it continued to be staffed by Exchequer officials, became a court of civil pleas like any other and was ended only by the Supreme Court of Judicature Act of 1873.

Other Modifications in Exchequer Machinery.—To return to the 13th century—the increasing length and variety of accounts led to various other efforts at reform besides those already mentioned. Even before Henry II.'s death, two problems had become apparent: the great roll had to be cleared of "desperate," or bad, debts in the twenty-eighth and thirty-third years, and the rapidly increasing number of amercements in the various courts was clogging the whole machinery. The 13th century saw a strenuous effort to meet the new conditions: its stages are marked by the reforms of 1236–42 (no statute), and the statutes of 1270 and of Rhuddlan in 1284; its termination by the codification of Exchequer practice (already well established in many respects) in the Stapledon Ordinances, 1323–26. By 1242 the farms of the counties and boroughs had been re-valued and the demesne lands removed from them and let to farm for a term of years; the estreats were no longer entered on the great roll in detail, the sheriff being charged on each estreat roll and only actual payments recorded on the great roll itself; while a new form of tally allowed the sheriff to pay large totals into the Exchequer in his own name instead of having to get a tally for every small debt. This simplified work at the Exchequer enormously: the machinery had stretched. The statute of 1270 codified the new procedure with regard to estreats; that of 1284 dealt with farms of counties, the new form of tally and, after earlier experiments, established a special "exannual roll" in which desperate debts were recorded, in order that the sheriff might be reminded yearly without their overloading the pipe roll.

But these were not the only changes in the 13th century. Thus, we note the appearance of a new system of anticipating revenue, sheriffs being frequently ordered to pay out locally the greater part of their receipts; and the "assignment" of tallies for moneys not yet paid in became common and was a feature of Exchequer procedure throughout its subsequent history. Again, under Henry III. and his son a large accession of financial business arose from the "foreign accounts," that is to say, the accounts of national services which, naturally, were not included among those of the counties and which under Henry II. had not formed part of Exchequer business; for in his reign such expenses as appeared on the pipe roll were paid by sheriffs or by bailiffs of "honours," and the spending departments frequently drew their supplies

only indirectly from the Exchequer, though in the course of the following (13th) century the Exchequer gradually acquired partial control of these national accounts. Finally we have to record the appearance before 1242 of "escheators," and from then onwards the accounts of these and of the officials of the customs, subsidies and wardrobe also occupy an increasingly important position in the national revenue. During the reign of Edward I., the wardrobe account became unmanageable, since it not only financed the household, army, navy and diplomatic service, but received money direct from accountants without its passing through the Exchequer. (*See* WARDROBE.)

Enough has been said to show that the 13th century was a period of rapid growth in many directions, and the reform of 1323–26, referred to above, codified and rounded off those already in existence. It greatly increased the number of "foreign accounts" by making the great wardrobe (the storing department), the butler, purveyors, keepers of horses and clerk of the "hanaper" of the chancery (who took the fees for the great seal) and the various ambassadors, directly accountable to the Exchequer. At the same time the sheriffs' accounts were expedited by further simplification of the great roll, and by the appointment of a special "foreign apposer" to take the account of the "green wax," or estreats, so that two sides of the sheriff's account could be dealt with simultaneously. An extra baron was also appointed to cope with the increase of business but this was only a temporary expedient and the fifth, or cursitor baron, does not appear as a permanent official until James I.'s reign. The whole business of foreign accounts was transferred to a separate building where one baron and certain auditors spent their whole time in settling the balances due on the accounts already mentioned, as well as those of royal lands not let to farm, of Wales, Gascony and Ireland, of aids (clerical and lay), of temporalities of vacant bishoprics, abbeys, priories and dignities, of silver and tin mines, of ulnage and so forth. The balances on these were accounted for in the Exchequer itself, and arrears still entered on the pipe roll, but the preliminary accounts were filed by the king's remembrancer, and the actual accounts enrolled separately by the treasurer's remembrancer on the "roll of foreign accounts," a supplement to the pipe roll.

Reform in the rest of the 14th century apparently worked along the lines laid down in 1323–26, with the addition of some attempts about 1360 to draw up something like a balance sheet of revenue and expenditure—a notion foreign, in general, to mediaeval accounting methods.

End of the Mediaeval Period.—The next important change came at the end of the 15th century, following a period during which assignment and other expedients for patching up the royal finances ran wild and the issue roll ceased to exist. It was inaugurated by Henry VII., who introduced summary methods of audit in certain connections, while carefully and personally supervising receipt and expenditure. In the next reign the dissolution of the monasteries led to the setting up of independent financial bodies —the Courts of Augmentations and of First Fruits—with wide powers and with new methods: and although these, in 1554, became departments of the Exchequer, a new act set up in 1560, in addition to the exchequer auditors, two new and independent "auditors of the prests" (predecessors of the commissioners for auditing public accounts, who were set up in 1785), to take certain specified accounts, such as those of clerks of the works, the treasurer of ships and the master of the ordnance, the clerks of the hanaper and of the great wardrobe and (later) the customs. These new authorities followed improved methods of auditing, though it was only by degrees that the various stages of "declaring" an account were worked out and the final stage of development was not reached until the treasurership of Juxon (1636–41). By the end of the 17th century a system had been evolved of "declaring" at the Treasury accounts presented in triplicate, one (on paper) being returned to the office of the auditors, while of the other two (on parchment) one went to the accountant and one was passed for enrolment through the offices of the two remembrancers to that of the clerk of the pipe, in order to secure the levying of any "remanets" or "supers" by process of the Exchequer.

Modern Developments.—It will be observed that by this device the connection with the old Exchequer machinery was maintained, though in effect the control over public accounting, asserted with so much trouble in the 13th and 14th centuries, passed from it to the Audit Office. Similarly when, in the 17th century, the other great step towards modern methods was accomplished by the putting of the office of treasurer into commission, the old machinery of the lower Exchequer, with its tallies, receipt rolls and a multitude of added apparatus, continued to function under the direction of the new body. This survival of the old machinery continued for 150 years and there were even additions of new administrations to which the name of Exchequer attached; there was, for instance, an Exchequer court of equity, established in the reign of Elizabeth, whose registrar was the king's remembrancer; and in the same reign there was added to the Exchequer's departments one for the audit of land revenue. It was not until the 19th century that a series of acts swept away one by one all these departments leaving only the name of the Exchequer and those of one or two of its officials as relics of the past.

Of these acts the most important from our point of view was that of 3 and 4 William IV. cap. 99; this by removing the sheriffs' accounts from its competence ended the series of pipe rolls and in effect destroyed the last vestige of that *Scaccarium* with which the tale began. (H. JE.; M. H. M.)

FROM THE ACT OF 1834

The Exchequer Act, 1834, swept away the cumbrous mediaeval procedure and the expensive sinecures that had survived at the exchequer till then. A simplified system of accounting was adopted; the great triple-locked chests in which the public money had been put away became unnecessary when accounts were opened at the Banks of England and Ireland for the Consolidated Fund; and for the work which remained to be done a single comptroller of the exchequer with a small clerical staff sufficed, the comptroller's duty being to see that sums were issued from the Consolidated Fund only to the amounts and for the purposes authorized by parliament.

For a long time the greater part of the issues from the exchequer had been made not by way of final payment to the people entitled to public money, but by way of advances to the paymasters of the departments concerned (the paymaster general of the Forces, the treasurer of the Navy and others), though a few payments (chiefly salaries and pensions) had continued to be made direct from the exchequer. After 1834 these direct payments ceased, and *all* issues from the Consolidated Fund were made to the paymasters and similar intermediaries. In 1836 the paymaster general of the Forces, the treasurer of the Navy and the treasurer of the Ordnance were amalgamated into one post, and in 1848 this post was combined with the paymaster of civil services into a single paymaster general for all voted services. Since then departments have drawn upon the paymaster general for their expenditure as if he were their banker; the drafts are often for advances to officers (sub-accountants) who are responsible for making the actual payments.

Exchequer and Audit Department, 1866.—The business of authorizing issues from the exchequer in conformity with parliamentary authority, whatever its constitutional importance, did not make work for a separate department. As a result of the recommendations of the Select Committee on Public Moneys (1856–57), while the functions of the exchequer were maintained substantially as under the act of 1834, the department was amalgamated with the audit department by the Exchequer and Audit Departments Act, 1866. In the constitutional system the same kind of independence was required of the comptroller of the exchequer as of the head of the audit office, who had to conduct the appropriation audit and discover *ex post facto* whether the expenditure of public departments had been in conformity with the terms of the parliamentary votes placed at their disposal.

At the head of the new Exchequer and Audit Department was placed a Comptroller General of H.M.'s Exchequer and Auditor

General of the Public Accounts. He is appointed by, but is not a servant of the Government; he is a statutory officer with responsibilities primarily to parliament, but also, in respect of some of his functions as auditor, to the Government.

The Consolidated Fund.—All the revenue and the proceeds of loans and other public receipts (with certain very restricted exceptions) have to be paid to the Consolidated Fund (originally created by an Act of 1787). Consequently all the expenses of Government have to be met from that fund, which is in the hands of the exchequer; whence balances to its credit at the Banks of England and Ireland (formerly at the Head Office in Dublin, now at the Belfast Branch) are commonly called the exchequer balances. Issues cannot be made from the exchequer account at the Bank of England without the consent of the comptroller and auditor general, and that consent he gives only by authority of parliament. Parliament is thus in a position to stop the machinery of Government by refusing supplies, and can thereby enforce its will on the Government. But for the intervention of an independent officer, the Government might go on spending in defiance of a parliamentary refusal of supplies, leaving the illegality to be reported long after on completion of the audit.

In order to safeguard certain services from the hazards of a political vote, permanent statutory authority is given for the exchequer issues required for them. These, known as Consolidated Fund services, include the national debt charges (interest, maturities and sinking fund), the king's civil list, the salaries and pensions of the judges, and some other items. The issues for the internal debt are the more effectually safeguarded in that they are made direct to the Bank of England (or of Ireland) without passing through the hands of the executive Government at all.

"Ways and Means" and "Supply."—The rest of the expenditure is provided for by annual votes. When parliament votes and appropriates money, it is really attaching conditions to the issue of money from the exchequer. In parliamentary procedure the two processes, the authorization of issues and the appropriation of the sums to be issued, are kept distinct. The former is initiated in Committee of Ways and Means, and the latter in Committee of Supply. The resolutions in Committee of Ways and Means have in themselves no operative effect. The comptroller and auditor general will only allow issues from the exchequer on the authority of an act of parliament. An act (called the Consolidated Fund Act) is always passed before the 1st April (when the new financial year begins) authorizing the issue of a sum equal to the vote on account and any other vote previously passed in Committee of Supply. The credit or power given by act of parliament to the Government to draw money from the exchequer is commonly called "Ways and Means."

Appropriation Act.—It is a constitutional convention that the issue of money from the exchequer is never authorized by this procedure without the purposes to which it is applicable being prescribed by parliamentary votes. The votes are regarded as operative even when they are no more than resolutions reported from Committee of Supply. But that is only so up to the end of the session, and therefore before the prorogation by which the session is ended there must be an act (the Appropriation Act) giving statutory authority for all the votes in supply. The Appropriation Act grants Ways and Means exactly sufficient, with those authorized by the Consolidated Fund Act (or Acts, for there are sometimes several), to meet the expenditure authorized by all the votes in supply of the session, and it then proceeds to direct the appropriation of the issues from the exchequer in accordance with the votes (set out at length in schedules). It is the regular custom always to grant Ways and Means equal to the supplies voted. But there is no constitutional reason why the Ways and Means should not be less.

The Treasury (fortified with a "royal order" under the king's sign manual) applies to the exchequer for issues of money as and when required, and, in applying, specifies the particular vote or Consolidated Fund service for which each sum is destined. But this is a mere expression of intention; the treasury is not bound actually to spend those particular sums in the manner indicated. They are merely *advances* to the paymaster general. The Government must conform strictly to parliamentary authority, as expressed in the acts charging the Consolidated Fund and in the votes in Supply, but only in its expenditure *as a whole*, and this conformity is enforced by the comptroller and auditor general not through his control of exchequer issues but through his subsequent audit. In complying with an application for issues from the exchequer, he is concerned only to know that statutory authority exists for the *total amount* of the issues applied for.

Parliamentary "Doles."—Parliament may be regarded as doling out money to the Government by means of the Consolidated Fund Acts and the Appropriation Act, each successive instalment giving the Government so many months of life. The responsibility of the Government to parliament is so well recognized that the very purpose of exchequer control, as the constitutional sanction of parliamentary government, is apt to be forgotten or overlooked. Occasionally a Government (like the Liberal Government engaged in 1910 in a conflict with the House of Lords) may deliberately ask for Ways and Means in small instalments in order that the House of Commons may keep a hold over a possible alternative Government, but this is rare.

Apart from its constitutional purpose exchequer control provides incidentally a very convenient index of the state of the public finances. As all receipts from revenue and loans are paid into the exchequer, and the money for public expenditure is issued out, the exchequer receipts and issues at any stage of the financial year show substantially the financial position up to date. Since the practice is to indicate the sources of the receipts under the principal heads of revenue (customs, excise, death duties, stamps, income tax, supertax, etc.) and the application of the issues to the several Consolidated Fund services and votes, it is possible to compile a detailed account showing the progress of each head of revenue and expenditure. But this account would differ from a true account of revenue and expenditure on account of variations in the balances held on the one hand by the revenue departments and awaiting payment into the exchequer, and on the other hand by the paymaster general and the sub-accountants of all the public departments and awaiting expenditure.

The Annual Balance.—For the purpose of calculating the surplus or deficit for the year, revenue and expenditure are calculated on the basis of exchequer receipts and exchequer issues. The justification for this convenient practice (which makes the surplus or deficit finally ascertainable on the very day the financial year ends) is that balances are invariably kept down as low as is practicable. In fact a change in balances when it occurs may be regarded as a real financial requirement of the public service on the same footing as actual expenditure, and it is quite right to budget for such a change. To show the amount of the surplus or deficit, the receipts and issues on capital account (such as the raising and repayment of loans, and expenditure chargeable by special acts to loans) are shown separately from those items which properly belong to the revenue and expenditure of the year. The new sinking fund (1923) is included in the expenditure, and since 1920 any further net sum applied from revenue to the reduction of debt has been similarly treated. Formerly a surplus used to be applied to the redemption of debt *after* the financial year in which it was realized, and this was not included in expenditure.

On any voted service the Government cannot spend more than parliament has allowed and may spend less, and any foreseen excess is covered by supplementary votes, accompanied by grants of the corresponding Ways and Means. On the votes as a whole there are invariably savings, the total of which is substantial. Therefore a part of the Ways and Means is not needed, and in the absence of parliamentary appropriation cannot be put to any legitimate use. The practice is to "surrender" these balances to the exchequer. Where possible this is done by a process called "write-off." The exchequer is deemed to issue a sum equal to the balance to be surrendered, and at the same time the paymaster general is deemed to have paid an equal sum from the vote to the exchequer. The settlement is effected by book entries without any actual payment. The result is that the exchequer issues approximate to the true expenditure from votes.

The issues for the purposes of any vote on which the savings in the year are substantial are kept down approximately to the amount actually needed ("short issue"), but where the savings are small the whole amount voted is usually issued. The surrender of balances by write-off can only be completed in the following financial year when the audit has disclosed the exact amount of the savings.

The discrepancy between the account of revenue and expenditure derived from the exchequer receipts and issues, and the true account disclosed by the ultimate audit, while by no means negligible, is not ordinarily large. But during the World War and for some years afterwards the inclusion of huge commercial accounts in the financial system resulted in exaggerated differences. The following comparison shows the position for a series of years (in £ millions):

	1921–2	1922–3	1923–4	1924–5	1925–6
Exchequer Receipts	1124·9	914·0	837·1	799·4	812·1
Exchequer Issues	1079·2	812·5	788·8	795·8	826·1
Surplus (+) or Deficit (−)	+45·7	+101·5	+ 48·3	+ 3·6	− 14·0
Revenue Net Receipts	1119·8	911·2	838·3	804·9	811·2
Audited Expenditure	1053·2	822·0	799·9	798·9	828·7
Surplus (+) or Deficit (−)	+66·6	+ 89·2	+ 38·4	+ 6·0	− 17·5

(R. G. H.)

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EXCHEQUER BILLS. The exchequer bill was the credit instrument in which the principal part of the floating debt of the British Government used to be embodied, till its place was taken by the modern treasury bill in 1877.

The exchequer bill was an obligation of the exchequer issued by direction of the Treasury. It was a negotiable instrument transferable by endorsement. It was sometimes for three months, sometimes for one year, sometimes for several years. Its special characteristics were (1) that the holder could use it during its currency (or during a specified part of its currency) in payment of taxes or other sums due to the exchequer, (2) that interest accrued on it from day to day at rates notified by the Treasury from time to time in the *London Gazette*. Sometimes holders were entitled to demand cash for the bills; for example, the holder of a five-year bill might have the option of demanding payment in cash at intervals of 12 months. The original exchequer bills of 1696 were payable at any time on demand, like bank notes.

The right to hand in bills in payment of taxes was in practice equivalent to a right to demand payment in cash. In order to prevent bills from being presented to an inconvenient extent, the Treasury relied on its power over the rate of interest. If the bills were quoted in the market at a discount, that meant that it was profitable to the holders to present them (or to sell them to taxpayers to be presented). The Treasury would then raise the rate of interest high enough to induce holders to keep them.

Exchequer bills were first issued in 1696, when Charles Montagu was chancellor of the exchequer. In the course of the 18th and 19th centuries they came to be issued under various authorities: (1) Supply bills were authorized as part of the permanent national debt, and were regularly renewed as they fell due. (2) Deficiency bills were issued whenever money was needed to make up the charge on the consolidated fund at the end of a quarter (including the interest on the funded debt), and had to be repaid in the ensuing quarter. (3) Bills were issued in anticipation of certain taxes (especially the malt and sugar duties and land tax). (4) From 1829 onwards the practice was adopted of authorizing temporary borrowing on exchequer bills in the Consolidated Fund Acts and the Annual Appropriation Act. These were known as ways and means bills, and took the place of the bills in anticipation of taxes, which were not resorted to after 1831. (5) Exchequer bills were issued to raise money to be lent from the exchequer to local authorities and others for the construction of public works. This system has been replaced by the local loans fund, financed by issues of local loans stock. *See* National Debt.

EXCHEQUER BOND: *see* National Debt.

EXCISE, a word derived through the Dutch *excijs* or *accijs*, from late Latin *accensare*—to tax (cf. *census*), meaning in British law any branch of the revenue placed by statute under the aegis of the commissioners of excise. In modern times, however, the term generally connotes a tax on articles of home manufacture in contradistinction to customs duties, which are levied on certain articles imported. Under the Tudors the sources of English revenue had been the anxious concern of the sovereign: the basis of taxation had remained unaltered for some three hundred years. Intercourse with Holland during the reigns of Elizabeth and James I. had familiarized statesmen and others with the system of excise duties in operation in the Low Countries and as early as 1626 an abortive proposal was made for their introduction into Great Britain. On the outbreak of the Civil War parliamentary need of money became acute and owing to the system of farming the tonnage and poundage for long terms it was impracticable to amend or add to those duties. The excise system, however, managed as it was by a board of commissioners, afforded a system of taxation which could be extended almost indefinitely at the shortest notice. Accordingly a parliamentary ordinance was enacted (July 26, 1643) imposing excise duties on a great variety of articles. The system was admittedly tentative and a succession of ordinances issued from parliament modifying the various taxes from time to time. It is to be noted that the early ordinances imposed excise duties on many foreign articles. Charles I. was not long in following the example of parliament and in the counties which remained loyal excise was collected on his behalf. Throughout the commonwealth the excise duties were regarded as temporary, but at the restoration the revenue of the country came under review, and as for some years past the old feudal revenues had fallen into desuetude it was necessary to find a permanent substitute. This the growing revenue of the excise provided. Half the excise revenue was definitely allotted to Charles and his heirs for their personal revenue, and half, termed the "temporary" excise, was voted him for life, and after the revolution went to form part of the ordinary revenue of the country. This arrangement continued until 1787 when, on the formation of the "consolidated fund," the whole of the excise was transferred to the State (27 Geo. III., cap. 13).

At its inception the excise revenue was placed under commissioners but for some time it was farmed out for short periods on the old system. With the restoration, farming was gradually abolished, though in some of the more distant counties the excise farm continued for some considerable time. Farming the revenue

was open to the objection, among others, that it was inelastic, it being difficult to vary the various duties during the continuance of the farm. At the same time, the restoration placed Charles in a difficult position with regard to the thousands of claims on his bounty made by adherents of the Stuart cause. The customs and excise services formed a very useful and welcome field for paying off these debts, as the hundreds of offices, small and great, were all available and were filled by patent or by direct Treasury nomination. At the revolution, William availed himself of the same facilities and by the end of his reign farming the excise had practically disappeared from the English fiscal system.

In Scotland, excise dates from Jan. 1644, when the first act was passed by the Edinburgh parliament. For many years it was collected with great difficulty, particularly in the Highlands, and farming was the rule. At the union, however, the English system was adopted, though both Scotland and Ireland retained their separate boards of commissioners. The United Kingdom excise was consolidated under one management in 1823 (4 Geo. IV., cap. 23).

Walpole and Pitt.—Walpole's famous excise bill of 1733 was introduced with a view to checking the frauds in the customs revenue from tobacco, and it included a system of bonding. Owing, however, to opposition raised throughout the country by Walpole's enemies, the bill had to be abandoned and the system of bonded warehouses received a set-back for 70 years. Pitt introduced many changes, giving the excise the collection of the wine and tobacco duties, while all through the 18th century the excise service was responsible for duties on many foreign articles, which necessitated the employment of revenue cutters, riding officers and other officials, and duplicated to a very large extent the establishment of the customs service.

With the coming of the 19th century "excise" gradually became associated with duties on articles of home manufacture, together with the revenue derived from licences to manufacture or deal in those articles, and also sundry other licences conferring certain classes of privileges. Up to the middle of the 19th century, and more particularly as a result of the Parnell commission of excise enquiry (1833–39), numerous articles were withdrawn from the tariff and by the end of the century the major part of the excise revenue was derived from spirits and beer. The Entertainments Duty was first levied in 1916, and the Betting Tax ten years later.

In the early 'eighties the warehousing systems of the customs and excise services were assimilated (44/5 Vic. cap. 12), and in 1889 a proposal was mooted for amalgamating the two departments. The scheme was shelved for the time being, mainly owing to the fact that the inland revenue board included the old board of stamps and taxes as well as excise, which had been amalgamated in 1849. In 1909, however, the excise was amalgamated with the customs under the board of customs and excise.

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EXCITATION (*see* CHRONAXIE). Excitation is sometimes used in physics to describe the process of electrification (*see* ELECTRICITY) and also the production of X-rays. (*See* X-RAYS, NATURE OF.) The term is used in physiology in connection with stimulation of muscle and nerve fibre.

EXCOMMUNICATION means the judicial exclusion of offenders from the rights and privileges of the religious community to whom they belong (Lat. *ex*, out of, away from; *communis*, common). The history of the practice may be traced through (1) pagan analogues, (2) Hebrew custom, (3) primitive Christian practice, (4) mediaeval usage, (5) modern survivals in Christian churches.

Pagan Analogues.—Among these are the Gr. χερνίβων εἴργεσθαι (Demosth. 505, 14). The exclusion from purification with holy water of an offender whose hands were defiled with bloodshed. (Aesch. *Choeph.* 283, *Eum.* 625 *seq.* Soph. *Oed. Tyr.* 236 *seq.*) The Roman *Exsecratio* and *diris devotio* was a religious curse calling down divine wrath upon enemies. The Druids claimed the right of excluding offenders from sacrifice (Caes. *B.G.* vi. 13). Primitive Semitic customs recognize that a ban or taboo (*herem*) restricts contact with the banned person. Impious persons might be devoted to utter destruction.

Hebrew Custom.—In a theocracy excommunication is both a civil and a religious penalty. In the N. Test. the word ἀνάθεμα is the Septuagint rendering of the Hebrew *herem* (1 Cor. xvi. 22, Gal. i. 8–9, Rom. ix. 3). The word means "set apart" (*cf.* ḥarem), and does not distinguish between things devoted to God and things devoted to destruction. Lev. xxvii. 16–34 defines the law for dealing with "devoted" things. "None devoted shall be ransomed, he shall surely be put to death." Whole cities or nations might be devoted to destruction by pronouncement of a ban (Num. xxi. 2.3, Deut. ii. 34, iii. 6, vii. 2). Israelites may fall under the curse (Judges xxi. 5.11). A milder penalty was temporary separation (*niddah*), prescribed for ceremonial uncleanness. This was the ordinary form of religious discipline. Both major and minor forms are recognized by the Talmud. The lesser (*niddah*) involved exclusion from the synagogue for 30 days, and other penalties, and might be renewed. The major excommunication (*herem*) excluded from the Temple and from all association with the faithful. Spinoza was excommunicated (July 16, 1656) for contempt of the law (Selden, *De jure nat. et gen.* iv. 7). *See* also the *Exemplar Humanae Vitae* of Uriel d'Acosta. The practice of the Jewish courts in N. Test. times may be inferred from Luke vi. 22, John ix. 22, xii. 42 where exclusion from the synagogue is a recognized penalty, probably inflicted on those who confessed Jesus as the Christ. John xvi. 2 ("Whosoever killeth you") seems to point to the major penalty. The Talmud says that the judgment of capital cases was taken from Israel 40 years before the destruction of the Temple, where "40" is probably a round number.

Primitive Christian Practice.—The use of excommunication as a form of Christian discipline is based on the teaching of Jesus and on apostolic practice. Matt. xviii. 15–17 prescribed a threefold admonition, first privately, then in the presence of witnesses (*cf.* Titus iii. 10), then before the Church. The tone of the passage when compared with the disciplinary methods of the synagogue indicates that it was intended to introduce elements of reason and moral suasion in place of sterner methods. Its aim is the protection of the Church rather than the punishment of the sinner. In the *locus classicus* on this subject (1 Cor. v. 5) Paul refers to a formal meeting of the Corinthian church at which the incestuous person is "delivered unto Satan for the destruction of the flesh that the spirit may be saved in the day of the Lord Jesus." These mysterious words imply: (1) a formal ecclesiastical censure, (2) a physical penalty, (3) the hope of a spiritual result. There is a reference in 2 Cor. ii. 6–11 to a case of discipline which may or may not be the same. 1 Tim. i. 20 refers to the excommunication of Hymenaeus and Alexander. 1 Cor. xvi. 22, Gal. i. 8, 9, Rom. ix. 3 refer to the practice of regarding a person as anathema. These passages seem to point to exclusion from church fellowship rather than a final cutting off from the hope of salvation. In the pastoral letters there is already a formal and recognized method of procedure. 1 Tim. v. 19, 20 requires two or three witnesses in the case of an accusation against an elder and a public reproof. Tit. iii. 20 recognizes a factious spirit as a reason for excommunication after two admonitions (*cf.* Tim. vi. and 2 John v. 10). In 3 John v. 9–10 Diotrephes appears to have secured an excommunication by the action of a party in the Church. It is clear that within the N. Test. there is development from spontaneous towards strictly regulated methods, and that excommunication is for protective rather than punitive purposes.

Mediaeval Usage.—The writings of the Fathers supply evidence that two degrees of excommunication, the ἀφορισμός and the ἀφορισμὸς παντελής were in use soon after the apostolic age. The former involved exclusion from the eucharist and from the eucharistic service, though not from the "service of the catechumens" and was the usual punishment for light offences; the latter involved "exclusion from all church privileges" (Bingham *Antiquities*, xvi. 2, 16). From some sins, such as adultery, the sentence of excommunication was in the 2nd century regarded as παντελής in the sense of being irrevocable. The important controversy associated with the names of Zephyrinus. Tertullian.

Calistus, Hippolytus, Cyprian and Novatian turned on whether such sins as theft, fraud, denial of the faith were "irremissible." The stricter party held that there should be no restoration to church fellowship even in the hour of death.

EMPLOYMENT OF EXCOMMUNICATION

A new chapter in the history of Church censure began with the imperial edicts against heresy, the first of which, *de summa trinitate et fide catholica,* dates from 380. From that time excommunication exposed a man to serious temporal risks. The temptation to wield it as an instrument of secular tyranny proved irresistible. During the next thousand years the developments of the practice are perversions of the New Testament standards. The magistrate becomes the excommunicating official (Synesius A.D. 410; *see* Bingham, *Antiq.*). Gregory the Great rebukes a bishop for using excommunication for private ends (*Epist.* ii. 34). The penalty became common and was dreaded for superstitious reasons (Haddan and Stubbs, *Councils and Documents* iii. 1737). Morinus, *De poenit* x. c.q., refers to excommunicating the dead. Pope Gregory V. (998) excommunicated France, Gregory VII. (1102) excommunicated Germany, Innocent III. (1208) excommunicated England, and Adrian IV. (1155) Rome itself. Recklessness was characteristic of the language used (*cf.* Burton, *History of Scotland,* vol. iii. 317 *seq.,* and also the often quoted curse of Arnulphus of Rochester). An instance of excommunication by "bell, book and candle" occurs about 1190.

Modern Survivals in Christian Churches.—At the Reformation the development of discipline took various lines. In the Anglican Church the bishops (subject to appeal to the sovereign) have the right of excommunicating, and their sentence, if sustained, may carry civil consequences. This right is never exercised. Legally sentence of excommunication, if properly certified by the bishop, is followed by the writ *de excommunicato capiendo* for the arrest of the offender. The statute 5 Eliz. c. 23 provided for the better execution of this writ. 53 George III. greatly limited the magisterial powers.

In the Churches which consciously reshaped their policy at the Reformation the principle of excommunication is preserved in the practice of Church discipline. Calvin devoted a chapter in the *Institutes* (bk. iv. cap. xii.) to the "Discipline of the church: its principal use in Censure and Excommunication." The ends of discipline are stated to be (1) that those who lead scandalous lives may not, to the dishonour of God, be numbered among Christians, seeing that the Church is the body of Christ; (2) that the good may not be corrupted by constant association with the wicked; (3) that those who are censured or excommunicated may be led to repentance. He differentiates decisively between excommunication and anathema. Anathema devotes the offending person to eternal perdition; whereas excommunication censures and punishes his conduct. Yet by warning him of his future condemnation it recalls him to salvation (*Inst.* bk. iv. chap. xii. 10). The Reformed Churches in England and America accepted the distinction between public and private offences. The usual provision is that private offences are to be dealt with according to the rule in Matt. v. 23–24, xvii. 15–17. Public offences are to be dealt with according to the rule in 1 Cor. v. 3–5.13. The public expulsion or suspension of the offender is necessary for the good repute of the Church, and its influence over the faithful members. The expelled member may be readmitted on showing the fruits of repentance.

A recent statement of Scottish (Presbyterian) practice, drawn up for parliamentary purposes in 1927, is as follows: The censures of the Church are admonition, rebuke, suspension, deposition from office and excommunication, and they are administered only on confession or proof of sin or offence. Private admonition, which is not a censure, may in certain cases meet the ends of discipline.

The question whether the power of excommunication rests in the church or in the clergy has been important in the history of English and American Reformed Churches. The general tendency has been to make it a matter for the church or congregation rather than the clergy (*see* Hooker, *Survey,* pt. 3, pp. 33–46). Hooker expressly denies the power of Synods to excommunicate, "that there should be Synods which have *potestatem juridicam* is nowhere proved in Scripture because it is not a truth" (*Survey,* bk. iv. pp. 48–49).

The Confession of faith issued in 1596 by the London-Amsterdam church, one of the original Pilgrim Fathers' churches declares that the Christian congregation having power to elect its minister has also power to excommunicate him if the case so require (Walker, *Creeds and Platforms of Congregationalism,* p. 66). In 1603 the document known as "Points of Difference" (*i.e.,* from Anglicanism) submitted to James I. sets forth "that all particular churches ought to be so constituted as having their owne peculiar officers, the whole body of every church may meet together in one place, and jointly performe their duties to God and one towards another. And that the censures of admonition and excommunication be in due manner executed for sinne, convicted, and obstinately stood in. This power also to be in the body of the church whereof the partyes so offending and persisting are members." The *Cambridge Platform* of 1648 follows in the main the line of Hooker and Calvin but expressly excepts civil rights from the operation of the sentences. The excommunicant may still "hear the word"; he is admonished as a brother, not accounted as an enemy. The Savoy Declaration of 1658 defines the theory and practice of the older English Nonconformist churches in the section on the "Institution of Churches and the order appointed in them by Jesus Christ" (xix).

In contemporary English Free Churches purity of fellowship in church is commonly secured by the removal of persons unsuitable for membership from the church books by a vote of the responsible authority. (D. M.)

EXCRETION is the elimination from the body of the waste products which would otherwise accumulate within it, and, in the case of many of these substances, would poison it. These substances come from many sources. Some are formed in the process of digestion, and are absorbed from the alimentary canal into the blood, changed to some extent by the liver but never built into the tissue. Other waste products are produced by the breakdown of body tissue, muscle, nervous tissue, glandular tissue, blood pigments and the like. To this latter class of waste products the term *endogenous* has been applied, to the former the term *exogenous.*

Paths of Excretion.—The principal paths of excretion are (1) the skin; (2) the lungs; (3) the bowel; (4) the kidneys.

1. **The Skin.**—The skin was probably the most primitive form of excretory organ. In forms of life which have no blood system, waste material is shed from the skin or from cells derived from it. In man there are two fluids excreted by the skin, namely, sweat (or perspiration) and sebum—the oily excrement of the glands attached to the hair roots.

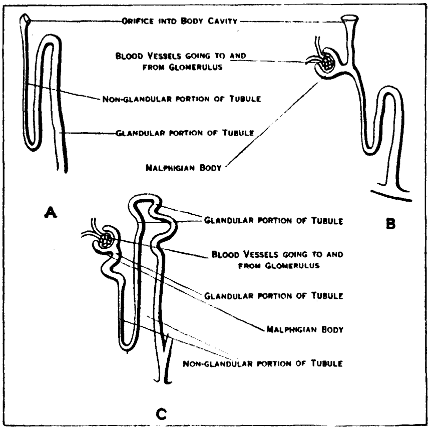
Sweat is credited with being composed of about 99% water, ·5% sodium chloride and traces of organic material of which urea is the principal. About 700 cu.cm. of water leave the skin per day in ordinary weather. Some of this is insensible evaporation from the surface of the cells rather than definite sweat secreted by the sweat glands. But taking it all as sweat—not more than 3·5 grams of urea per day (and probably much less) could be accounted for as cutaneous secretion—about one tenth of the amount secreted by the kidneys.

Nevertheless this potentiality of the skin to serve as an excretory organ can be turned to account in cases of kidney disease in order to relieve the kidney. Thus residence in Egypt or some place of similar climate attains this end.

The secretion of sweat, apparently unlike that of urine, is under the direct ordering of the central nervous system (*see* SYMPATHETIC SYSTEM). Many foreign substances such as guanine, iodine, arsenic, mercury and certain organic acids are capable of being excreted from the body in the sweat. The main function of the perspiration is however concerned with the regulation of temperature (*see* ANIMAL HEAT).

2. **The Lungs.**—Next to carbonic acid, water is the most important substance secreted by the lungs. The amount of water lost to the body through the respiratory system depends simply

on the amount of air passed into and out of the respiratory passage. Each litre of air inhaled, in ordinary temperate climates acquires about 50 milligrams of water. Something in the region of 500 cc. of water per day leaves the body in the breath if respiration is quiet. When active exercise is taken the amount of water evaporated in the lung rises *pari passu* with the total ventilation and it is possible that in a contest such as the University Boat-race



SCHEMATIC DIAGRAM OF (A) NEPHRIDIAS TUBULE OF EARTH-WORM, (B) TUBULE OF EMBRYONIC DOG-FISH, (C) TUBULE OF HUMAN KIDNEY

lasting about 20 minutes, 50 grams of water might be evacuated in the breath of each oarsman. Any easily vapourizable substance which may be present in the blood, is liable to be eliminated to some extent through the lungs, such as ether or chloroform; alcohol if drunk or acetone if produced as the result of abnormal metabolic processes as in diabetes. Hydrogen sulphide gas, if introduced into the intestine is exhaled in a short time in the breath.

3. **The Bowel.**—The stools contain such residue of the food as has escaped digestion, but to this are added other substances which give the matter eliminated from the bowel more definitely the character of a *bona fide* excretion.

The liver pours bile into the intestine, this fluid containing among its constituents bile salts, bile pigments, lecithin and cholestrin. Bile-pigments (bilirubin and biliverdin) represent the breakdown of the haemoglobin of the blood. They consist substantially of the haemoglobin minus the globin and the iron. Factors which increase the breakdown of blood will therefore increase the quantity of bile pigment eliminated. In the intestine, these pigments undergo reduction so that the actual yellowish colour of the faeces is due to the reduced product stercobilin. If the normal path of excretion of bile pigment be interfered with bilirubin becomes deposited in the skin, the condition being that of jaundice.

Certain metals, iron and possibly calcium appear to be excreted through the bowel and of course in abnormal cases water in large quantities may be so excreted.

Much of the solid portion of the faecal matter consists not of the residues of food but of actual material produced in the bowel—the dead bodies of bacteria, the residue of cells which have been shed by the mucosa and so forth. This fact perhaps accounts for the large amount of purine bodies found in the faeces as compared with the urine.

4. **The Kidneys.**—By far the most important organs of excretion are the kidneys and on them principally falls the burden of preserving the constancy of composition of the blood. They are always secreting, though not always at the same rate. The fluid secreted is driven down the ureters to the bladder in which it accumulates until such time as micturation takes place. The composition of urine naturally varies greatly from time to time, because the object of the kidney is *not* to produce so much urine of such and such a composition per day, but to leave the blood at the end of the day in the same condition as that in which it found it twenty-four hours previously.

Taking, however, the example of a person not engaged in active employment and on a standard diet—such for instance as an accident case in hospital—the composition of the urine secreted in 24 hours would be somewhat as follows:

TABLE I. *Composition of 24 Hours' Secretion of Urine*

Water	1,500 cu. cm.		Chlorine	10	grams
Solids	60	grams	Phosphoric acid	2·5	,,
Urea	33	,,	Sulphuric acid	2·5	,,
Uric acid	0·75	,,	Sodium	5	,,
Creatinine	1·0	,,	Potassium }		
Hippuric acid	0·5	,,	Calcium }	4	,,
Ammonia	0·75	,,	Magnesium }		

In examining the particulars given it will be observed that the kidney does not merely abstract certain substances such as urea, which are present only in small quantities in the blood, but it refrains from abstracting other substances such as protein and sugar which though present in considerable quantities in the blood are absent or nearly so from normal urine.

Of the materials enumerated in table 1 two only are known to be produced in the kidney itself, hippuric acid and ammonia salts. The other nitrogenous bodies are brought to the kidney in the blood.

Urea is by far the most important nitrogenous constituent of normal urine. It is made in the liver from amino bodies or ammonium salts and represents the final breakdown of protein, whether of the food or of the tissues. Normally more than half the urea is formed directly from the breakdown of proteins in food. In birds there is little urea, the principal nitrogenous excrement being uric acid. This gives the avian droppings their white solid nature.

Uric acid in mammals represents only the waste products of the nuclei of cells.

Creatinine is probably the constituent in the daily output which is most constant in amount, being 1–2 grams per day and is believed to be entirely of endogenous origin though the precise substances from which it is formed are by no means certain.

The Work Done by the Kidney.—Any process by which a solution of a certain saline concentration is converted into two other solutions each of different saline concentration from the original involves the absorption of energy in whatever apparatus—living or dead—the transformation is carried out. No mere filter could ever transform plasma into urine, though even in a filter some source of energy must be postulated to supply a head of pressure necessary to drive the materials through the filter.

The actual process of urinary excretion consists of an act by which urine is derived from blood plasma. The average composition of the two may be compared. The following are some of the more bulky constituents of each, expressed in percentages:—

Constituent	Blood plasma	Urine
Water	91–93	97
Protein	8	Nil
Urea	·02–·05	2·2
Sugar	·1–·15	Nil
Sodium chloride	0·9	1·2
Phosphate	·002	·17

For any one component the actual work is calculated in the following formula. If W be the work in calories: T the absolute temperature: C the molecular concentration of the substance in the arterial blood and C′ that in the urine and V the volume of urine secreted in litres—

$$W = 2VT\left(C'\log\frac{C'}{C} - (C'-C)\right)$$

Take for instance the case of urea secretion per day. V = 1·5 litres: T = 310° absolute: C = ·004 gram molecules per litre (·024%): C′ = 4 gram molecules per litre (2·4%)

$$W = 2 \times 1\cdot 5 \times 310 \left[\cdot 4 \log_e \frac{\cdot 4}{\cdot 004} - (\cdot 4 - \cdot 004) \right] = 1{,}344 \text{ calories}$$

As the efficiency of the kidney is not likely to be less than that of other organs, which means that at least three times as much energy must be expended by the organ as is actually represented by work accomplished, therefore the expenditure of energy in secreting this one constituent of the urine is about 4,000 calories which represents about ·15 of the total energy of the food eaten per day.

Functioning of the Kidney.—Few questions have intrigued physiologists more than the enquiry into the means by which the kidney works the transformation from plasma to urine. In the ultimate sense we do not know how the miracle is performed any more than we know how living matter carries out any of the other manifestations of its vitality. Between ultimate knowledge and complete ignorance there is, however, a wide territory, much of which has been explored and some of which has been mapped out with certainty.

One of the simplest forms of kidney is that of the earth-worm, though possibly the word "kidney" is scarcely applicable here, inasmuch as the multitudinous tubules of which the renal apparatus is composed are not bound up into a single organ but exist separately—a pair being situated in each typical segment of the worm. Each tubule is distinct from its neighbours. The tubule is open at each end, one orifice leads from the interior of the body cavity of the worm, the other to the outer air. The body cavity of the worm contains fluid; this fluid passes in greater or less quantities down the tubule. Its passage is promoted by the movement of the ciliary coat which lines the tubule. But that is not all: the tubule, which is a much coiled affair, is not uniform either in calibre or in the structure of its walls. In certain parts the so-called "glandular" portions, the tubule is of greater diameter than elsewhere, the wall is thicker and the cells of which the wall is composed, are made of granular protoplasm—protoplasm of the type which we are accustomed to associate with glandular secretion. These portions of the tubule also are well supplied with blood vessels, and it is clear that in some way there is an exchange of material between the blood and the fluid passing down the tubule. But what is the nature of this exchange? Is material transferred from the tubule fluid to the blood; or is it transferred from the blood to the interior of the tubule; or do both operations take place? Does the cell of the tubule say in effect, "Here is all this body fluid running to waste; let me reclaim such of its water and other constituents as may be useful to the body and restore them to the blood"? Or does it say, "Here is a water-course running to the exterior; let me pick out such things from the blood as are superfluous and cast them into this channel"? Or can the tubule perform both these functions? These are questions difficult to answer, but they are among those asked concerning all the higher forms of kidney.

Passing to the vertebrates, the kidney of the embryonic dog-fish is not entirely unlike the excretory system of the worm. It, too, consists of a series of tubes, passing down a portion of the body. A typical tube in this embryo opens by a funnel into the body cavity; the other end of this tube does not, like that of the worm, open directly into the external air, but into a longitudinal duct which gathers up all the urine from all the tubules on its side of the body. Something new, however, appears on the tubule of the dogfish: a sort of hollow shaped expansion or cup grows out in one place. Into the cavity of the cup grows a knot of blood vessels called the glomerulus. The cup is called the Malpighian Body. Such primitive tubules may develop into sperm ducts or kidney tubules; in the latter case the opening into the body cavity becomes closed. There remains, therefore, a series of closed tubules which form the kidney, each of which has two contacts with the blood (1) along the general length of the tubule, this being surrounded with capillaries and (2) at the Malpighian Bodies, one or more of which occurs on each tubule.

The Human Kidney.—The human kidney consists of a mass of tubules, each coiled into an S shape, each terminating at one end with a Malpighian Body, and each making, therefore, two contacts with the blood, one along the length of the tubule and one with the glomerular tuft of capillaries in the Malpighian Body. The actual expansion of the tubule surrounding the glomerulus is called the capsule of Bowman, the capsule of Bowman and the glomerulus together forming the Malpighian Body.

The same question arises with regard to the function of the human kidney as in the case of the kidney of the earth-worm. Does this tubule cell abstract material from within the tubule and transfer it to the blood, thus saving it for the organism? Or does the tubule cell select material from the blood and transfer it to the tubule? Or do both processes occur?

But in addition there is another question not met with in the tubule of the worm—what is the function of the glomerulus? Physiologists would agree that in a sense the function of the glomerulus has much in common with that of the funnel of the earth-worm; that is to say, the glomerulus is the source of the stream of fluid which passes down the tubule. As, however, this fluid is derived from the blood and not from the coelom, a series of open tubes would allow the animal to bleed to death. Some permeable filter must be placed between the blood vessel and the tubule; and such a filter is the combined capillary wall and surface of the Bowman's capsule. Through this filter, so far as is known, neither red blood corpuscles nor plasma proteins normally pass.

As to precisely what other materials pass through the glomerular filter there is no real agreement. Some authorities believe that all the constituents of plasma, other than their proteins are so filtered and that the urine attains its ultimate composition by the reclamation of some of the constituents as the fluid passes down the tubule. If this theory is correct, all the sugar which filters into the cavity of the Bowman's capsule would have to be either reabsorbed or oxidised in the tubular passage, for the urine is normally free from sugar. Moreover, since the concentration of urea in urine is seventy (or more) times that in plasma, it follows that if no urea is added to the urine in its way down the tubule, seventy times as much water must be filtered through the glomerulus as appears in the urine, *i.e.*, about 100 litres per day.

At the other end of the scale is the view that only water and certain crystalline bodies such as salt pass into the tubules, through the glomerulus but that the remainder, including the nitrogenous bodies, the phosphates, the sulphates, etc., leave the blood vessels which surround the tubules and are secreted into the fluid which is passing down the tubules. On this theory both the functions of the glomerulus and of the tubules would be acts of secretion involving the transformation of potential energy stored in the cells. Between the two views put forward there are many grades of opinion. Thus it is quite possible to believe that the glomerulus is simply a filter and the tubule an apparatus which is capable both of secretion and reabsorption. If such a view seems somewhat more complicated than either of the two extreme views, it must be borne in mind that the histology of the renal tubule is also very complicated and it seems probable that different histological units should have different functions.

It is a matter of common experience that much more urine is secreted at some times than at others. Exposure to cold, for instance, causes increased flow (*diuresis*). The cause of such changes is to be sought frequently in the regulation of the blood supply to the kidney. So far as may be judged from observation of the frog's kidney, only a fraction of the whole number of renal tubules are in use; the remainder are usually out of action because blood is withheld from them. When the skin is cold the blood flow through it becomes reduced and by way of compensation the kidney vessels open out, increasing probably not only the amount of urine which passes down each tubule but also the whole number of tubules in action. Some articles of diet, tea, coffee, etc., increase the flow of urine. This is in part simply due to the amount of water which they contain, but in part to chemical ingredients which stimulate them, *e.g.*, theobromine, caffeine, etc., such as are known as *diuretics*.

While some diuretics may act directly on the kidney-cells, others undoubtedly act on the renal vessels, in either case promoting the flow of urine.

Among the paradoxes presented by the kidney there is none

greater than its relation to the central nervous system. Apparently the cells of the kidney are not themselves directly supplied with nerves, yet their activity responds with great delicacy to the emotions, shock producing suppression of urine, while fear or excitement causes untoward production. Here also there is little doubt that in the regulation of the blood-flow is to be found the key to this paradox.

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EX DIVIDEND. When the price of a stock or share is quoted "ex dividend" it means that the price does not include the dividend which has just been paid or is just about to be paid on it. It often happens that after a seller has sold a security he finds that a dividend received by him is demanded by the buyer because the security was sold ex dividend. This happens because the transfer of the security, although legally signed and stamped, did not reach the company's office in time for the formal transfer to be made in the shareholders' list before the books were closed to enable the dividend warrants to be prepared; obviously they could only be prepared by definitely closing the books for the purpose. The rules under which a security becomes ex dividend should, therefore, be thoroughly understood, and they will be found set out in the article entitled CUM-DIVIDEND; EX DIVIDEND.

EXECUTION: *see* PRACTICE AND PROCEDURE.

EXECUTORS AND ADMINISTRATORS, in English law, those persons upon whom the property of a deceased person both real and personal devolves according as he has or has not left a will. An executor can only be appointed by the will of his testator and the estate of his testator vests in him from the date of the testator's death. An administrator on the other hand is appointed by the probate division of the High Court and no estate vests in him till such appointment, the title to the property being vested till then in the judge of the probate division. Since the Administration of Estates Act 1925 this is the case whether the property be personalty or realty. As to whom the court will appoint administrators and the various kinds of administrators *see* ADMINISTRATION. Apart from these two points the rights and liabilities of executors and administrators are the same, and they may be indifferently referred to as the representatives of the deceased. Before the Land Transfer Act 1897 the real estate of the deceased did not devolve upon the representative but vested directly in the devisee or the heir-at-law, but by that Act it was provided that the personal representative should also be the real representative. Under this Act legal estates in copyhold and fees tail did not vest in the deceased's personal representatives, but now copyhold tenure is abolished and by the Administration of Estates Act 1925 fees tail, whether in land or goods, vest in the owner's executors if he disposes of them by his will. As the representative stands in the shoes of the deceased he is entitled to sue upon any contract or for any debt which the deceased might have sued in his lifetime.

The Duties of a Representative are as follows:

1. To bury the deceased in a manner suitable to the estate he leaves behind him; and the expenses of such funeral take precedence of any duty or debt whatever; but extravagant expenses will not be allowed.

2. Administration (which includes probate) will now be granted to not more than four persons. A person appointed executor by the will of another cannot be compelled to act as executor unless he intermeddles with the testator's assets; but he can be called upon either to take out probate or renounce. Where administration has been improperly granted all acts done by the persons to whom it is granted in due course of administration before the grant is revoked are valid.

3. Strictly speaking he should compile an inventory of all the estate of the deceased, whether in possession or outstanding, and he is to deliver it into court on oath. He is to collect all the assets so inventoried and in his discretion to commence actions to get in all those outstanding. It is necessary to file an affidavit setting out the value of the estate of the deceased upon applying for a grant of probate or letters of administration. The representative must pay the debts of the deceased to the extent of the assets real and personal which he has received or which he might have received but for his own wilful default. Realty and personalty are now equally liable for the payment of the deceased's debts. Formerly intricate rules as to the priority of payment of debts applied at least to personal assets. These rules are not expressly abolished where the estate is solvent, but there they are of no importance. Where the estate is insolvent the deceased's debts of all kinds are payable according to the rules applicable in bankruptcy whether the estate is wound up by the personal representatives or by the court (Administration of Estates Act 1925; *see* also BANKRUPTCY). Though the creditors can, if necessary, take all the estate of the deceased to satisfy their claims, yet as between the various classes of assets the representative must pay the debts out of assets in the following order: (i.) Property not disposed of by will; (ii.) property disposed of by a residuary gift; (iii.) property specifically appropriated by the will for the payment of debts; (iv.) property charged with and left subject to the payment of debts; (v.) general legacies; (vi.) specific legacies and devices; (vii.) property over which the will exercises a general power of appointment and fees tail of which the testator was life tenant and which he disposes of by will.

4. The debts of the deceased being satisfied, the representative must next proceed to satisfy the legacies and devises left by the testator. In order to enable him to do this with safety to himself, it is provided that he cannot be compelled to divide the estate among the legatees or next of kin until 12 months from the death of the deceased (this is commonly known as "the executor's year"), though if there is no doubt as to the solvency of the estate he may do so at once. As a further protection the representative may give notice by advertisement for creditors to send in their claims against the estate, and on expiration of the notices he may proceed to divide the estate, though even then the creditor may follow the assets to the person who has received them and recover for his debt. As between legatees the following priorities must be observed: (1) Specific legatees and devisees, (2) demonstrative legatees and (3) general legatees. Formerly real estate was not liable for the payment of general legacies. Now all the testator's property is treated as a single fund and general legacies are payable out of it without any charge.

5. The residue, after all the legacies and devises are satisfied, must, if there be a will, be paid to the residuary beneficiary therein named, and if there be no will it is divisible among the statutory next of kin. (*See* INTESTACY.) It was held at one time that in default of a residuary legatee the residue fell to the executor himself, but now nothing less than the expressed intention of the testator can give it to him.

The liabilities of the representative may be shortly stated. He is liable in his representative capacity in all cases where the deceased would be liable were he alive. To this general rule there are some exceptions. The representative cannot be sued for breach of contract for personal services which could be performed only in the lifetime of the person contracting, nor again can he be sued in a case where unliquidated damages only could have been recovered against the deceased. He is liable in his personal capacity in the following cases: if he contracts in writing to pay a debt due by the deceased, or if having admitted that he had assets in his hands sufficient to pay a debt or legacy he has misapplied such assets so that he cannot satisfy them; or lastly, if by mismanaging the estate and effects of the deceased he has made himself liable for a *devastavit.* Shortly stated, a representative is bound to exercise the ordinary care of a business man in administering the estate of the deceased, and he will be liable for the loss to the estate caused by his own negligence, or by the negligence of a co-representative which his act or neglect has rendered possible. Though the general rule of *delegatus non potest delegari* holds

good of a representative, yet in certain cases he may "rely upon skilled persons in matters in which he cannot be expected to be experienced," *e.g.*, he must employ solicitors to conduct a lawsuit.

The privileges of the representative are these: he may prefer one creditor to another of equal degree; he may retain a debt owing to him from the deceased as against other creditors of equal degree (*see* RETAINER); he may reimburse himself out of the estate all expenses properly incurred in the execution of his trust.

An executor *de son tort* is one who, without any title to do so, wrongfully intermeddles with the assets of the deceased, dealing with them in such a way as to hold himself out as executor. In such a case he is subject to all the liabilities of an executor, and can claim none of the privileges though recent legislation seems to have conferred upon him the right to retain. He may be treated by the creditor as the executor, and, if he is really assuming to act as executor, creditors and legatees will get a good title from him, but he is liable to be sued by the rightful representative for damages for interfering with the property of the deceased.

Scotland.—Executor in Scots law is a more extensive term than in English. He is either nominative or dative, the latter appointed by the court and corresponding in most respects to the English administrator. Caution is required from the latter, not from the former. By the common law doctrine of passive representation the heir or executor was liable to be sued for implement of the deceased's obligations. The Roman principle of *beneficium inventarii* was first introduced by an Act of 1695. As the law at present stands, the heir or executor is liable only to the value of the succession, except where there has been vitious intromission in movables, and in *gestio pro haerede* (behaviour as heir) and other cases in heritables. The present inventory duty on succession to movables and heritables depends on the Finance Acts 1894–1909. (*See* ESTATE DUTY.) All debts are payable *pari passu* except privileged debts. (*See* PRIVILEGE.) (J. A. ST.; X.)

UNITED STATES

In the great majority of the States of North America, special courts have been established by statute and invested with jurisdiction over the administration of the estates of deceased persons. These courts are commonly denominated as probate, orphans' or surrogate courts. The court of the county in which the deceased was resident at the time of his death is primarily entrusted with the duty of administration. It is the law of that State which will govern the devolution of his property. Other States in which the deceased may have had assets will order their distribution according to the law of the deceased's domicile. The executor or administrator, however, is only an officer of the court which confirms his appointment, and letters testamentary or of administration have no legal effect outside the territorial limits of the State in which they were granted. Consequently, ancillary administration must be secured in order to collect assets of the estate in any jurisdiction in which the deceased was not a resident. Statutes provide for the ready appointment of ancillary administrators and often give preference in this respect to the domiciliary executor or administrator. Without such authority the domiciliary executor or administrator, though invested with title to the assets in the foreign State, has no right to remove them nor can he sue upon outstanding claims due to the deceased in order to reduce them to possession.

The fact of death and the deceased's residence within the county are essential to the validity of a grant of letters testamentary or of administration. Statutes make provision for administration of estates of persons who have disappeared for such a length of time as would lead to a presumption of their death. In the United States, contrary to the common law doctrine, an executor is not entitled to exercise his powers before the probate of the will and the grant of letters testamentary, though until that time he may perform such acts as may be necessary to preserve the estate. Statutes also provide for revocation of powers granted to an executor upon proof of fraud or mismanagement in the conduct of his duties.

The executor's duty, broadly speaking, is to wind up the business of the deceased and distribute the assets. He has no power, except under extraordinary circumstances or by leave of the probate court, to carry on the business or change the character of the deceased's investments. He must file an inventory of the deceased's assets within a period commonly prescribed as between three and six months. Statutes impose upon him a duty to give notice to creditors of the deceased to present their claims. Failure to present claims within a stipulated time operates to bar them. The deceased's estate is liable upon all contract claims except those where death operates as an excuse for non-performance. Statutes have generally changed the common law rule absolving the estate from liability for torts committed by the deceased during his lifetime. Obligations incurred by the executor in behalf of the estate after the death of the testator impose a liability upon the executor and not upon the estate, though in proper cases he can demand reimbursement from the estate. The executor must render an account to the probate court of his administration of the estate. Statutes usually provide that a final settlement cannot be demanded of the executor until the expiration of a year or 18 months.

At common law realty descended to the heirs and could not be sold by the executor for the payment of the deceased's debts unless the deceased had specified to the contrary. In most States to-day, though the realty still descends to the heirs, the executor or administrator is authorized to apply to the court and obtain leave to sell real estate in order to pay debts. Such legislation may make the realty equally liable with the personalty for the payment of debts or provide that the personalty must first be exhausted before recourse may be had against the realty. So much of the realty as consists of homestead rights is exempted from this liability and preserved for the benefit of the widow or children. Where the estate is insolvent the problem as to what debts should first be satisfied and what preferences may be made by the executor as between competing creditors is now governed by legislation which has abrogated much of the ancient common law doctrine. The order in which legacies are to be paid, however, generally follows the common law principles.

The executor's compensation is usually governed by statutes allowing a certain percentage upon the value of the estate. In the absence of statute he is entitled to a reasonable allowance which is determined by the probate court.

American jurisdictions have been unfriendly to the common law doctrine of executors *de son tort*. Some States have expressly abolished the institution; the courts of other States by regarding the extensive statutory regulation of executors and administrators as a completed system that superseded common law doctrines have treated such legislation as impliedly abolishing the office of executor *de son tort*. Still other States by judicial decision have narrowed the broad liabilities imposed upon him at common law. (J. M. LA.)

EXEDRA, a term originally describing any outdoor seat or recess. Because such seats were usually semicircular, in modern architectural usage the term has come to signify any semicircular seat or recess, however large, indoors or out. In the Roman baths they were of large size and like apses were covered with a hemispherical vault. An example exists at Pompeii in the Street of the Tombs. From Vitruvius we learn that they were often covered over, and they are described by him as places leading out of porticoes, where philosophers and rhetoricians could debate or harangue. The term is differentiated from apse (*q.v.*) by the fact that an apse is usually at the end of an aisle or building, and designed to enshrine an altar, tomb or statue, whereas an exedra may be in any location and without such definite purpose.

EXELMANS, RENÉ JOSEPH ISIDORE, COUNT (1775–1852), marshal of France, was born at Bar-le-Duc on Nov. 13, 1775. He volunteered into the 3rd battalion of the Meuse in 1791, and served almost continuously through the Revolutionary Wars. He became a lieutenant in 1797, and in 1798 was aide-de-camp to General Éblé, and in the following year to General Broussier. In his first campaign in Italy he greatly distinguished himself, and in April 1799 he was rewarded for his services by the grade of

captain of dragoons. In the same year he took part with honour in the conquest of Naples and was again promoted. In 1801 he became aide-de-camp to Murat, whom he accompanied in the Austrian and Polish campaigns of 1805, 1806 and 1807. At the passage of the Danube, and in the action of Wertingen, he specially distinguished himself; he was made colonel for the valour which he displayed at Austerlitz, and general of brigade for his conduct at Eylau in 1807. In 1808 he accompanied Murat to Spain, but was there made prisoner and conveyed to England. On regaining his liberty in 1811 he became grand-master of horse to Murat at Naples, but rejoined the French army just before the Russian campaign. He was promoted general on the field of Borodino. In the retreat from Moscow his steadfast courage was conspicuous. In 1813 he was made, for services in the campaign of Saxony and Silesia, grand-officer of the Legion of Honour, and in 1814 he reaped additional glory by his intrepidity and skill in the campaign in France. When the Bourbons were restored Exelmans retained his position in the army. Napoleon after his return from Elba made Exelmans a peer of France and placed him in command of the II. Cavalry Corps which he led in the Waterloo campaign, the battle of Ligny and Grouchy's march on Wavre. In the closing operations around Paris he won great distinction. After the second restoration he denounced, in the House of Peers, the execution of Marshal Ney as an "abominable assassination" and was thereafter compelled to live in exile until 1819. In 1828 he became inspector-general of cavalry, and in 1851 a marshal of France. He died on July 10, 1852.

EXEQUATUR, the letter patent, issued by a foreign office and signed by a sovereign, which guarantees to a foreign consul the rights and privileges of his office, and ensures his recognition in the State in which he is appointed to exercise them. If a consul is not appointed by commission he receives no exequatur; and a notice in the *Gazette* in this case has to suffice. "Exequatur" is also used, in some countries of Europe, of the order made by a court authorizing the enforcement of a foreign judgment.

EXETER, EARL, MARQUESS AND DUKE OF. These English titles have been borne at different times by members of the families of Holand or Holland, Beaufort, Courtenay and Cecil. The earls of Devon of the family of de Redvers were sometimes called earls of Exeter; but the 1st duke of Exeter was JOHN (*c.* 1355–1400), a younger son of Thomas Holand, earl of Kent (d. 1360). He owed his high station at the English court to the fact that he was the king's half-brother, his mother having married Edward, the Black Prince. He married Elizabeth (d. 1426), a daughter of John of Gaunt, duke of Lancaster, and was constantly in Richard's train until 1385, when his murder of Ralph Stafford disturbed these friendly relations. In 1387 he was created earl of Huntingdon, admiral of the fleet and chamberlain of England, and was again high in the king's favour. In 1397, after assisting Richard in the proceedings against the lords appellant, he was created duke of Exeter. After the accession of his brother-in-law, Henry IV., Holand was tried for his share in the events of 1397, and was reduced to his earlier rank of earl of Huntingdon. His plots against Henry, led to his capture and execution at Pleshey, Essex, on Jan. 16, 1400[1]. He was afterwards attainted and his titles and lands were forfeited.

In 1416 THOMAS BEAUFORT, earl of Dorset, was created duke of Exeter for life. In the same year JOHN (1395–1447), son of John Holand, the former duke of Exeter, was allowed to take his father's earldom of Huntingdon. This nobleman assisted Henry V. in his conquest of France, fighting both on sea and on land. He was marshal of England, admiral of England and governor of Aquitaine under Henry VI.; was one of the king's representatives at the conference of Arras in 1435; and in 1443 was created duke of Exeter. When he died on Aug. 5, 1447, his titles passed to his son HENRY (1430–1473), who, although married to Anne (d. 1476), daughter of Richard, duke of York, fought for Henry VI. during the Wars of the Roses. After having been imprisoned by York at Pontefract, he was present at the battle of Towton, sailed with Henry's queen, Margaret of Anjou, to Flanders in 1463, and was wounded at Barnet in 1471. In 1461 he had been attainted and his dukedom declared forfeited, and he died without sons, probably in 1473.

Coming to the family of Courtenay the title of marquess of Exeter was borne by HENRY COURTENAY (*c.* 1496–1538), earl of Devon, who was made a marquess in 1525. Courtenay was a prominent figure at the court of Henry VIII. until Thomas Cromwell rose to power, when his high birth, his great wealth and his independent position made him an object of suspicion. Some slight discontent in the west of England gave the occasion for his arrest, and he was tried and beheaded on Dec. 9, 1538. A few days later he was declared a traitor and his titles were forfeited; although his only son, EDWARD (*c.* 1526–1556), who was restored to the earldom of Devon in 1553 and was a suitor for the hand of Queen Mary, is sometimes called marquess of Exeter.

The title of earl of Exeter was first bestowed upon the Cecils (*see* CECIL: *Family*) in 1605 when THOMAS, 2nd Lord Burghley (1542–1623), the eldest son of William Cecil, Lord Burghley, was made earl of Exeter by James I. Thomas was a member of parliament during the reign of Queen Elizabeth, who knighted him in 1575, and had fought under the earl of Leicester in the Netherlands. In 1598 he became president of the Council of the North and was made a knight of the Garter. He died on Feb. 7, or 8, 1623. His direct descendants continued to bear the title of earl of Exeter, and in 1801 HENRY (1754–1804), the 10th earl, was advanced to the dignity of marquess of Exeter, the present marquess being his lineal descendant. The 1st marquess is Tennyson's "lord of Burghley."

See G. E. C(okayne), *Complete Peerage* (1887–98).

EXETER, a city and county of a city, municipal borough, and the county town of Devonshire, England, 172 m. W.S.W. of London, on the S.R. and the G.W.R. Pop. (1921) 59,582.

History.—Exeter was the Romano-British country town of *Isca Damnoniorum*. Mosaic pavements, potsherds, coins and other relics have been found, and probably traces of the Roman walls survive. It is said to be the *Caer Isce* of the Britons, and its importance as a British stronghold is shown by the great earthwork which the Britons threw up to defend it, on the site of which the castle was afterwards built, and by the number of roads which branch from it. Exeter is famous for the number of sieges which it sustained as the chief town in the south-west of England. In 1001 it was unsuccessfully besieged by the Danes, but in the following year was given by King Aethelred to Queen Emma, who appointed as reeve, Hugh, a Frenchman, owing to whose treachery it was taken and destroyed by Sweyn in 1003. By 1050, however, it had recovered, and was chosen by Leofric as the new seat of the bishops of Devon. In 1068, after a siege of 18 days, Exeter surrendered to the Conqueror, who threw up a castle which was called Rougemont, from the colour of the rock on which it stood. Again in 1137 the town was held for Matilda by Baldwin de Redvers for three months and surrendered, at last, owing to lack of water. Three times subsequently Exeter held out successfully for the king—in 1467 against the Yorkists, in 1497 against Perkin Warbeck, and in 1549 against the men of Cornwall and Devon, who rose in defence of the old religion. During the civil wars the city declared for parliament, but was in 1643 taken by the royalists, who held it until 1646. The only other historical event of importance is the entry of William, prince of Orange, in 1688, shortly after his arrival in England. Exeter was a borough by prescription some time before the Conquest, since the burgesses are mentioned in the Domesday Survey. Its first charter granted by Henry I. gave the burgesses all the free customs which the citizens of London enjoyed, and was confirmed and enlarged by most of the succeeding kings. By 1227 government by a reeve had given place to that by a mayor and four bailiffs, which continued until the Municipal Reform act of 1835. Numerous trade gilds were incorporated in Exeter, one of the first being the tailors' gild, incorporated in 1466. This by 1482 had become so powerful that it interfered with the government of the town, and was dissolved on the petition of

[1]There is some difference of opinion about the place and manner of the earl's death, and this question has an important bearing upon the privilege of trial by peers of the realm. *See* L. W. Vernon-Harcourt, *His Grace the Steward and Trial of Peers* (1907).

the burgesses. Another powerful gild was that of the merchant adventurers, incorporated in 1559, which is said to have dictated laws to which the mayor and bailiffs submitted.

From 1295 to 1885 Exeter was represented in parliament by two members, but in the latter year the number of representatives was reduced to one. Exeter was formerly noted for the manufacture of woollen goods, introduced in Elizabeth's reign, and the value of its exports at one time exceeded half a million sterling yearly. The trade declined partly owing to the stringent laws of the trade gilds, and by the beginning of the 19th century had entirely disappeared, although at the time of its greatest prosperity it had been surpassed in value and importance only by that of Leeds.

Site.—The ancient city occupies a broad ridge of land, which rises steeply from the left bank of the Exe. At the head of the ridge is the castle, on the site of a great British earthwork. There is a maze of streets within the ancient walls, the line of which may be traced. All the gates have disappeared. The suburbs, which have greatly extended since the beginning of the 19th century, contain many good streets, terraces and detached villas. The lofty mound of the castle is laid out as a promenade, with trees and walks.

Cathedral and Institutions.—The cathedral is mainly of Decorated Gothic except for its Norman transeptal towers, and dates from 1280 to 1369. Transeptal towers occur elsewhere in England only in the collegiate church of Ottery St. Mary, in Devonshire, for which Exeter cathedral served as a model. The west front is of later date than the rest, and the porch is wholly covered with statues. Within, the most noteworthy features are the long unbroken roof, extending throughout nave and choir, with no central tower or lantern; the sculpture of bosses and corbels; the minstrel's gallery, projecting from the north triforium of the nave; and the manner in which the several parts of the church are made to correspond. The window tracery is much varied; but each window answers to that on the opposite side of nave or choir; pier answers to pier, aisle to aisle, and chapel to chapel, while the transeptal towers complete the balance of parts. A complete restoration under Sir G. G. Scott was carried out between 1870 and 1877. The episcopal throne, a sheaf of tabernacle work in wood, was erected by Bishop Stapeldon about 1320, and in the north transept is an ancient clock and a bell weighing 2,500 lbs. Some important mss., including the famous book of Saxon poetry given by Leofric to his cathedral, are preserved in the chapter-house. The united sees of Devonshire and Cornwall were fixed at Exeter from the installation there of Leofric (1050) by the Confessor, until the re-erection of the Cornish see in 1876. The bishop's palace embodies Early English portions. The diocese covers the greater part of Devonshire, with a very small part of Dorsetshire.

The guildhall in the High Street is an Elizabethan building, and contains some portraits by Sir Peter Lely. The assize hall and sessions house dates from 1774. There is a good collection of local birds, and some remarkable pottery and bronze relics extracted from barrows near Honiton or found in various parts of Devonshire in the Albert Memorial Museum. Of the castle, called Rougemont, a portion of a gateway tower which may be late Norman, remains. Traces are also seen of the surrounding earthworks, which may have belonged to the original British stronghold. The Devon and Exeter Institution, founded in 1813, contains a large and valuable library. The Grammar school was founded by Walter de Stapeldon, bishop of Exeter and founder of Exeter College, Oxford, in 1332, and refounded in 1629, but occupies modern buildings outside the city. There are two market-houses in the city, and many institutions, including the hospital or almshouse of William Wynard, recorder of Exeter (1439).

Commerce.—Exeter is one of the principal railway centres in the south-west, and it also has some shipping trade, communicating with the sea by way of the Exeter ship-canal, originally cut in the reign of Elizabeth (1564), and enlarged in 1675 and 1827. This is the first canal carried out in the United Kingdom for the purpose of enabling sea-going vessels to pass to an inland port. The river Exe was very early utilized by small craft trading to Exeter, parliament having granted powers for the improvement of the navigation by the construction of a canal 3 m. long from Exeter to the river; at a later date this canal was extended lower down to the tidal estuary of the Exe. Previous to the year 1820 it was only available for vessels of a draft not exceeding 9 ft., but by deepening it, raising the banks, and constructing new locks, vessels drawing 14 ft. of water were enabled to pass up to a basin and wharves at Exeter. These works were carried out under the advice of Thomas Telford. A floating basin is accessible to vessels of 350 tons. Larger vessels lie at Topsham, at the junction of the canal with the estuary of the Exe; while at the mouth of the estuary is the port of Exmouth. The imports are coal, oilcake, timber, slates, grain, fish, cement, manure, pig iron, etc., while ground barytes, timber, scrap iron, paper and cider are exported. Brewing, paper-making and iron-founding are carried on, and the city is an important centre of agricultural trade. The parliamentary borough returns one member. The eastern suburb of Heavitree is an urban district with a population (1921) 11,465.

EXETER, a town of south-eastern New Hampshire, U.S.A., on the Squamscott river, 12m. S.W. of Portsmouth; the county seat of Rockingham county. It is served by the Boston and Maine railroad. The population was 4,604 in 1920. It is the seat of Phillips Exeter academy, one of the foremost secondary schools of the country, founded in 1781 by Dr. John Phillips (1719–95), a Harvard graduate who acquired considerable wealth as a merchant at Exeter and gave nearly all of it to promote education. The academy numbers among its alumni Daniel Webster, Edward Everett, John Parker Hale, George Bancroft, Jared Sparks, Robert T. Lincoln and many other men of prominence. The town was founded in 1638 by the Rev. John Wheelwright, an Antinomian leader who with a number of followers settled here after he was banished from Massachusetts. For their government the settlers adopted a plantation covenant, but in 1643 the majority submitted to the jurisdiction of Massachusetts, while the minority, including the founder, moved away. In 1680 the town became a part of the new province of New Hampshire. During the French and Indian wars it was usually protected by a garrison. One of the garrison houses and some fine colonial homes are still standing. New Hampshire was the first of the colonies to adopt a constitution, and it was in Exeter, in Jan. 1776, that the first independent State government was formed. The legislature met here regularly from 1776 to 1782, and usually thereafter until 1800. Exeter was the birthplace of Lewis Cass, Henry A. Shute, Ambrose Swasey, Edward Tuck and Daniel Chester French.

EXETER BOOK (*Codex Exoniensis*), an anthology of Anglo-Saxon poetry presented to Exeter cathedral by Leofric (bishop of Exeter from 1050 to 1071), and still there. It contains legal documents, the poems entitled *Crist, Guthlac, The Wanderer,* etc., and 80 or 90 riddles. It was first described in Wanley's *Catalogus* (1705), with many inaccuracies; subsequently by Conybeare, "Account of a Saxon Manuscript" (*Archaeologia*, xvii. 180–197, 1814). A complete transcript made (1831) by Robert Chambers is in the British Museum (Addit. ms. 9,067). It was first printed in 1842 by Thorpe for the Soc. of Antiq., London. More recent editions are:—in Grein's *Bibliothek der A.S. Poesie* (vol. iii. part 1, ed. Wülker, Leipzig, 1897). Schipper in Pfeiffer's *Germania*, xix. 327–339, and Gollancz, *Exeter Book*, pt. i. (1895), with translation (E.E.T.S.).

A detailed account, with bibliographies, is given by R. Wülker, in *Grundriss . . . der A.S. Literatur*, 218–236 (Leipzig, 1885); *see* also the introduction to *The Crist of Cynewulf*, ed. Cook (Boston, U.S.A., 1900). For the poems contained in the ms. *see* also CYNEWULF and RIDDLES. For Leofric, *see* F. E. Warren, *The Leofric Missal* (1883).

EXHAUST. The exhaust steam from an engine is disposed of in various ways: (1) It escapes direct to the atmosphere, or by way of an *exhaust-head* which acts as a silencer, and also prevents condensed steam and oil from being thrown down on to adjacent buildings. In a portable engine or locomotive it creates draught to help the fire by being directed up the chimney. (2) It operates an injector (*see* INJECTOR) or a feed-water heater, as illustrated, thus assisting the boiler by so much heat already raised and avoiding strain on the plates by feeding a cold flow against

the hot surfaces. Or some other kind of heating apparatus is worked by exhaust steam, such as an air-heater for warming buildings, workshops, or drying clothes in laundries, also wheat, cloth, timber, yarn, etc. (3) In condensing engines and turbines it passes into a partial vacuum created in a condenser (*q.v.*).

Exhaust steam from a big engine, such as a colliery winder or a rolling-mill engine, is made to do further work in low-pressure turbines. As winders run intermittently the supply of exhaust steam fluctuates and a *steam accumulator,* a large boiler-like object, containing a mass of hot water, is employed to pass steam into and furnish a reserve for short carry-over periods when the winder stops.

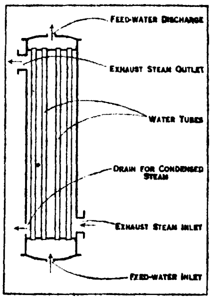

DIAGRAM OF FEED-WATER HEATER
This apparatus utilizes waste heat of exhaust steam. The steam is made to circulate round the tubes, through which the feed-water flows

Another practice which is economical of fuel is concerned with factories requiring large quantities of low-pressure heating steam for processes; these include flour-mills, paper-mills, dye-works, bleach-works, tanneries, wool-combing sheds, breweries and others. This *process steam* can be generated in low-pressure boilers, but it is cheaper to produce high-pressure steam, pass it through the engine, and take the exhaust for the process work. If the demand for heating steam is about equal to that given out by the engine, a single-cylinder *back-pressure engine* is employed, giving up all its exhaust, but with fluctuating requirements a compound cylinder *heat-extraction engine* is selected. The whole of the steam required for driving and heating passes through the high-pressure cylinder to an intermediate receiver. From this latter the desired quantity of process steam is drawn, and any excess goes in to the low-pressure cylinder and thence to the condenser.

The chief feature in respect to the exhaust from an internal-combustion engine is to let it escape as freely as possible, so as not to hamper the engine; but the necessity for silencing in so many cases renders this ideal difficult of realisation. Exhaust from large units may be led into a pit, or into a box providing for expansion of the gases, baffles or small stones assisting to break up the flow. On motor-cars baffles or perforated compartments perform a similar duty. Extra service may be obtained from an exhaust, such as to blow a whistle, or warm a car.

EXHAUSTION: *see* FATIGUE; VACUUM.

EXHIBITION AND TRADE FAIR. Although the terms "fair" and "exhibition" (or "exposition" as it is called in America) are somewhat loosely used, it may be accepted that by the latter is meant the long period show accompanied by bands, amusement park, etc., while by the former term is meant the short-period trade show. What is now known as an exhibition is of comparatively recent date, while fairs (*q.v.*) have existed from time immemorial.

The precise starting-point of the present day exhibition is not very clearly defined. There was naturally a transition period, but it may fairly be stated that the great exhibition of 1851 held in Hyde park, London, marked a definite stage in the development of the latter-day type of international or national exhibitions. Particulars of some of the more important exhibitions are given in the table on opposite page.

The Value of Exhibitions.—Considerable divergence of opinion existed and still exists as to the exact value of these great international exhibitions. Unquestionably they are of immediate gain and profit to the cities in which they are held. Vast numbers of people are attracted from all over the world to see them, with obvious benefit to those directly concerned. But the cost of participation by industrialists, especially those of the other countries, is considerable, involving the immobilization of stocks and the employment of special staffs for long periods. In those industries dependent for their prosperity on fulfilling the daily domestic needs of the bulk of the population, they are generally popular. Food, clothes, the luxury and sport trades, musical instruments and appliances of all kinds fall within this category.

The increasing frequency of exhibitions during the latter half of the 19th century, and the heavy burden which was entailed both upon the governments participating and on the individual exhibitors, pointed urgently to the need for some measure of international agreement for their limitation and control. In several important countries national committees were set up, inaugurated in 1885 by the "Comité Français des Expositions à l'Étranger," which was formed to protect the interests of French exhibitors in foreign exhibitions. The committee was so successful that in 1901 it was officially recognized (*reconnu d'utilité publique*). In 1904 a similar committee was set up in Belgium, and subsequently others were formed in Switzerland, Denmark, Germany, Italy, Austria, etc. On the invitation of the French committee, these various bodies formed themselves into an international federation for the advancement of their common interests.

In England, the task of organizing the national displays at exhibitions in which the Government participated officially had been entrusted to a body specially appointed for that purpose on each occasion, generally a royal commission. There were obvious disadvantages in this procedure, the most serious being that, owing to the complete lack of any continuity of organization, the experience gained at one exhibition was not readily available for the next.

In 1906 the British board of trade appointed a special committee to enquire into the nature and extent of the benefit accruing to British arts, industries and trade from participation in great international exhibitions. The committee found that while there was a conflict of opinion as to the direct benefit accruing, such participation could not be discontinued. It constituted an advertisement both for the individual exhibitors and for national trade in general. The chief argument in favour of participation was the necessity of keeping pace with foreign competitors. It was further remarked that political considerations were often a potent factor in determining participation.

Lack of continuous policy or system and of adequate machinery for determining the question of participation, had prevented proper preparation. The immediate result of this enquiry was the creation of a special British exhibitions department. (*See* INTERNATIONAL TRADE ASSOCIATIONS AND CONGRESSES.)

It is unfortunate that the initiative for fairs and exhibitions is often undertaken by individuals or bodies having little or no connection with the industries which such exhibitions are supposed to serve. In some instances the object is that of gain, whether direct or indirect, to the organizers or organizing localities, rather than to the exhibitors. This tendency has given rise to prejudice and suspicion, but in the case of the great international exhibitions organized under the immediate aegis of their respective governments, or enjoying the substantial and general support of all the interests involved, there can be no question of the value of their lessons. In the course of the last century they have probably had a greater influence on the development of the tastes, habits and activities of the civilized peoples than the less direct, slower process of a natural development of needs following in the train of modern scientific and mechanical progress.

Frequency of Exhibitions.—The growing tendency towards the multiplication of international exhibitions was taken up in the Convention relative to International Exhibitions, signed at Berlin on Oct. 26, 1912. The parties to the convention were the principal European powers and Japan, but not any nation of the American continent. The convention made detailed recommendations as to international exhibitions. It dealt with the recognition, patronage or authorization of such exhibitions, and the interval between universal exhibitions. (A universal exhibition is defined in the convention as one which embraces the majority of the products of human activity. It is contrasted with a "special exhibition," the scope of which is limited to one or to a few branches of human activity.) The convention was signed subject to ratification which, owing to the World War, never took place.

Place	Date	Area(acs.)	Exhibitors	Receipts	Cost	Attendance	Remarks
London . .	1851	21	13,937	£506,243	£292,794	6,039,195	The building was the nucleus of the present Crystal Palace.
Paris . .	1855	24½	20,839	128,099	1,000,000	5,162,330	
London . .	1862	22¾	28,653	459,631	460,000	6,211,103	The death of the Prince Consort had a detrimental effect on this exhibition.
Paris . .	1867	41	43,217	420,735	800,000	6,805,969	
Vienna . .	1873	40	25,760	206,477	2,200,000	6,740,000	
Philadelphia .	1876	60	60,000	763,899	1,600,000	9,892,625	
Paris . .	1878	66	52,835	Fr 23,700,000*	Fr 55,400,000†	16,100,000	The Trocadero Palace was erected on this occasion.
Sydney . .	1879	15	9,345	£210,372**	£313,987	1,117,536	
Melbourne .	1880	20¾	12,792	331,901	330,330	1,330,279	
London . .	1886	13	..	249,861	215,218	5,550,745	
Melbourne .	1888	45½	10,240	100,242	338,026	2,003,593	
Paris . .	1889	72	61,722	..	Fr 44,000,000	32,350,297	The Eiffel Tower was built for this exhibition.
Chicago . .	1893	200	..	£3,029,000	£6,000,000 (Approx.)	21,477,212	International juries were, on this occasion, replaced by single judges for each class with unsatisfactory results.
Paris. . .	1900	549	9,000,000‡	4,578,249	4,660,000	39,000,000	Germany participated for the first time in a French international exhibition.
Buffalo . .	1901	350	3,500	$8,869,757	$9,447,702	8,120,048	
Glasgow . .	1901	..	..	£404,105	£350,600 (Approx.)	11,559,649	
St. Louis . .	1904	1,240	..	$46,488,000¶	..	14,000,000	
Liége . .	1905	173	16,119	Fr 14,526,930	Fr 14,451,813	7,000,000	
London . . (Franco-British)	1908	140	..	£798,771	£783,521	8,396,673	
Brussels . .	1910	200	..	692,933	702,933	4,196,939 (exclusive of season ticket holders)	The loss is attributed to a fire which occurred during the period of the exhibition and destroyed several important buildings.
Panama-Pacific (San Francisco)	1915	635	30,000	$27,178,065	$25,865,914		
Wembley (British Empire)	1924–25	220	..	£2,814,935	£4,396,840	27,102,498	

*Including subvention from City of Paris. **Including sale of buildings. ¶(Unofficial).
†Including cost of permanent buildings. ‡Including staffs.

The organization for the administration of exhibitions is most varied. As a general rule each project has created its own organization, and although it has had the assistance of committees of experts, sometimes of a national and permanent character, such organizations lack the benefit of past experience and continuity. The work initiated at the Berlin congress is likely to be followed up by another congress in Paris. Surely such deliberations will be able to find agreement in regulating international exhibitions and fairs in the manner most directly profitable to the interests involved. Having regard to their great cost and the strain imposed on participants, it seems likely that the universal exhibition will give place to specialized exhibitions dealing with one industry at a time. Indeed, the limitations of space in close proximity to the centres of our great capitals, the high cost of building, the increased difficulty of concentrating large numbers of people at a given spot, make such a conclusion practically imperative. It is probable, however, that exhibitions on the grand scale will continue to be held from time to time, subject to such restrictions as may be determined by international agreement, as they have come to be regarded as an appropriate form of national celebration. Examples of this are the exhibitions held at Rome and Turin in 1911 (fiftieth anniversary of the unification of Italy), at Rio de Janeiro in 1922 (centenary of Brazilian independence), at Philadelphia in 1926 (sesqui-centenary of American independence), and those announced to be held at Antwerp in 1930 (centenary of Belgian independence), and at Brussels in 1935 (centenary of Belgian railways and fiftieth anniversary of the Congo State).

The British Empire Exhibition.—Two exhibitions held since the war call for brief notice, both for their intrinsic interest and in view especially of the important influence which they have had. The first is the British empire exhibition held at Wembley park (near London) in 1924 and 1925. The exhibition was unique in its scope and purpose, inasmuch as it was confined to the products of the British empire and had as its objects the demonstration of the wealth and resources of the empire, and the promotion of inter-imperial unity. The exhibition will probably be regarded in years to come as one of the most significant events in the story of British imperial development.

Paris Exhibition, 1925.—The Exhibition of Modern Decorative and Industrial Arts held at Paris in 1925 also marked in some ways a new departure. At previous exhibitions the art exhibits—if any—had been segregated in "art palaces" (usually confined to the "fine arts"), instead of forming an integral part of the industrial exhibition. The aim of the Paris exhibition, which was abundantly fulfilled, was to secure a comprehensive display of industrial products of all kinds in which modern design plays an important part. The result was a highly interesting series of national pavilions erected by the various participating countries. The exhibits exercised an influence which can be detected in almost every form of artistic effort.

The Question of Awards.—The Paris exhibition was notable, moreover, in rehabilitating the system of awards, which had fallen somewhat into disrepute, so much so indeed that it was decided that no awards should be given at the British empire exhibition. The prestige attaching to awards given in connection with exhibitions is entirely dependent on the methods of their distribution. A well deserved award of success in industrial competition is of the highest value to the winner. Unfortunately the system of

granting awards at international exhibitions has provoked considerable criticism: whether the tendency has been towards distribution to firms rather on the basis of their commercial status and previous successes than on the intrinsic merits of their actual exhibits, or whether other less deserving considerations have been at work, the value of exhibition diplomas and medals has unquestionably depreciated. But if the methods adopted at the Paris exhibition in 1925 can be maintained, there is no reason why the system of awards should not regain its place as a true gauge of merit, with its attendant commercial value. The test of all efficiency must eventually be competition. As the high value attaching to winning an international competition, whether it be a contest in the air or on the road or track, is sufficient evidence.

TRADE FAIRS

During the World War, and to a greater extent after its close, new trade fairs sprang up all over Europe. The progress of these fairs has been remarkable. In most instances they are international, but there are a few national fairs, notably the British Industries fair in London and Birmingham and the Swiss Industries fair at Basle. They are of short duration, usually two weeks and sometimes less. In the case of the larger fairs the exhibitors run into several thousands and they are attended by buyers from all over the world. It may be that the number is excessive, but those which do not fill a need will disappear in time. The majority of fairs in Europe are held early in the spring, and in some cases an autumn fair is also organized. They generally comprise all industries except heavy machinery, and even this is sometimes shown in special halls, notably at Leipzig and Birmingham.

Apart from the general trade fairs referred to, there are a vast number of special fairs of short duration dealing with one or more industries. In this category come the great automobile shows, also shows for electrical appliances of all kinds, radiography, and all the latter-day developments of communication of speech and sound, and it is obvious that this last category will attain increased importance and dimensions. Practically every industry has its special annual demonstration and in many cases these comprise competitive sections.

The rapid post-war growth of trade fairs has also marked very clear stages in their method of development. Road-side booths or huts distributed often over large areas sometimes in a haphazard way have gradually given place to substantial permanent buildings in which trades can be arranged in their appropriate sections. This evolution on the whole has been general, but most marked perhaps in the case of Lyons and Leipzig. The system of sectional arrangement has been strictly enforced in the case of the British Industries fair since its initiation in 1915, and the convenience to buyers needs no emphasis. The question of concentration of *locale* presents far greater difficulties. Local interests, whether commercial or political, have so far prevented any approach to complete concentration in any one country. Nor does it appear probable that these conditions will disappear, but even with these disabilities it is certain that trade fairs as they at present exist have become an important and permanent factor in international commerce, and indications generally are towards development rather than diminution. The increased costs of communication and living tend to hamper the ranges of activity of the commercial traveller, and there is a growing tendency to resort to the convenient and expeditious methods of the periodic trade fair with the wide range of selection which is offered at this kind of exhibition.

The following may be noted as amongst the more important of the post-war fairs in Europe:—British Industries fair (London and Birmingham); Paris, Lyons, Lille, Bordeaux (France); Antwerp, Brussels (Belgium); Leipzig, Cologne, Frankfort, Königsberg (Germany); Basle, Lausanne (Switzerland); Milan, Padua, Naples (Italy); Valencia (Spain); Vienna (Austria); Prague, Bratislava (Czechoslovakia); Danzig; Copenhagen (Denmark); Reval (Estonia); Salonika (Greece); Budapest (Hungary); Riga (Latvia); Kaunas (Lithuania); Luxembourg; Utrecht (Holland); Bergen (Norway); Gothenburg, Malmö (Sweden); Poznan (Poland); Zagreb (Yugoslavia); Nijni Novgorod (U.S.S.R.).

One of the largest fairs in the world is the Great National exhibition held at Toronto in the early autumn, which covers an area of 350ac. and 1,500,000 sup.ft. of buildings. (*See* also FAIR.)

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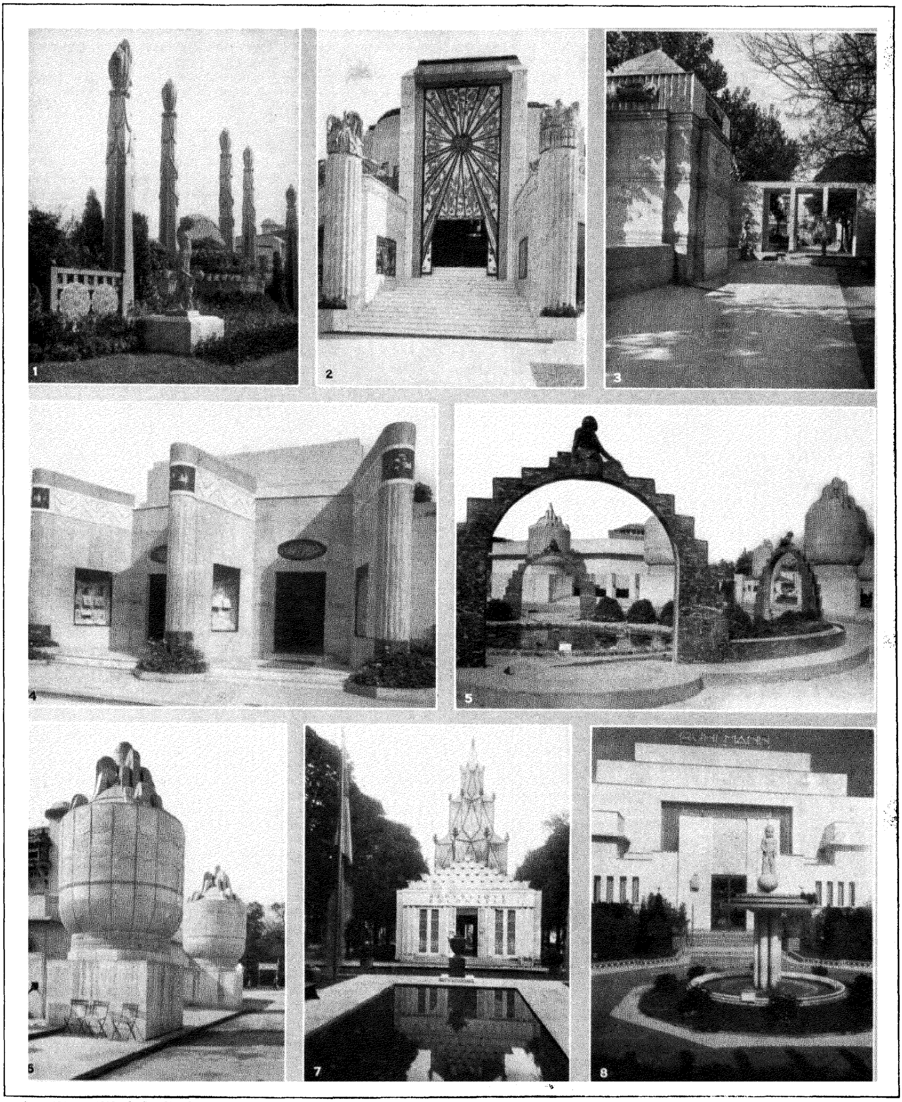
EXHIBITION ARCHITECTURE. An exhibition or exposition is an organized display of works of industry and art, usually international in range of selection and appeal. Market, fair, mart, exhibition and exposition are terms used almost interchangeably. A fair is often a special market; and a mart has been defined as a greater species of fair. An exhibition is any general and public display, and in particular a public show of goods for the promotion of trade. By decision of an international exhibitors' conference called by the German Government in Berlin in 1912 an exhibition is universal when opened to every possible expression of human effort; it is official when it is originated directly by a Government; and it is under official patronage when it is originated by a non-Governmental body with the patronage of a Government. Generally, an exhibition or exposition is assumed to reflect human progress, to be open to every branch of human effort and to have a didactic import. A fair may be assumed to assemble raw and manufactured articles for brief display and to be commercial.

Design.—Some of the later "sample" fairs have made use of temporary and flimsy structures, like booths in a market place. The larger of such fairs, however, have inclined to use great permanent buildings, however scattered. Special expositions, following the example set by London with the Crystal Palace, have erected on such open spaces as were available huge structures, at least one of which is usually permanent.

Breadth, freedom and largeness of scale were given to all planning and designing for world's fairs by Daniel H. Burnham and his associates in Chicago for the Columbian exposition of 1893. These men worked on 600 ac. of undeveloped park land as on a blank piece of paper. They conceived an entire investiture for the exposition—landscape, buildings and sculpture—and had the satisfaction of seeing their broad conception grow into a reality. The firm of Carrère and Hastings, for the Buffalo Pan-American exposition of 1901, essayed to represent in the buildings of one major section of their plan what man had gained after long years of strife with the elements, and in the buildings of the corresponding section the elements themselves. The struggle between these forces was intended to be denoted by positive colours of red, blue, green and gold, which graduated gently into tints until an electric tower was reached, where the prevailing tone was a deep green as nearly as possible the colour of Lake Erie. The tower, which had works of sculpture on its four corners at the base, was of a light ivory and was tinted with blue, green and gold, which grew fainter as the top was reached, terminating in a gilt figure of the Goddess of Light. St. Louis, in 1904, employed the largest area so far given to such a plan, about 800 acres. The programme of obtaining an open space and planning for it a series of entirely new buildings in a setting of lagoons, drives, gardens, fountains and sculpture, all to combine in a single, new, comprehensive art expression, was generally adopted. E. L. Masqueray was the architect and designer-in-chief.

By the time the San Francisco exposition for 1915 was planned, the designing of exposition buildings and grounds had become almost a profession. One of Burnham's later associates, Edward



PHOTOGRAPHS, COPR. F. R. YERBURY

ARCHITECTURE AT THE PARIS EXPOSITION DES ARTS DECORATIFS

1. Garden on the terrace of the railway station, by J. H. Lambert. **2.** Pavilion of Galeries Lafayette, by J. Hiriart, G. Triboul and G. Beau. **3.** Promenade before Austrian Pavilion by Josef Hoffmann. **4.** Pavilion for Crès, bookseller, designed to represent enormous books, with top in white, yellow and bronze. **5.** Sèvres Pavilion, and Garden, by Patout et Ventre. **6.** Sèvres Pavilion. **7.** Polish Pavilion with glass top, by Czajkowski. **8.** Pavilion of a collector, showing façade and garden by P. Patout

H. Bennett, was employed as architect of the grounds, and he produced a novel plan—a series of courts which met the climatic need of trapping the sunlight and sheltering the visitors from the brisk breezes that blow across San Francisco bay in midsummer. This led to an architectural treatment of the structures by courts, so that each designer in reality did the sides of four buildings, while other designers did the outer walls of the same buildings. The second respect in which the designing for San Francisco was unusual was that Jules Guerin was chosen as head of the department of colour, and while working in co-operation with the architects he went somewhat independently to work planning for a freer use of colour than in any other group of modern times. Several schools of architecture were represented in the designing of the courts—Moorish-Spanish, Romanesque, Italian Renaissance; and it is remarkable that with the extensive use of pink, tan, orange, red, yellow and green, the effect of the whole was harmonious and rich. San Diego in the same year employed only one architect, Bertram G. Goodhue, and he adapted the more ornate architecture of Spain to the needs of modern life. In contrast with the exterior application of colour at San Francisco, the colour was built into the structures of San Diego by the use of tiles and was introduced into the setting by truly magnificent planting.

For the British empire exhibition at Wembley (1924–25), four general buildings and 21 special buildings were erected of concrete on the most simple of classic lines. Variety and colour were introduced into the composition by the kiosks, band-stands and pavilions. Rio de Janeiro in 1922 and Seville and Barcelona for 1928 and 1929 adopted comprehensive plans. All designing and displays for the Paris Exposition des Arts Décoratifs of 1925 were required "to present the character of art and to be of strictly modern tendency." Nothing was to be exhibited which to the authorities would seem to be an expression or an imitation of any ancient style. The effect was to bring to one centre illustrations of the increasing radicalism that has marked recent design throughout continental Europe. Frankly temporary, the new constructions and the treatments of the gardens and plazas offered the appeal of lightness, brilliance and the bizarre.

Influence.—Fairs and expositions of all sorts must be assumed to exercise an influence that is immediate, continuous, far-reaching. Two years sufficed to carry to all the centres of the Occident the influence of the Exposition des Arts Décoratifs of 1925. Its diagonal lines, its "philosophical" and original motifs, its independence of tradition, its studied avoidance of natural and pictorial forms, were soon reflected in design.

To the San Diego exposition and the ascendancy of Goodhue in the United States is attributed the striking spread of Moorish-Spanish architecture throughout the southern States of the American Union. In Florida the projectors of the large east coast hotels had long before proposed this type of design as especially suited to that section. But it was not until great numbers of real estate promoters and owners had been made familiar with buildings of this small exposition, and in a lesser degree with those of San Francisco, that the movement became truly popular.

Probably the most impressive evidence of the influence of such an exposition is provided by the exposition in Chicago in 1893. The magnificence of the court of honor, the manifest harmony suggested by a uniform cornice line, the dignity and grace of the classic orders, came to the people of the United States and Canada as something akin to a revelation. Rough stone and imitations of the designs of H. H. Richardson suddenly ceased to be fashionable even in remote localities. The public buildings erected in the United States from 1893 to 1915 were, with few exceptions, built on the more usual classic lines.

For the making of parks city authorities were more easily persuaded to employ landscape architects. Burnham's personal influence moved officials of Chicago, Cleveland and Washington, D.C., to enter upon the study of street extensions and the improvement of existing streets with regard for their relation to a general economic and functional plan for the city. With Charles F. McKim, Augustus St. Gaudens and F. L. Olmsted, he accepted appointment to the Washington park commission and provided the U.S. Senate with a development of the original plan of L'Enfant and Ellicott for the capital city. Social workers, engineers and architects related the teachings of Burnham and his associates to the problems of rapidly growing cities in new countries, and, traceable primarily to this exposition, there came into existence the new efficiency and correspondingly new profession of city planning (*see* TOWN AND CITY PLANNING).

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EXHUMATION: *see* BURIAL.

EXILARCH, in Jewish history, "Chief, or Prince, of the Captivity." The Jews of Babylonia, after the destruction of the First Temple, were termed the people of the "Exile." Hence the head of the Babylonian Jews was the Exilarch (in Aramaic *Resh Galutha*). The office was hereditary and carried with it considerable power. Some traditions regarded Jehoiachin, the captive king of Judah, as the first exilarch, and all later holders of the dignity claimed to be scions of the house of David. The office comes into prominence under the Arsacids and Sassanids. In 520 an attempt was made to secure political autonomy for the Jews by force, but the exilarch who led the movement (Mar Zutra) was executed. For some time thereafter the office was in abeyance, but it was revived under Muslim rule with enhanced dignity. From the middle of the 7th century the exilarchs were all descendants of Bostanai (*q.v.*) through whom "the splendour of the office was renewed and its political position made secure" (Bacher). The last exilarch of importance was David, son of Zakkai (d. 940), whose contest with Saadiah had momentous consequences. A persecution culminating in the death of his descendant Hezekiah (1040) put an end to the grandeur of the institution. However (contrary to what was formerly supposed), it continued sporadically until late in the 13th century, having as its counterpart the office of *Nagid* in Egypt and *Nasi* in Palestine and elsewhere.

A vivid account has come down of the ceremonies at the installation of a new exilarch during the period of Muslim rule, from which most of our knowledge dates. Homage would be paid on that occasion by the heads of the rabbinical academies each of whom was called Gaon. The exilarch could excommunicate, appoint judges, exact taxes, and had in addition considerable secular jurisdiction. An hyperbolical description of the glories of the office is given in Disraeli's novel *Alroy*.

See F. Lazarus, *Die Haupter der Vertrieben*, from Brull's *Jahrbuch für judische Geschichte und Literatur*, vol. x. (1890); Bacher in *Jewish Encyclopaedia* v. 288; Malter, *Saadia*, p. 92 *seq.*; Mann, *The Jews in Palestine and Egypt under the Fatimids, passim.*

EXILE, banishment from one's native country by the sovereign authority. In a general sense exile is applied to prolonged absence from one's country either through force of circumstances or when undergone voluntarily. Among the Greeks, in the Homeric age, banishment (φυγή) was sometimes inflicted as a punishment by the authorities for crimes affecting the general interests, but is chiefly known in connection with cases of homicide. With these the State had nothing to do; the punishment of the murderer was the duty and privilege of the relatives of the murdered man. Unless the relatives could be induced to accept a money payment by way of compensation (ποινή, weregeld; *see* especially Homer, *Iliad*, xviii. 497), in which case the murderer was allowed to remain in the country, his only means of escaping punishment was flight to a foreign land. If, during his self-imposed exile, the relatives expressed their willingness to accept the indemnity, he was at liberty to return and resume his position in society.

In later times banishment is (1) a legal punishment for particular offences; (2) voluntary.

1. Banishment for life with confiscation of property was inflicted upon those who destroyed or uprooted the sacred olives at Athens; upon those who remained neutral during a sedition (by a law of Solon which subsequently fell into abeyance); upon those who gave refuge to or received on board ship a man who had fled to avoid punishment; upon those who wounded with intent to kill and those who prompted them to such an act (it is uncertain whether in this case exile was for life or temporary); upon anyone who wilfully murdered an alien; for impiety. Certain political crimes were also similarly punished—treason, laconism, sycophancy (*see* SYCOPHANT), attempts to subvert existing decrees. For the peculiar form of banishment called OSTRACISM, *see* separate article.

2. Citizens sometimes voluntarily left the country for other reasons (debt, inability to pay a fine). Since extradition was only demanded in cases of high treason or other serious offences against the State, the fugitive was not interfered with. He was at liberty to return after a certain time had elapsed.

Little is known about exile as it affected Sparta and other Greek towns, but it is probable that the same conditions prevailed as at Athens.

At Rome, in early times, exile was not a punishment, but rather a means of escaping punishment. Before judgment had been finally pronounced it was open to any Roman citizen condemned to death to escape the penalty by voluntary exile (*solum vertere exsilii causa*). To prevent his return, he was interdicted from the use of fire and water; if he broke the interdict and returned, anyone had the right to put him to death. The *aquae et ignis* (to which *et tecti* "shelter" is sometimes added) *interdictio* is variously explained as exclusion from the necessaries of life, from the symbols of civic communion, or from "the marks of a pure society, which the criminal would defile by his further use of them." Subsequently (probably at the time of the Gracchi) it became a recognized legal penalty, practically equivalent to "exile," taking the place of capital punishment. The criminal was permitted to withdraw from the city *after* sentence was pronounced; but in order that this withdrawal might as far as possible bear the character of a punishment, his departure was sanctioned by a decree of the people which declared his exile permanent. Authorities are not agreed whether this exile by interdiction entailed loss of *civitas;* according to some this did not ensue until (as in earlier times) the criminal had assumed the citizenship of the State in which he had taken refuge and thereby lost his rights as a citizen of Rome, while others hold that it was not until the time of Tiberius (A.D. 23) that *capitis deminutio media* became the direct consequence of trial and conviction. *Interdictio* was the punishment for treason, murder, arson and other serious offences which came under the cognizance of the *quaestiones perpetuae* (permanent judicial commissions for certain offences); confiscation of property was only inflicted in extreme cases.

Under the Empire *interdictio* gradually fell into disuse and a new form of banishment, introduced by Augustus, called *deportatio,* generally *in insulam,* took its place. For some time the two probably existed side by side. *Deportatio* consisted in transportation for life to an island (or some place prescribed on the mainland, not of Italy), accompanied by loss of *civitas* and all civil rights, and confiscation of property. The most dreaded places of exile were the islands of Gyarus, Sardinia, an oasis in the desert (*quasi in insulam*) of Libya; Crete, Cyprus and Rhodes were considered more tolerable. Large bodies of persons were also transported in this manner; thus Tiberius sent 4,000 freedmen to Sardinia for Jewish or Egyptian superstitious practices. *Deportatio* was originally inflicted upon political criminals, but in course of time became more particularly a means of removing those whose wealth and popularity rendered them objects of suspicion. It was also a punishment for the following offences: adultery, murder, poisoning, forgery, embezzlement, sacrilege and certain cases of immorality.

Relegatio was a milder form of *deportatio.* It either excluded the person banished from one specified district only, with permission to choose a residence elsewhere, or the place of exile was fixed. *Relegatio* could be either temporary or for life, but it did not in either case carry with it loss of *civitas* or property, nor was the exile under military surveillance, as in the case of *deportatio.* Thus, Ovid, when in exile at Tomi, says (*Tristia,* v. xi.): "he, *i.e.,* the emperor, has not deprived me of life, nor of wealth, nor of the rights of a citizen . . . he has simply ordered me to leave my home." He calls himself *relegatus,* not *exsul.*

In later writers the word *exsilium* is used in the sense of all its three forms—*aquae et ignis interdictio, deportatio* and *relegatio.*

See ALIEN; DEPORTATION; EXPATRIATION; EXPULSION.

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EXILI, an Italian chemist and poisoner in the 17th century. His real name was probably Nicolo Egidi or Eggidio. Tradition credits him with having been originally the salaried poisoner at Rome of Olympia Maidalchina, the mistress of Pope Innocent X. Subsequently he became a gentleman in waiting to Queen Christina of Sweden, whose taste for chemistry may have influenced this appointment. In 1663 he was imprisoned in the Bastille. Here he is said to have made the acquaintance of Godin de Sainte-Croix, the lover of the marquise de Brinvilliers (*q.v.*). After three months' imprisonment, powerful influences secured Exili's release, and in 1681 he was again in Italy, where he married the countess Fantaguzzi, second cousin of Duke Francis of Modena.

EXMOOR FOREST, a high moorland in Somersetshire and Devonshire, England. The uplands of this district are bounded by the alluvial plain of Sedgemoor (east), the basin of the Exe (south), that of the Taw (west) and the Bristol channel (north), and in this area is included also the Brendon and Quantock hills. The area of Exmoor above 1,000 ft. is 120 sq.m. The geological formation is Devonian. The ancient forest (area 20,000 acres) was enclosed in 1815. Large tracts are still uncultivated; and the wild red deer and native Exmoor pony are characteristic of the district. The highest point is Dunkery Beacon (1,707 ft.), but Span Head is 1,618 ft., and a height of 1,500 ft. is exceeded at several points. The Exe, Barle, Lyn and other streams, traversing deep picturesque valleys except in their uppermost courses, are in favour with trout fishermen. The villages Exford, Withypool and Simonsbath, with Lynton and Lynmouth on the coast, afford centres for tourists and sportsmen. Exmoor is noted for its stag hunting.

EXMOUTH, EDWARD PELLEW, 1ST VISCOUNT (1757–1833), English admiral, was born at Dover, on April 19, 1757. In 1770 he entered the navy, where his great ability soon became apparent. He had no opportunity of active service till 1776, when his action at the battle of Lake Champlain gained him a lieutenant's commission and the command of the "Carleton." In 1777 he commanded a brigade of seamen in General Burgoyne's American campaign, and three years later he compelled three French privateers to run ashore, for which act he received the rank of post-captain. During the French revolutionary wars he commanded the "Nymph" and the "Arethusa," and then hoisted his flag as a squadron commander in the "Indefatigable"; for his bravery in boarding the wrecked transport "Dutton," and the measures which he adopted to save the lives of all on board, he was in 1796 created a baronet. In 1798 he joined the channel fleet, and in command of the "Impétueux" (74) took part in several actions with great distinction.

In 1802 Pellew was elected M.P. for Dunstable. In 1804 he became commander-in-chief in India, where he entirely cleared the seas of French cruisers, and secured complete protection for British commerce. He returned to England in 1809, held the North Sea (1810) and Mediterranean (1811) command, and in 1814 was created Baron Exmouth. When the dey of Algiers, in 1816, violated the treaty for the abolition of slavery, Exmouth was

directed to attack the town. Accordingly, on Aug. 26, he engaged the Algerine battery and fleet, and after a severe action, set on fire the arsenal and every vessel of the enemy's fleet, and shattered the sea defences into ruins. For this victory Exmouth was advanced to the dignity of viscount. Shortly before his death, on Jan. 23, 1833, he was made vice-admiral.

His descendant, Charles Ernest Pellew (b. 1863), became the 7th viscount in 1923.

Exmouth's second son, Sir Fleetwood Broughton Reynolds Pellew (1789–1861), was like his father an admiral. The third son was George Pellew (1793–1866), author and divine, who married Frances (d. 1870), daughter of the prime minister, Lord Sidmouth, whose biography he wrote (*The Life and Correspondence of Henry Addington, 1st Viscount Sidmouth*, 1847).

Exmouth had a brother, Sir Israel Pellew (1758–1832), also an admiral, who was present at the battle of Trafalgar.

A *Life* of the 1st viscount, by Edward Osler, was published in 1835.

EXMOUTH, a market-town, seaport and watering-place in the Honiton parliamentary division of Devonshire, England, on the east bank at the mouth of the river Exe, 8½ m. S.E. by S. of Exeter and 5 m. W. of Budleigh Salterton by either of those routes on the Southern railway. Pop. of urban district (1921) 13,606. In the 18th century it consisted of a fishing village at the base of Beacon hill, a height commanding fine views over the estuary and the English channel. After its more modern terraces were built up the hillside, Exmouth became one of the leading seaside resorts in Devon. Its excellent bathing and the beauty of its coast and moorland scenery attract many visitors in summer, while it is frequented in winter by sufferers from pulmonary disease. The climate is unusually mild, as a range of hills shelters the town on the east. A promenade runs along the sea wall; there are golf links and public gardens, and the port is a favourite yachting centre, a regatta being held annually. Near the town is a natural harbour called the Bight. Docks for the river shipping were built in 1869. A steam ferry connects Exmouth with Starcross on the west shore of the estuary and a station on the G.W. railway. The local industries include fishing, brick-making and the manufacture of Honiton lace. Exmouth was early a place of importance, and in 1347 contributed 10 vessels to the fleet sent to attack Calais. It once possessed a fort or "castelet," designed to command the estuary of the Exe, which was garrisoned for the king during the Civil War, and captured in 1646.

EXODUS, BOOK OF, in the Bible, a book of the Old Testament which derives its name, through the Greek, from the event which forms the most prominent feature of the history it narrates, viz., the deliverance of Israel from Egypt. Strictly speaking, however, this title is applicable to the first half only, the historical portion of the book, and takes no account of those chapters which describe the giving of the Law on Mt. Sinai, nor of those which deal with the Tabernacle and its furniture.

The book of Exodus, like the other books of the Hexateuch, is a composite work which has passed, so to speak, through many editions; hence the order of events which it sets forth cannot lay claim to any higher authority than that of the latest editor. Moreover, the documents from which the book has been compiled belong to different periods in the history of Israel, and each of them, reflects the standpoint of the age in which it was written. The contents are not of equal historical value, but greater weight naturally attaches to the earlier documents in those cases in which the sources are at variance with one another. The contents may be most conveniently treated under three main heads: (*a*) the historical portion (ch. i.–xviii.); (*b*) the sections dealing with the giving of the Law (xix.–xxiv., xxxii.–xxxiv.), and (*c*) the construction of the Tabernacle and its furniture (xxv.–xxxi., xxxv.–xl.).

(*a*) (1) *Israel in Egypt and the Exodus* (ch. i.–xviii.). The narrative which is derived from JE sets forth the rise of a new king in Egypt, who endeavoured to check the growing strength of the children of Israel; it thus prepares the way for the birth of Moses, his early life in Egypt, his flight to Midian and marriage with Zipporah, the theophany at Mt. Horeb, and his Divine commission to deliver Israel from Egypt. The two sources betray their divergent origin and point of view. J presents the Israelites as dwelling apart in the province of Goshen: to meet the danger of their rapid increase the Egyptians subject them to severe measures of repression. At his call Moses is given three signs to attest his Divine commission, one of which is wrought with his rod. He and the elders of Israel are bidden to interview Pharaoh and to request that they may go three days' journey into the wilderness for the purpose of sacrifice. The request is met by the imposition of harsher conditions of service. According to E the Israelites dwell among the Egyptians, and two midwives are sufficient for the needs of the growing population. Aaron, who occupies a prominent position throughout this narrative, is appointed to be Moses' spokesman with the people, and the only sign given to Moses is the promise that after their release the people "shall serve God upon this mountain." Moses and Aaron are directed to demand the release of Israel, an event which will be marked by a spoiling of the Egyptians. Finally not one but many signs are to be performed with the rod, referring probably to the plagues of Egypt, which were invariably wrought according to E by "the rod of God." The section concludes with P's parallel account (vi. 2–vii. 13) of the events recorded in cc. iii.–v. Apart from its literary style this narrative presents the following points of variation: (1) The people refuse to listen to Moses; (2) Aaron is appointed to be Moses' spokesman not with the *people* but with Pharaoh; (3) one sign is given with Aaron's rod, which is turned into a reptile (*tannin*), not a serpent (*nāḥāsh* iv. 3), before Pharaoh.

(2) vii. 14–xi. 10. *The First Plagues of Egypt.* In this section the three main sources are clearly marked off from one another both by their linguistic features and by their difference of representation. The principal source is J from which are derived six plagues, viz., killing of the fish in the river, frogs, insects, murrain, hail, locusts and the threat to slay all the first-born. The plagues are represented as mainly due to natural causes and follow a natural sequence. Other distinctive features of J's narrative are: (1) Moses alone is bidden to interview Pharaoh; (2) on each occasion he makes a formal demand; (3) on Pharaoh's refusal the plague is announced, and takes place at a fixed time without any human intervention; (4) when the plague is sent, Pharaoh sends for Moses and entreats his intercession, promising in most cases to accede in part to his request; when the plague is removed, however, the promise is left unfulfilled, the standing phrase being "and Pharaoh's heart was heavy," or "and Pharaoh made heavy his heart"; (5) the plagues do not affect the children of Israel in Goshen. E's account (water turned into blood, hail, locusts) is more fragmentary, having been doubtless superseded in most cases by the fuller and more graphic narrative of J, but the plague of darkness (x. 20–23, 27) is found only in this source. As contrasted with J the narrative emphasizes the miraculous character of the plagues. They are brought about by "the rod of God," which Moses wields, the effect being instantaneous and all-embracing. The Israelites are represented as living among the Egyptians, and enjoy no immunity from the plagues, except that of darkness. Their departure from Egypt is deliberate; the people have time to borrow raiment and jewels from their neighbours. E regularly uses the phrase "and Pharaoh's heart was strong," or "and Yahweh made strong Pharaoh's heart" and "he would not let the children of Israel (or, them) go." In the priestly narrative (P) the plagues assume the form of a trial of skill between Aaron, who acts at Moses' command, and the Egyptian magicians, and thus connect with vii. 8–13. The magicians succeed in turning the Nile water into blood, and in bringing up frogs, but they fail to bring forth lice, and are themselves smitten with boils; the two last-named plagues have no parallel either in J or E. Throughout the P sections Aaron is associated with Moses, and the regular command given to the latter is, "Say unto Aaron": no demand is ever made to Pharaoh, and the description of the plague is quite short. The formula employed by P is similar to that of E, but it is distinguished by the addition of "and he hearkened not unto them as Yahweh had spoken."

(3) xii. 1–xiii. 16. *The Last Plague, the Deliverance from*

Egypt, the Institution of the Passover and of the Feast of Unleavened Cakes, the Consecration of the First-born. This section presents repetitions and inconsistencies. Thus J's regulations for the Passover (xii. 21–23, 27*b*) are a parallel and divergent account of those given in *vv.* 1–13 (P). In these verses the choice of the lamb and the manner in which it is to be eaten constitute the essential feature, the smearing with the blood being quite secondary; in *vv.* 21 *seq.* the latter point is all-important, and no regulations are given for the paschal meal (which, possibly, formed no part of J's original account). Similarly the institution of the Feast of *Mazzoth,* or Unleavened Cakes (xiii. 3–10J), does not form the sequel to the regulations laid down in xii. 14–20 (P), but is independent of them: it omits all reference to the "holy convocations" and to the abstinence from labour, and is obviously simpler and more primitive. J's account, again, makes important exceptions (xiii. 11–13) to the severe enactment of P with reference to the first-born (xiii. 1). The description of the smiting of the first-born of Egypt is mainly derived from J, who sees in the Feast of *Mazzoth* a perpetual reminder of the haste with which the Israelites fled from Egypt.

(4) xiii. 17–xv. 21. *The Crossing of the Red Sea.* According to J the children of Israel departed from Egypt under the guidance of Yahweh, who leads them by day in a pillar of cloud and by night in a pillar of fire (xiii. 21, 22). On hearing of their flight Pharaoh at once starts in pursuit. The Israelites, terrified by the approach of the Egyptians, upbraid Moses, who promises them deliverance by the hand of Yahweh. Yahweh then causes a strong east wind to blow all that night, which drives back the waters from the shallows, and so renders it possible for the host of Israel to cross over. The Egyptians follow, but the progress of their chariots is hindered by the soft sand, and in the morning they are caught by the returning waters. The story, however, has been combined with the somewhat different account of E, which doubtless covered the same ground, and also with that of P. According to the former Moses divided the waters by stretching out his rod, thus presupposing that the crossing took place by day, and the dark cloud which divided the two hosts was miraculously caused by the angel of God. P also represents the sea as divided by means of Moses' rod, but heightens the effect by describing the crossing as taking place between walls of water. J's version of the Song of Moses probably does not extend beyond xv. 1, and has its counterpart in the very similar song of Miriam (E), in *vv.* 20, 21. The rest of the song (*vv.* 2–18) is probably the work of a later writer; for these verses set forth not only the deliverance from Egypt, but also the entrance of Israel into Canaan (*vv.* 13–17), and further presuppose the existence of the temple (*vv.* 13*b*, 17*b*).

(5) xv. 22–xviii. 27. *Incidents in the Wilderness.* The narrative of the first journeying in the wilderness (xv. 22–xvii. 7) presents a series of difficulties which probably owe their origin to the editorial activity of R^P, who appears to have transferred to the beginning of the wanderings a number of incidents which rightly belong to the end. The concluding verses of ch. xv. contain J's account of the sweetening of the waters of Marah. Then follows (ch. xvi.) P's version of the sending of the manna and quails. Neither of these stories, however, is in its proper position. The story of the manna belongs to a later period *after* the departure from Mt. Sinai, and had originally no immediate connection with the story of the quails. The latter, which is incomplete, is derived from Num. xi. (JE) where the incident is placed at the end of the wanderings.

xvii. 8–16. *The Battle with Amalek at Rephidim.* This incident is derived from E, but is clearly out of place in its present context. Its close connection with the end of the wanderings is shown by (*a*), the description of Moses as an infirm old man; (*b*) the rôle played by Joshua in contrast with xxiv. 13, xxxiii. 11, where he is introduced as a young man and Moses' minister; and (*c*) the references elsewhere to the home of the Amalekites who dwelt in the south or south-west of Judah near Kadesh.

Ch. xviii. *The visit of Jethro to Moses and the appointment of judges.* This story, like the preceding one, is mainly derived from E and is also out of place. Allusions in the chapter itself point unmistakably to a time just before the departure from Sinai-Horeb, and this date is confirmed both by Deut. i. 9–16 and by the parallel account of J in Num. x. 29–32.

(*b*) Ch. xix.–xxiv., xxxii.–xxxiv. The contents of these chapters, which, owing to their contents, form the most important section in the book of Exodus, may be briefly analysed as follows: In ch. xix. we have a two-fold description of the theophany on Mt. Sinai (or Horeb), followed by the Decalogue in xx. 1–17. Alongside of this code we find another dealing in part with the civil and social (xxi. 2–xxii. 17), in part with the religious life of Israel, the so-called Book of the Covenant, xx. 22–xxiii. 19. Ch. xxiv. contains a composite narrative of the ratification of the covenant. In chs. xxxii. and xxxiii. we have again two narratives of the sin of the people and of Moses' intercession, while in ch. xxxiv. we are confronted with yet another early code, which is practically identical with the religious enactments of xx. 22–26; xxii. 29, 30; xxiii. 10–19.

Ch. xix. contains two parallel accounts of the theophany on Horeb-Sinai, from E and J respectively, which differ materially from one another. According to the former, Moses is instructed by God (Elohim) to sanctify the *people* against the third day (*vv.* 9*a*, 10, 11*a*). This is done and the people are brought by Moses to the foot of the mountain (Horeb), where they hear the divine voice (14–17, 19). In J, on the other hand, it is the *priests* who are sanctified, and great care must be taken to prevent the people from "breaking through to gaze" (20–22). In this account the mountain is called "Sinai" throughout, and "Yahweh" appears instead of "Elohim." *Vv.* 3*b*–8 should follow after xx. 21.

Of the succeeding legislation in xx.–xxiii., xxxii.–xxxiv., undoubtedly the earlier sections are xx. 22–26; xxii. 29, 30; xxiii. 10–19, and xxxiv. 10–26, which contains regulations with regard to worship and religious festivals, and form the basis of the covenant made by Yahweh with Israel on Horeb-Sinai, as recorded by E and J respectively. The narrative which introduces the covenant laws of J has been preserved partly in its present context, ch. xxxiv., partly in xxiv. 1, 2, 9–11; the narrative of E, on the other hand, has in part disappeared owing to the interpolation of later material, in part has been retained in xxiv. 3–8. J's narrative xxiv. 1 *seq.*, 9–11 clearly forms the continuation of xix. 20 *seq.*, 11*b*, 13, 25, but the introductory words of *v.* 1, "and unto Moses he said," point to some omission. Originally, no doubt, it included the recital of the Divine instructions to the people in accordance with xix. 21 *seq.*, the statement that Yahweh came down on the third day, and that a long blast was blown on the trumpet (or ram's horn). From xxiv. 1 *seq.* we learn that Moses and Aaron, Nadab and Abihu, and 70 of the elders were summoned to the top of the mountain, but that Moses alone was permitted to approach Yahweh. Then followed the theophany, and, as the text stands, the sacrificial meal (9–11). The conclusion of J's narrative is given in ch. xxxiv., which describes how Moses hewed two tables of stone at Yahweh's command, and went up to the top of the mountain, where he received the words of the covenant and wrote them on the tables. As it stands, however, this chapter represents the legislation which it contains as the renewal of a former covenant, also written on tables of stone, which had been broken (1*b*, 4*a*). But the document from which the chapter, as a whole, is derived, is certainly J, while the previous references to tables of stone and to Moses' breaking them belong to the parallel narrative of E. Moreover, the covenant here set forth (*v.* 10 *seq.*) is clearly a new one, and contains no hint of any previous legislation, nor of any breach of it by the people. In view of these facts we are forced to conclude that 1*b* ("like unto the first . . . brakest"), 4*a* ("and he hewed . . . the first") and *v.* 28 ("the ten words") formed no part of the original narrative, but were inserted by a later Deuteronomic redactor. In the view of this editor the Decalogue alone formed the basis of the covenant of Sinai-Horeb, and in order to retain J's version, he represented it as a renewal of the tables of stone which Moses had broken.

The legislation contained in xxxiv. 10–26, which may be described as the oldest legal code of the Hexateuch, is almost entirely religious. The parallel collection of E is preserved in xx. 24–26, xxiii. 10–19, to which we should probably add xxii. 29–31 (for

which xxiii. 19*a* was afterwards substituted). The two collections resemble one another so closely, in form and extent, that they can only be regarded as two versions of the same code. E has, however, preserved certain additional regulations with regard to the building of altars (xx. 24–26) and the observance of the 7th year (xxiii. 10, 11), and omits the prohibition of molten images (xx. 22, 23, appear to be the work of a redactor); xxiii. 20–33, the promises attached to the observance of the covenant, probably formed no part of the original code, but were added by the Deuteronomic redactor. The narrative of E relative to the delivery of these laws has disappeared, but xxiv. 3–8 clearly point back to some such narrative. These verses describe how Moses wrote all the words of the Lord in a *book* and recited them to the *people* (*v.* 7), as the basis of a covenant, which was solemnly ratified by the sprinkling of the blood of the accompanying sacrifices.

In the existing text the covenant laws of E are combined with a mass of civil and other legislation; and the title "Book of the Covenant" has usually been applied to the whole section, xx. 22–xxiii. 33. However, this section includes three distinct elements; (*a*) the "words" found in xx. 24–26, xxii. 29–31, xxiii. 10–19; (*b*) the "judgments," xxi. 2–xxii. 17; and (*c*) a group of moral and ethical enactments, xxii. 18–28, xxiii. 1–9; and though the last two groups are unmistakably derived from E, they cannot have formed part of the original "Book of the Covenant"; for the "judgments" consist of a number of legal decisions concerning points of civil law, which could not have been included in the covenant which the *people* (xxiv. 3) promised to observe. It is now generally admitted that the words "and the judgments" have been inserted in xxiv. 3*a* by the redactor to whom the present position of the "judgments" is due. The majority of critics adopt Kuenen's conjecture that the "judgments" were originally delivered by Moses on the borders of Moab, and that when D's revised version of Ex. xxi.–xxiii. was combined with JE, the older code was placed alongside of E's other legislation at Horeb. The third group of laws (xxii. 18–28, xxiii. 1–9) appears to have been added somewhat later than the bulk of xxi.–xxiii. It consists largely of moral injunctions affecting the individual, which cannot have found place in a civil code. At the same time, these additions must for the most part be prior to D, since many of them are included in Deut. xii.–xxvi.

It is obvious that the results obtained by the foregoing analysis of J and E have an important bearing on the history of the remaining section of E's legislation, viz., the *Decalogue* (*q.v.*), Ex. xx. 1–17 (=Deut. v. 6–21). At present the "Ten Words" stand in the forefront of E's collection of laws, and it is evident that they were already found in that position by the author of Deuteronomy, who treated them as the sole basis of the covenant of Horeb. The evidence, however, afforded (*a*) by the parallel version of Deuteronomy and (*b*) by the literary analysis of J and E not only fails to support this tradition, but excites the gravest suspicions as to the originality both of the *form* and of the *position* in which the Decalogue now appears. For when compared with Ex. xx. 1–17 the parallel version of Deut. v. 6 *seq.* is found to exhibit a number of variations, and in particular, assigns an entirely different reason for the observance of the Sabbath. It is probable that all the commandments were originally expressed in the form of single short sentences, and that the Decalogue in this form was promulgated after the completion of E, but before the writing of D. The two main incidents that precede the departure of the children of Israel from the mountain (Num. x. 29 *seq.*) are (1) the sin of the people, and (2) the intercession of Moses, of both of which a double account has been preserved.

(1) *The Sin of the People.* According to J (xxxii. 25–29) the people, during the absence of Moses, "break loose," *i.e.*, mutiny. Their behaviour excites the anger of Moses on his return, and in response to his appeal the sons of Levi arm themselves and slay a large number of the people: as a reward for their services they are bidden to consecrate themselves to Yahweh. The fragmentary form of the narrative is doubtless due to a later editor, who substituted the story of the golden calf (xxxii. 1–6, 15–24, 35), according to which the sin of the people consisted in direct violation of the 2nd commandment. At the instigation of the people Aaron makes a molten calf out of the golden ornaments brought from Egypt; Moses and Joshua, on their return to the camp, find the people holding festival in honour of the occasion; Moses in his anger breaks the tables of the covenant which he is carrying: he then demolishes the golden calf, and administers a severe rebuke to Aaron. The punishment of the people is briefly recorded in *v.* 35. This latter narrative, which is obviously inconsistent with the story of J, shows unmistakable traces of E. In its present form, however, it can hardly be original, but must have been revised in accordance with the later Deuteronomic conception.

(2) *Moses' Intercession.* The account of Moses' intercession has been preserved in J, though the narrative has undergone considerable dislocation. The true sequence of the narrative appears to be as follows: Moses is commanded to lead the people to Canaan (xxxiii. 1–3); he pleads that he is unequal to the task (Num. xi. 10*c*, 11, 12, 14, 15), and, presumably, asks for assistance, which is promised (omitted). Moses then asks for a fuller knowledge of Yahweh and his ways (xxxiii. 12, 13): this request also is granted (*v.* 17), and he is emboldened to pray that he may see the glory of Yahweh; Yahweh replies that his prayer can only be granted in part, for "man shall not see me and live"; a partial revelation is then vouchsafed to Moses (xxxiii. 18–23, xxxiv. 6–8): finally, Moses beseeches Yahweh to go in the midst of his people, and is assured that Yahweh's presence shall accompany them (xxxiii. 14–16, xxxiv. 9). The passage from Numbers xi., which is here included, is obviously out of place in its present context (the story of the quails), and supplies in part the necessary antecedent to Ex. xxxiii. 12, 13. A similar displacement has taken place with regard to Ex. xxxiv. 6–9, which clearly forms the sequel to xxxiii. 17–23. The latter passage, however, can hardly represent the conclusion of the interview, which is found more naturally in xxxiii. 14–16.

It is a plausible conjecture that the original narratives of J and E also contained directions for the construction of an ark, as a substitute for the personal presence of Yahweh, and also for the erection of a "tent of meeting" outside the camp, and that these commands were omitted by R^P in favour of the more elaborate instructions given in ch. xxv.–xxix. (P). The subsequent narrative of J (Num. x. 33–36, xiv. 44) implies an account of the making of the ark, while the remarkable descriptions in Ex. xxxiii. 7–11 (E) of Moses' practice in regard to the "tent of meeting" points no less clearly to some earlier statement as to the making of this tent. (According to Deut. x. 1 *seq.*, which is in the main a *verbal* excerpt from Ex. xxxiv. 1 *seq.*, Yahweh ordered Moses to make an ark of acacia wood *before* he ascended the mountain). The history of Exodus in its original form doubtless concluded with the visit of Moses' father-in-law and the appointment of judges (ch. xviii.), the departure from the mountain and the battle with Amalek (xvii. 8–16).

(*c*) *The Construction of the Tabernacle and its Furniture* (ch. xxv.–xxxi., xxxv.–xl.). It has long been recognized that the elaborate description of the Tabernacle and its furniture, and the accompanying directions for the dress and consecration of the priests, contained in ch. xxv.–xxxi., have no claim to be regarded as an historical presentment of the Mosaic Tabernacle and its service. The language, style and contents of this section point unmistakably to the hand of P; and it is now generally admitted that these chapters form part of an ideal representation of the post-exilic ritual system, which has been transferred to the Mosaic age.

Bibliography.—Fuller references will be found in the following works, which are especially worthy of mention: S. R. Driver, *Introd. to the Literature of the O.T.*, and "Exodus" in the *Camb. Bible;* B. W. Bacon, *The Triple Tradition of the Exodus* (Hartford, U.S.A., 1894), A. H. McNeile, *The Book of Exodus* (Westminster Commentaries, 1908); also the articles on "Exodus" by G. Harford-Battersby (Hastings, *Dict. Bib.*, vol. i.) by G. F. Moore, *Ency. Biblica*, vol. ii.
(J. F. S.)

EXODUS, THE, the name given to the escape of Israel from Egypt and their journey to Palestine (Gr. ἔξοδος). The narrative as we have it is derived from at least three accounts

which have been interwoven with one another. In outline the story is as follows. The Israelites are in bondage in Egypt, where their numbers and strength arouse the jealous fears of the Egyptian court. They are put to forced labour, and attempts are made to reduce their numbers by the slaughter of all male children. One child, Moses, is saved, partly through the intervention of an Egyptian princess, goes into exile to Midian, meets the God of the fathers of Israel, and is commissioned by Him to deliver His people. He returns and demands of Pharaoh that the Israelites shall be allowed to take a journey into the wilderness to share in a festival to Yahweh. The request of Moses is met by repeated refusal, and each refusal is followed by calamity sent by Yahweh. Finally, as the time for the sacrifice draws near, Yahweh himself (or his "angel") comes to Egypt, the festival is celebrated as best it can be in Egypt, and Yahweh slays the first-born of all Egyptians. Israel is hastily sent away, but is later pursued by Pharaoh, who overtakes the fugitives on the banks of the Red sea. Israel crosses safely (one of the traditions attributes this to unusual but natural causes, the other, and later, makes it miraculous), the Egyptian army follows but is drowned. Israel then makes its way to the sacred mountain, variously called Sinai and Horeb, and there enters into a solemn covenant of mutual adoption with Yahweh. An abortive attempt is made to enter Palestine from the south, and, nearly 40 years later, Israel moves east and north from the neighbourhood of the sacred mountain, and approaches Palestine from the east. Just before the crossing of Jordan and the entry into Palestine, Moses dies.

No certain reference to these events has yet been discovered in Egyptian records, unless, with Josephus and a few modern scholars, *e.g.*, Hall, we regard the story as an account of the expulsion of the Hyksos, seen from the Asiatic side. There are, nevertheless, the strongest grounds for regarding the narrative as historical in outline, though details cannot always be trusted. The whole of Israel's national and religious life was traced back to the covenant at the sacred mountain, and the memory of a divine deliverance from Egypt remained throughout history one of the most powerful factors in the national life. Some kind of disaster overtook the Egyptian troops by the Red sea, and we may regard as substantially accurate the older of the two narratives interwoven in Ex. xiv. 15–31. According to this the combination of a very high wind and a very low tide laid bare a wide stretch of sand normally covered by water. It was still firm when the Israelites crossed, but the Egyptians were caught by the tide returning under the sand, the wheels of their vehicles were clogged, and they themselves were first trapped by the quicksands and then overwhelmed by the water. There is, further, no reason to doubt the accuracy of the main outline of the other events already mentioned, though it is unlikely that the covenant between Yahweh and Israel involved the whole of the Law assigned to the period in the Pentateuch.

The date of the Exodus is still a matter of uncertainty. If the details of the oppression given in Ex. i. 11 are held to be accurate, then the Pharaoh of the oppression must be Rameses II., and the Pharaoh of the Exodus his son Merneptah. The main difficulty in accepting this date lies in the mention of Israel as a settled people of Palestine overthrown by Merneptah, occurring on an inscription of that king. This means that the 19th Dynasty is probably too late a period for the Exodus. Many scholars think that the invading Hebrews are to be identified with the Khabiru of the Tell el-Amarna tablets, or are to be included, wholly or in part, among these wilderness nomads, who attacked Palestine during the decline of the 18th Dynasty. This, on the whole the most probable suggestion, would throw the Exodus back to a point in or near the reign of Thothmes III. and make the 15th century B.C. the earliest possible period. (T. H. R.)

EXOGAMY. In every human society there are certain regulations which control the relation of the sexes and the selection of a mate. Intercourse between close blood-relations as brother and sister, father and daughter, and mother and son, is almost everywhere condemned. But among very many tribes it is forbidden both on grounds of consanguinity and because two individuals are members of the same social group. This prohibition, based upon common membership of a social group, is the law of *exogamy*. If the group is a territorial unit, *e.g.*, a village, the *exogamy* is local. More commonly, membership of the group concerned is determined by kinship, real or fictitious, as in the clan (*see* RELATIONSHIP SYSTEMS). Hence exogamy is often loosely used to indicate *clan exogamy*.

That exogamy prevents the marriage of all near relatives is true only if membership of the exogamous group is determined by descent reckoned through both parents, but this is very rare. Normally descent is traced through only one parent and it is therefore inevitable that certain close blood-relations will not belong to the same group and will therefore be possible mates for each other. Thus if a tribe is patrilineal a man can select wives from among his mother's sisters, her brother's daughters and her brother's son's daughters, and, were exogamy the only marriage prohibition, even his mother would be available to him. On the other hand, clan exogamy does prevent unions between people bearing no relationship to each other, since membership of a clan is dependent upon fictive, not blood relationship.

The rigidity with which the law of exogamy is observed varies considerably. Among some people a breach of it is regarded as incest; among others, though marriage is forbidden, extra-marital relations between clan members are tolerated; while in some cases even marriage can be condoned.

McLennan, who first coined the word, regarded it as the outcome of female infanticide which, by limiting the number of women available within the group, forced tribesmen to capture their wives from their neighbours, but increased knowledge of the facts has made this theory untenable. Another suggestion is that the horror of incest, supposedly innate, has extended to all those women whom, under the classificatory system of relationship, a man addresses by the term for "sister." On another view the original form was local exogamy arising from a natural distaste on the part of those who have been reared together to cohabit. Others believe it originated with Totemism (*q.v.*), while the diffusionists consider that it developed under special conditions in one place and spread thence throughout the world. (*See* ENDOGAMY.) (C. H. W.)

EXORCISM, the expulsion of evil spirits from persons or places by incantations, magical rites or other means. As a corollary of the animistic theory of diseases and of belief in Possession (*q.v.*), we find widely spread customs whose object is to get rid of the evil influences. These customs may take the form of a general expulsion of evils, either once a year or at regular intervals, either immediately by spells, purifications or some form of coercion; or by transfer to a scapegoat or other material vehicle. Among the means of compelling the evil spirits are assaults with warlike weapons or sticks, the noise of musical instruments or of the human voice, the use of masks, the invocation of more powerful good spirits, etc.; both fire and water are used to drive them out, and the use of iron is a common means of holding them at bay.

The term exorcism is applied more especially to the freeing of an individual from a possessing or disease-causing spirit; the means adopted are frequently the same as those mentioned above.

The professional exorcist was known among the Jews; in Greece the art was practised by women, as was charged against the mothers of Epicurus and Aeschines by the Stoics and Demosthenes. Exorcism in the early ages of the Christian church was frequently mentioned in the writings of the fathers. (*See* EXORCIST.) The rite of exorcism in connection with baptism, and a form of service for the exorcising of possessed persons, is still retained in the Roman ritual. The exorcist signs the possessed person with the figure of the cross, desires him to kneel, and sprinkles him with holy water; after which the exorcist asks the devil his name, and adjures him by the holy mysteries of the Christian religion not to afflict the person possessed any more. Then, laying his right hand on the demoniac's head, he repeats the form of exorcism as follows: "I exorcise thee, unclean spirit, in the name of Jesus Christ; tremble, O Satan, thou enemy of the faith, thou foe of mankind, who hast brought death into the world, who hast deprived men of life, and hast rebelled against

justice, thou seducer of mankind, thou root of evil, thou source of avarice, discord and envy." Houses and other places supposed to be haunted by unclean spirits are likewise to be exorcised with similar rites, and in general exorcism has a place in all the ceremonies for consecrating and blessing persons or things (*see* BENEDICTION).

BIBLIOGRAPHY.—*See* Tylor, *Primitive Culture;* Skeat, *Malay Magic,* p. 427 *seq.;* Frazer, *Golden Bough* (2nd ed.), vol. iii. 189; Krafft, *Ausführliche Historie von Exorcismus;* Koldeweg, *Der Exorcismus im Herzogthum Braunschweig;* Brecher, *Das Transcendentale, Magie, etc. im Talmud,* pp. 195–203; *Zeitschr. für Assyriologie* (Dec. 1893, April 1894); Herzog, *Realencykl. s.v.* "Exorcismus"; Waldmeier, *Autobiography,* p. 64; L. W. King, *Babylonian Magic.* Modern ethnographical works deal fully with the subject.

EXORCIST, in the Roman Catholic church, the third grade in the minor orders of the clergy, between those of acolyte and reader. The office, which involves the right of ceremonially exorcising devils (*see* EXORCISM), is actually no more than a preliminary stage of the priesthood. The earliest record of the special ordination of exorcists is the 7th canon of the council of Carthage (A.D. 398).

EXOTIC, of foreign origin, not indigenous or native, a term usually applied to plants introduced from foreign countries. Figuratively, "exotic" conveys the sense of something rare, delicate or extravagant.

EXPATRIATION: *see* ALIEN; ALLEGIANCE; NATIONALITY AND NATURALIZATION.

EXPECTATION OF LIFE. The term expectation of life denotes the average number of years which the persons of a specified age, taken one with another, will live according to a given mortality table. (*See* LIFE TABLE.)

If of l_x persons aged exactly x, l_{x+1} survive to age $x+1$, l_{x+2} to age $x+2$, etc., then the average number of completed years of future life-time which the l_x persons will experience is $(l_{x+1}+l_{x+2}+\text{etc.})\div l_x$. This expression is represented by the symbol e_x, and is technically known as the *curtate expectation of life.* No allowance is included in the formula for that portion of life-time lived by each individual in the year of his death, which on the average will amount to approximately one-half of a year. The *complete expectation of life,* $\mathring{e}_x$, is therefore approximately equal to $e_x+\frac{1}{2}$. Also $\mathring{e}_x$ may be derived directly by means of the formula

$$\mathring{e}_x=\frac{L_{x+1}+L_{x+1}+\text{etc.}}{l_x}=\frac{T_x}{l_x}, \text{ where } L_x \text{ is equal to } \tfrac{1}{2}(l_x+l_{x+1})$$

and therefore denotes the population between the ages x and $x+1$, and T_x denotes the total population at age x and over.

There can be few technical terms so generally misunderstood and misused as the expectation of life. Several additional phrases have therefore been suggested as more appropriately describing the function, *e.g.,* the mean after life-time, the average after life-time, the mean duration of life and the average duration of life.

Amongst non-technical people the expectation of life has acquired a prestige greatly in excess of its actual merits. It is seldom used by actuaries, yet there appears to be a wide-spread impression that it forms the basis of all actuarial calculations involving the probabilities of survivorship. One of the most conspicuous instances of this popular fallacy is the assumption that the value of a life annuity is equivalent to that of an annuity-certain for a term of years corresponding to the expectation of life. The latter value is demonstrably in excess of the true value (*see* ANNUITY).

Another common misconception is that the expectation of life is an actuarial estimate of the number of years an individual may reasonably expect to live. The expectation of life is, however, an average value which is derived from a particular series of rates of mortality and, even if these rates accurately represent the future mortality experience at all ages, will correspond to the future life-time of only a very small proportion of the individuals concerned, the superior vitality of those who survive for a longer term being counterbalanced by the heavier mortality amongst the others.

Objections have recently been urged against the use of the expectation of life as an index of future mortality experience, owing to the fact that the progressive improvement in vitality revealed by successive investigations has suggested that it has become unreliable as a measure of the average future life-time of a body of lives. In such circumstances the figure that would have been the true expectation of life can only be determined after all the lives, whose experience is being reviewed, have died.

The expectation of life provides a means by which the mortality experience of different investigations may be compared. In recent years its use for this purpose has been the subject of much adverse criticism, and certainly as an instrument for detailed comparison it is not so satisfactory as several other criteria, *e.g.,* the probability of survivorship for an indicated period, say five or ten years. The expectation of life at a particular age does, however, provide a comprehensive figure which summarizes the experience at higher ages, and its value at birth is probably the best available statistical measure of the health conditions of a community. It is, therefore, of great value to medical officers and other statistical workers.

From the following table, which shows the expectation of life at specimen ages according to successive life tables, the improvement in the vitality of the population will be apparent.

Expectation of Life (Years), $\mathring{e}_x$.

Age	English Life Table No. 6 (1891–1900)	English Life Table No. 9 (1920–22)	United States (whites) Life Table 1901	United States (whites) Life Table 1919–20
Males				
0 . .	44·13	55·62	48·23	55·33
10 . .	49·63	54·64	50·59	53·46
20 . .	41·02	45·78	42·19	44·94
30 . .	33·07	37·40	34·88	37·14
40 . .	25·64	29·19	27·74	29·55
50 . .	18·90	21·36	20·76	22·00
60 . .	12·93	14·36	14·35	15·11
70 . .	8·05	8·75	9·03	9·43
80 . .	4·62	4·93	5·10	5·39
90 . .	2·58	2·82	2·85	2·96
Females				
0 . .	47·77	59·58	51·08	57·52
10 . .	51·97	57·53	52·15	54·43
20 . .	43·44	48·73	43·77	45·77
30 . .	35·39	40·26	36·42	38·25
40 . .	27·82	31·86	29·17	30·67
50 . .	20·64	23·69	21·89	22·93
60 . .	14·10	16·22	15·23	15·82
70 . .	8·78	9·95	9·59	9·89
80 . .	5·05	5·56	5·50	5·69
90 . .	2·87	3·13	3·02	3·06

(P. G. B.)

EXPEDITIONARY FORCE, a body of troops sent overseas from its home country for operations in foreign territory. The name was applied during the World War to any important force sent out to a separate theatre of war under an independent commander. Thus the British Expeditionary Force (B.E.F.), the first to proceed overseas, fought in France and Belgium, and the Mediterranean Expeditionary Force (M.E.F.) in Gallipoli, Salonika and Egypt; and the United States troops in France were known as the American Expeditionary Force (A.E.F.).

EXPENDITURE, NATIONAL: *see* FINANCE.

EXPERIMENTAL EMBRYOLOGY. The study of general or comparative embryology reveals the fact that during their normal development, animals pass through a number of visibly different stages; each stage being characterized by the possession of various structures in a condition more or less well formed, as compared with earlier and later stages. In other words, the development of an animal can be unravelled into a series of sequences of structural patterns. Once the fact of these structural patterns has been established, it becomes interesting to enquire into the reasons why certain stages are preceded and followed by certain others; why the various organs of the body appear when and as they do; and whether the stages which follow one another in time, also follow one another as the effect does the cause.

Many such questions can be answered by applying directly to the animal, and artificially altering the conditions at the preceding stage. The process of interfering with the normal development is an experiment, and for this reason the study of the causal relationships between the various stages of development is called experimental embryology. The experiments themselves may consist of the removal or addition of definite parts of the embryo, or its subjection to abnormal conditions of temperature, electric currents, or chemical reagents, to give only a few examples. The experimental methods depend of course on the material which is being studied and the question which is being attacked. It must suffice to say, that in all cases, the results of an experimental operation must be interpreted in the light of a control experiment carried out alongside, and under normal conditions.

Development is usually held to start from the stimulation of the egg by Fertilization, or Parthenogenesis. Both these phenomena have yielded interesting results to experimentation. After stimulation of the egg, the development of the embryo consists of three main processes: cell-division, growth and differentiation.

Cell-division.—The starting-point of sexual and parthenogenetic development, the egg, is a single cell; whereas the adult animal to which it will give rise (excluding the Protozoa) contains countless cells. It is obvious that cell-multiplication must take place during development, and its importance is increased by the fact that it has a bearing on the other two processes, growth and differentiation. The volume of a cell cannot be increased above a certain limit without upsetting the convenient ratio of surface to volume. This means that when growth takes place and new living tissue is formed, the existing cells must multiply in order to accommodate the new material. At the same time, if cells are too highly differentiated (*see* below), they will be unable to divide. This is especially true of the cells of the nervous system of vertebrates; after a stage reached quite soon in man, the cells of his brain and spinal cord never divide again. According to Gurwitsch cell-division is a response to stimulation by ether waves of a length of between 1,900 and 2,000 Angström units. Apart from this theory, it must be confessed that very little is known as to the causes which result in the splitting of the cell-nucleus into two, and the subsequent division of the whole cell itself. For further information the reader is referred to the section on Parthenogenesis (artificial), for the active stimulus in causing an egg to start developing appears to be that which causes it to divide.

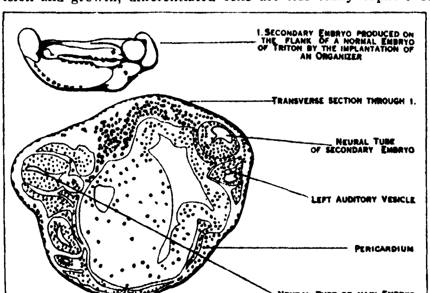
Growth.—Growth is increase in bulk. In an animal it may be caused by accumulation of non-living substances, as when an egg-cell is filled with yolk, or when the whole organism absorbs water. "True" growth, however, is the production of new living material, new protoplasm. This is one of the fundamental properties of life, which is constantly concerned in assimilating foreign matter and building it up into protoplasm. At the same time, protoplasm is always being broken down with wear and tear; but when the process of building-up (anabolism) is more active than that of breaking-down (katabolism) the result is growth.

It has been found that apart from the ordinary food-substances, others are necessary for growth. Chief among these are the vitamins, about which little is known, except that the effect which they produce appears to bear little relation to the quantity of them present. This would indicate that they act not as raw building-materials, but as ferments and catalysers accelerating the processes of building. Other substances are known whose property it is to accelerate the growth of tissues; these were discovered by means of experiments of growing pieces of tissue under aseptic conditions in small glass vessels, a technique which is called "tissue-culture," or growth "*in vitro.*" One of these substances, obtained from young embryos and hence called embryo-extract, encourages growth *in vitro,* which without it, would not take place. Another such substance is obtained by killing some cells and maintaining them at the normal temperature of the body, when they undergo a disintegrative process known as autolysis and furnish a substance (autolysed extract) which is a very powerful promoter of growth. The interest of this substance is increased by the fact that its effects are similar to those produced by extracts of malignant tumours (cancers).

For further details the reader is referred to the section on Growth, but before leaving the subject it must be mentioned that if growth takes place at unequal rates in the various parts of an embryo, the result will be an alteration of its shape; or in other words, its various parts which may previously have been similar, come to be different. This process is known as morphological (form-) differentiation. The importance of such changes of shape become obvious when it is realized that for example the fertilized egg of a man is spherical.

Differentiation.—The definition of morphological differentiation, or change of shape, has just been given. The earliest example of this in the development of most animals is the conversion of the solid egg-cell into a hollow ball composed of many smaller cells: the blastula. Later, this hollow ball is converted into a double-layered sac or gastrula, in which the original cavity of the ball (the blastocoel) is obliterated and its place taken by the cavity contained by the innermost of the two layers of the sac (the enteron, or future alimentary canal). Then, the sac elongates and the general shape of the future animal is roughed out. If the animal is a newt, the rudiments of the limbs and of the tail arise as little cones in which growth takes place more rapidly than in the neighbouring regions. All these cases are examples of morphological differentiation.

It is now necessary to turn to the cells of which the embryo is composed. These cells have been derived by repeated cell-division from the egg-cell, and as up to this stage there has been little or no increase in the total amount of living matter; the cells are thus much smaller than the original egg. If the egg contained yolk, then some of the cells produced from it will contain yolk, and others not, but otherwise, there is no visible difference (save, usually, size) between these cells. Later on, however, an actual difference between the cells becomes visible. Some become muscular cells, others nervous, others again form part of epithelia which line the cavities and surfaces of the embryo. Sheets of cells which have been modified in the same way form a tissue, and the process of modification which these cells have undergone, rendering them different from any other cells, is called histological (tissue-) differentiation. Undifferentiated cells, such as are found in the earliest stages of developing embryos, are called embryonic; and it is found that whereas embryonic cells are capable of rapid cell-division and growth, differentiated cells are less easily capable of



FROM MANGOLD & SPEMANN IN ROUX, "ARCHIV FUR ENTWICKLUNGSMECHANIK" (JULIUS SPRINGER)

FIG. 1.—THE "ARTIFICIAL" FORMATION OF AN EMBRYO

cell-division and therefore of growth. This is the connection between cell-division and differentiation referred to above; the reason for it must be that a differentiated cell no longer consists of pure protoplasm like an embryonic cell, but is encumbered with other inert substances which confer upon it its differentiation and hinder its division. The experimental evidence for this is obtained from tissue-cultures, in which it is found as a rule that the rate at which tissues grow is greater if they lose their differentiation (undergo dedifferentiation). Conversely, cells which divide too rapidly will not redifferentiate.

Cleavage.—The process of repeated cell-division whereby the egg-cell is fractionated into a number of smaller cells or blastomeres, is known as segmentation or cleavage. Whether the first cleavage separates the future right and left halves, or the future front and rear halves, or diagonal halves of the embryo, it is obvious that the first cleavage (and subsequent cleavages also) separate from one another parts of the embryo which have very different prospective fates in normal development. It therefore becomes important to enquire whether the origin of differentiation may be due to inequalities of cell-division during cleavage. In such a matter it is necessary to consider the division of the nucleus and the division of the body of the cell or cytoplasm.

Nuclear Division.—Experiments have proved that it is not in divisions of the nuclei during cleavage that differentiation originates. For by making eggs (of the frog, of the worm *Nereis,* or of the sea-urchin) undergo cleavage compressed between plates of glass, or by shaking them, the normal arrangement of the blastomeres is completely upset. After release from the glass plates, the embryos round themselves off again, and a given blastomere contains a nucleus which, in normal circumstances, would be situated in a different blastomere. Nevertheless, subsequent development of embryos operated upon in this way is normal. This can only mean that all the nuclei are equivalent, that their division has been strictly equal, and that they are not responsible for the origin of differentiation. The most elegant demonstration of this was obtained by tying a loop of fine hair round a fertilized but still undivided newt's egg, and constricting it almost into two, in the form of a dumb-bell. By this process, the nucleus was restricted to one side, in which it underwent division, while the other side had no nucleus at all. When the nucleated side contained sixteen nuclei, the hair-constriction was released slightly, and one nucleus was able to pass across the narrow bridge into the previously enucleate half. When the nucleus had passed, the hair was pulled tight and completely separated the two sides from one another. Both sides could develop normally into diminutive embryos, and as the nucleus which passed across could hardly be the same one in any two experiments, the experiment proves that all the sixteen nuclei were equivalent, and capable by themselves of ensuring normal development.

The experimental results just described are of fundamental importance, for they definitely disprove the celebrated Roux-Weismann theory of development. This theory attempted to attribute the origin of differentiation to unequal nuclear division during cleavage.

Cytoplasmic Division.—Turning now to the consideration of the nature of the division of the cytoplasm between the blastomeres during cleavage, the results obtained from experiments on different kinds of animals are apparently (but only apparently) contradictory. The method adopted is to separate the blastomeres from one another at the 2-cell, 4-cell or subsequent stages of cleavage.

In the sea-urchins, it is found that a single isolated blastomere from the 2-cell or the 4-cell stage is capable of developing into a perfect little larva, of half or quarter normal size respectively. These blastomeres which would normally have produced only one-half or one-quarter of the larva, are thus shown to be capable of regulating and giving rise to a whole. Eggs which divide into blastomeres capable of such regulation are called "regulation-eggs," and their blastomeres are called totipotent.

At the other end of the scale are eggs like those of the Ascidians (Sea-squirts) and Ctenophores (Comb-jellies or Sea-gooseberries), in which isolated blastomeres will only give rise to that which they would have ordinarily produced in normal development. Here, the blastomeres are differentiated and "set," like the separate pieces which make up the pattern of a mosaic. Such animals are consequently said to have "mosaic-eggs."

The difference between regulation-eggs and mosaic-eggs is really only due to a matter of time. In the regulation-eggs, the equivalence of the cytoplasm persists longer than in the mosaic-eggs, and in time, even in the sea-urchin, the different regions lose their totipotence. The mosaic-eggs, on the other hand, have portions of their cytoplasm determined for various fates already in the egg, before fertilization, and even when it is still in the ovary of its mother.

Experiments on cleavage therefore show that it is in determinations (as yet invisible) of the cytoplasm, or in the specialization of "organ-forming substances," that the first manifestations of differentiation are to be found. The next problem is to find out the cause for the determination and localization of these regions of the cytoplasm.

Polarity and Symmetry.—The eggs of frogs and newts occupy a peculiar position as regards the power of regulation, and therefore the degree of determination of the cytoplasm of their blastomeres. In the first place it must be realized that these eggs contain a fair amount of yolk which is accumulated in one (the lower, or so-called vegetative) hemisphere. The upper (or so-called animal) hemisphere contains little yolk. The distinction between the animal and vegetative hemispheres enables the comparison to be made between the frog or newt's egg and the globe, with its north and south poles. In other words, the egg has an axis and polarity, and the upper (or *animal)* pole of the egg will become the head of the future embryo, while the lower (or *vegetative*) pole will become the tail. The axis of the egg appears to be determined while it is still in the ovary by the orientation of the little arteries and veins; the animal pole is the region where the blood is brought to the egg-cell, and where the rate of protoplasmic activities is higher than elsewhere. This rate diminishes away from the animal pole and towards the vegetative hemisphere, so that the axis of the egg coincides with an axial gradient (*q.v.*). From experiments on the eggs of sea-urchins it is known that if the axial gradient of rate of activities of the protoplasm is abolished (*i.e.*, the rate of activities is made uniform), the embryo has no polarity. It is therefore legitimate to conclude that the localization of the site of the future head in the egg of a frog or newt, is due to that site being the highest point on an axial gradient, and that the axial gradient itself is determined by the greater stimulation which that site received as a result of the orientation of the blood-vessels in the ovary.

Thus far, the egg has a future head-end and tail-end, but it remains to determine which side shall be right, which left, and accordingly which dorsal and ventral. This determination is that of a plane of bilateral symmetry, which of course passes through the egg-axis. The plane of bilateral symmetry is as a rule fixed by the point of entry of the sperm fertilizing the egg, and in such a way that the mid-dorsal line of the embryo is the meridian exactly opposite that on which the sperm entered. The mid-dorsal line is taken as the most important, because it is on this meridian that the process of conversion of the blastula into the gastrula begins, by the overgrowth of the so-called dorsal lip of the blastopore. It will be shown below that the region of the dorsal lip of the blastopore is essential for the formation of the embryo. Its interest from the present point of view is the fact that an isolated blastomere of the 2-cell stage will develop normally into a perfect embryo if it contains a part of this region, but not if it lacks it. This region is therefore a cytoplasmic determination, or origin of differentiation (visible in the frog as the so-called grey crescent), and which is itself due to the point of entry of the sperm. This fact is proved by causing sperm to enter an egg on a selected meridian and observing its subsequent relation to the plane of bilateral symmetry; and also by the experiment of causing two sperms to enter the same egg simultaneously, when it is found that the site of the dorsal lip of the blastopore lies on the meridian opposite that which bisects the angle subtended at the centre of the egg by the points of entry of the two sperms. This conclusion, arrived at with frogs, must, however, not be over-generalized, for it does not apply to sea-urchins. It is important to notice that polarity and bilateral symmetry, which are the prime differentiations in the egg of frogs and newts are induced by stimuli which act on the egg from outside. This means that the origin of differentiation is to be found in the reactions of the cytoplasm to external stimulation at a definite site. The origin of differentiation also coincides with the formation of an axial gradient of rate of protoplasmic activities, and the importance of this is that the qualitative nature of the tissue differentiated at any point is in

the first place determined by the relative quantitative rate of protoplasmic activities at that point. In other words, the prospective fate of a cell in normal development is determined by its position relatively to the axial gradients. This principle will now be further illustrated.

Axial Gradients and Differentiation.—When a piece is cut out of the body of a Planarian worm, the anterior cut end of the piece may regenerate a head, or a tail. That it should be capable of doing either is due to the fact that the nuclei all over the body are equivalent, and that the cells of such a lowly animal as Planaria are easily capable of reverting to an embryonic undifferentiated condition. Actually which structure will be formed depends on how much higher the rate of protoplasmic activities is in the cells of the anterior cut surface than in the rest of the piece. If the rate at the anterior cut surface is relatively sufficiently high, a head will form, and the degree of perfection of this head varies with the height of the rate. If the rate is too low, no head will be formed. The relative rates of protoplasmic activities can be controlled by means of certain substances (which have selective effects in increasing or depressing the activities of regions of high or low rate), and there is therefore experimental evidence that the quality of the tissue differentiated is determined by the relative quantitative rate of protoplasmic activities at the place in question. So it may be imagined that in the development of the egg, the axial gradients evoke qualitative differential responses from the cells according to the level of quantitative activity at which they are situated. Further examples will be given of the action of gradients in determining differentiation, but attention must now be turned to the nature of differentiation.

Plasticity and Determination.—Without being totipotent like the blastomeres of the 4-cell stage of the sea-urchin, cells may still show plasticity, in the sense that they are capable of differentiating into tissues other than those to which they would normally give rise. In the double-layered sac or gastrula, the outer layer is the ectoderm which will produce the epidermis and nervous system while the inner layer or endoderm will furnish the alimentary canal and its derivatives, like liver, lungs, etc. If a cap of cells be cut off from the animal hemisphere of the blastula of a sea-urchin, the remainder of the blastula cuts its loss and forms a gastrula smaller than normal (owing to the loss of tissue); and its inner layer or endoderm is reduced in size proportionately. This means that some of the cells which would normally have come to form part of the endoderm, actually become ectoderm; for the endoderm is in these animals formed by an inpushing from the surface of the blastula, and the proportionate reduction in size of the endoderm implies that fewer cells than normal are pushed in. That these cells should be capable of turning into ectoderm instead of into endoderm means that at the time when the operation was performed, they were not irrevocably determined. Identical results are obtained in newts up to an early stage of gastrulation, by experiments of transplanting pieces which would normally have become ectoderm, for instance ("presumptive" ectoderm), into other regions (*see* GRAFTING IN ANIMALS).

By transplanting between two different species of newts (heteroplastic transplantation), the cells of which differ as to their pigmentation, and in other respects, it is possible to identify the pieces of grafted tissue long after the operation, and to make certain of their actual fate. So, at this early stage in newts, a piece whose presumptive fate was ordinary epidermis, when transplanted to the appropriate region, actually became part of the brain and eye; and a piece of presumptive brain could be made to become part of the gills.

After a certain stage, however, these exchanges can no longer be made. If a cap of cells be cut off from the animal hemisphere of a gastrula of the sea-urchin, the endoderm remains of its normal size and is therefore out of proportion to the reduced ectoderm. The endoderm is therefore determined at this stage, and can no longer be converted into ectoderm. At the same time, within the endoderm itself determination has not yet taken place. The endoderm normally becomes divided into a number of regions bearing a certain proportion to one another. If at this gastrula stage when the endoderm cannot be turned into ectoderm, a piece of the endoderm be removed, the remainder will parcel itself out into the normal number of subdivisions in correct relative but reduced proportions. This illustrates the important fact that during development, determination takes place progressively.

Similarly in the newt, at a late stage of gastrulation, presumptive material shows when transplanted that it is determined. Presumptive eye material will differentiate into an eye even in abnormal positions such as the abdominal wall, facing inwards. Tissue which is "fixed" in this way is called self-differentiating. In the sea-urchin larva the mouth is self-differentiating, for it forms regardless of whether the alimentary canal is normally pushed-in or is experimentally everted (as in the so-called "exogastrula"). On the other hand, tissue which requires to be acted upon by neighbouring tissue in order to differentiate, is called dependent-differentiating.

Interesting examples of the effects which certain tissues exert upon certain others, can be obtained from tissue-culture experiments. Epithelium by itself, or connective tissue by itself, when grown *in vitro*, tends to lose its differentiation, and its cells revert to an embryonic condition. If, however, these tissues are cultured together, they maintain their differentiation; and if one of the two tissues dies, the other loses its differentiation. Use has been made of this property of inducing dependent differentiation in order to cause certain tissues to differentiate at will. Cultures of kidney-tissue of a mouse, or of a carcinomatous tumour of the mammary gland, grow as sheets of undifferentiated tissue *in vitro*. If some connective tissue is added to the cultures, the kidney-tissue redifferentiates its tubules, and the tumour gives rise to structures resembling those of a normal mammary gland. It is possible, therefore, that the contributory causes in tumour-formation may include not only an excessive amount of a growth-promoting substance (such as the autolysed extract mentioned above) but also the removal of the restraining influence on the part of other tissues, which normally produce and maintain a dependent-differentiated condition in the tissue which has become tumorous. Further examples of dependent differentiation will be mentioned below.

Chemo-differentiation.—In the newt and in the frog, the brain and spinal cord arise as a groove along the back, between a pair of so-called neural folds. The folds eventually meet over the groove, which thus becomes converted into a tube sunk beneath the surface. From the front end of this tube which is enlarged to form the brain, the eye-balls are pushed out to each side. If at an early stage, when the brain is still an open groove, a rectangular piece is cut out from it, rotated through 180°, and replaced, it continues its development by self-differentiation. In such a case, the anterior cut of the rectangular piece might pass through the eye-rudiments, and after rotation, portions of these eye-rudiments would find themselves transported back to abnormal regions. It is a fact that such operated embryos when they develop have not two eyes, but four, one pair behind the other, and of such a size that the sum of the sizes of all four is equal to the joint size of two normal eyes. This shows that the presumptive eye-rudiments were, although invisibly, yet nevertheless qualitatively and quantitatively, determined at the stage operated upon. A fixation of presumptive fate in this manner must be based on the presence of a definite amount of a chemical substance in the area which is determined. For this reason, determination of future organs may be called chemo-differentiation. The experiment just described is further interesting for two reasons. It shows by the variation of the constitution of the four eyes which are formed (which do not all possess the correct proportion between the sizes of the stalk, sensory layer and pigment layer), that not only is the eye determined as a whole, but that its constituent portions are also severally determined. The other point is that although the amount of determined tissue in any one of these four eyes is less than in a normal eye, nevertheless, it rounds itself off after the manner typical of an eye-ball. The same result can be obtained from other organs such as the nerve-cord itself, and it shows that the process of shaping the organ (or morphological differentiation) is distinct from the process of specialization of its constituent cells (or histological differentiation). The former is concerned with

conditions of available space and material and is the property of all the cells of the organ in general. The latter is the specific effect of chemo-differentiation on certain cells.

Organizers.—One region of the embryos of newts and frogs is peculiar, and that is the region of the dorsal lip of the blastopore. The tissue in this region becomes tucked-in beneath the superficial layer, and grows forwards beneath it, forming the roof of the enteron, or cavity of the gastrula. If a portion of this region be grafted into another position, it does not follow the differentiation of its surroundings nor does it simply pursue its normal prospective fate by self-differentiation, but it actually induces the cells which surround it, wherever it happens to be, to differentiate into the essential structures of an embryo. These structures are the nerve-cord, notochord, plates of muscle, kidney-tubes, eyes and ears. Since these structures lie along the axis of the body they are called the axial structures. The dorsal lip of the blastopore, therefore, has the power of organizing an embryo, for which reason it is called an organizer.

The organizer is that region which arises opposite the point of entry of the sperm, which is visibly differentiated as the grey crescent in the frog, and which an isolated blastomere must possess if it is to develop. The organizer is therefore an origin, and originator of differentiation, itself due to an external stimulus. With regard to its method of action, it is non-specific, for not only can organizers induce the formation of embryos in tissue of a different species, but even of a different order, as when the organizer of a toad works on tissue of a newt. Further, the quality of the tissue "organized" depends on the place from which the organizer was taken, and the level on the axial gradient of the other embryo (or "host") at which it is grafted. As new tissue is constantly turning over the edge of the dorsal lip of the blastopore and growing forwards, a piece of the organizer-region removed at an early stage of gastrulation would normally come to lie in the head, whereas pieces removed at later stages would lie in the trunk. A piece of head-organizer grafted into a host near the animal pole will organize a head, while a piece of trunk-organizer grafted into the host at a greater distance from the animal pole will organize a trunk.

Lastly, it is known that the property of organizing is not inherent in the cells of the organizer, but is something common to the region which they occupy. For if a piece of indifferent presumptive epidermis is grafted into the region of the organizer, and then cut out and grafted into a host, it will be found to function as an organizer. In other words, during its sojourn in the organizer-region, it has been infected with the capacity to organize.

The Eye and the Lens.—The eye-balls are, as already described, pushed out from the brain and subsequently become converted into the eye-cups. The lens fits into the rim of the cup, but it arises from a separate rudiment altogether, viz., the superficial epidermis. How, then, does it come about that the lens differentiates at the correct place so as to collaborate with the eye-cup in the formation of the perfect eye? This developmental correlation is of the greatest interest and importance. In the first place it was found that in the grass-frog (*Rana fusca*), the lens did not differentiate if the eye-cup was removed, and that any epidermis grafted over the eye-cup could be induced to differentiate into a lens, whether that was its presumptive fate or not. In other words, in *R. fusca*, the differentiation of the lens is dependent on that of the eye-cup which itself is dependent on the organizer. With regard to the lens, therefore, the eye-cup is a secondary organizer. The problem is however complicated by the fact that in the edible frog (*Rana esculenta*) the lens develops by self-differentiation when the eye-cup is removed (at the tail-bud stage), and not all esculenta epidermis can be induced to differentiate into a lens when grafted over the eye-cup. At the same time, the eye-cup has the power to organize a lens from suitable tissue, as is shown by the fact that it can do so from the epidermis of toads. *Rana esculenta*, therefore, has a self-differentiating lens, and at the same time its eye-cup is capable of organizing one; there is therefore what appears to be a "double assurance" that a lens will be formed. On the other hand, *Rana fusca* has a dependent-differentiating lens. The apparent contrast between the two methods of lens-formation in such closely related species is, here again, only a matter of time. The self-differentiating capacity of the lens of *Rana esculenta* only means that at the stage operated upon, the presumptive lens-rudiment had already been sufficiently chemo-differentiated to continue its development independently. At the operated stage, this condition had not yet been reached in the case of the lens-rudiment of *Rana fusca*. In almost all cases which have been sufficiently analysed, an organ which is self-differentiating at a particular stage is dependent-differentiating at an earlier stage. In the final analysis the chemo-differentiation of the various rudiments is referable to their position with regard to the gradient-system of the whole and to the organizer. In this way, in the frog and newt for instance, it may be imagined that the organism becomes mapped-out roughly into a number of eventually self-differentiating territories, and this has already been proved with regard to the nerve-cord, eye, lens, ear, nose, sense-organ placode, hypophysis, limb, liver, pancreas and heart.

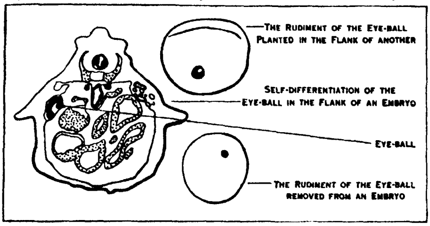
Once chemo-differentiated, these regions lose the power of differentiating into other regions, but within themselves, as in the case of the endoderm of the sea-urchin, they are still capable of regulation. So two limb-buds grafted together will regulate to form one normal limb, and the same applies to two heart-rudiments. The organism is progressively split up into smaller and smaller self-differentiating regions. This is well shown in the case of the limb-bud of a 4-day incubated chick. Each quarter of the limb-bud, when grown separately, differentiated independently, as a piece of a mosaic, to its presumptive fate.

The Periods of Development.—So far, in this account, it has been shown that differentiation originates in relation to axial gradients and organizers, until the organism is a collection of self-differentiating rudiments, developing without regard to one another and without co-ordination or correlation. It is important to notice that during this period, the organs and tissues differentiate without functioning, as is indeed obvious, for functions cannot be performed until a certain degree of differentiation has taken place. Nevertheless, this distinction is important, for in subsequent stages of development the further differentiation of the organs is conditioned by their functioning. The two periods may accordingly be called the non-functional and the functional periods of development respectively, and it is to Wilhelm Roux, the founder of modern experimental embryology, that the science is indebted for this distinction. Meanwhile, it must be noticed that during the earlier period of non-functional development, when the self-differentiating rudiments are pursuing their development independently of one another, regeneration and regulation is not possible. If the limb-bud rudiment is extirpated from a chick embryo during this period, the chick will always lack this limb. This matter has considerable philosophical interest, for it is common to find that regulation is regarded as a characteristic and fundamental phenomenon of living matter, and thereby distinguishing the latter from non-living matter. That regulation should not be of unfailing occurrence even among living things indicates that caution is necessary before adducing regulation as evidence for the exclusiveness of the nature of living processes. This is further shown by a study of the processes of regeneration, in which it is untrue to say that that which is regenerated is always that which was lost. It may be that too little is regenerated, or too much, or the quality of the regenerate may be entirely different from that of what was lost. Be this as it may, it is nevertheless true that regulation when it does occur is none the less interesting: a matter to which return will be made below. It is now time to turn to the second of Roux's periods of development.

Functional Differentiation.—The blood-vessels of the body are at first laid down roughly in certain definite positions and directions during the earlier period of non-functional self-differentiation. Their subsequent differentiation and the details of their connections with the tissues and one another take place during the later period of functional differentiation, and are governed actually by the functions which they perform in supplying the various tissues with blood according to their needs. The diameter of the vessels and the shaping of their bifurcations become adapted to the flow of blood so as to oppose the least resistance to it. The walls

of the vessels differentiate in accordance with the internal pressure of the blood which they have to withstand. So when a section of vein (which normally only has to deal with low pressures, and has a relatively feeble muscular wall) is transplanted into a position in the course of an artery (which has to withstand high pressures, and has a well-developed muscular wall), it becomes structurally converted into an artery, and its muscular wall becomes twice as thick. The definitive form of the blood-vessels is therefore the manifestation of their functional activity.

Tendons form the link between muscles and the bones to which they are attached. From their position it is obvious that they have



FROM "THE BRITISH JOURNAL OF EXPERIMENTAL BIOLOGY" (CAMBRIDGE UNIVERSITY PRESS)

FIG. 2.—SELF-DIFFERENTIATION OF THE EYE

to stand great tensions, and the fibres of connective tissue of which they are composed are arranged parallel to one another. The differentiation and parallel arrangement of these fibres is brought about by the pull which the muscle exerts at the end of them. This can be proved by cutting a tendon and allowing it to regenerate. Instead, however, of allowing the muscle to exert its pull on the fibres, the muscle can be cut out and a silk thread can be left in the track of the differentiating fibres. If this silk thread is pulled, the fibres of the tendon become orientated parallel to the line of this artificial tension. It is the function which they subserve, therefore, which is responsible for the differentiation and perfection of tendons.

The formation of bone presents a case not very dissimilar from that of tendons. Bone is not solid all through, but is composed of a large number of splinters and spicules, and the first appearance of these is a result of self-differentiation without function. The structure of a fully-formed bone, however, shows that the splinters are so arranged that they are in a position to withstand the maximum amount of pressure and tension to which the bone is normally exposed. It looks as if the differentiation of these splinters was determined by the incidence of these pressures and tensions. This must in fact be the case; for if a bone is broken and reset, the incidence of the pressures and tensions will be slightly altered, and it will be found that the old splinters of bone will be removed and replaced by others which answer more accurately to the functional requirements of the whole bone. To account for this, it is necessary to assume that there is a particular condition of pressure and tension which is most suitable for the differentiation of bone-splinters. That being so of a number of splinters lying in all directions, those which lie in the lines of pressure and tension will be favoured, while the others will be handicapped in their differentiation. This means that there is an internal struggle between the parts of an organism, some of which are preserved and others eliminated by a particular form of natural selection. The optimum conditions for which such a competition strives may not only be special functional situations, but also conditions of available space and nourishment.

The muscles of the body of a higher animal such as a dog may be of one of three kinds. There is the smooth muscle which forms the wall of the blood-vessels, the alimentary canal, and the bladder, and which is not subjected to any very violent or prolonged exertion. Then there is the musculature of the heart, which possesses a particular striated structure, and which is given to a perpetual and rhythmical life of contraction. Lastly there is the striped skeletal musculature of the body, which is under the control of the will, and which is capable of very violent effort, as in running upstairs for instance. Now, the function of the musculature of the wall of the bladder (of a dog) may be increased by connecting the bladder (by means of a cannula) with a tube leading from a jar containing a neutral fluid. In this way the amount of fluid in the bladder and the pressure at which it stands can be artificially, and precisely, increased. In this way the wall of the bladder can be made to expel more than a hundred times the normal amount of fluid per day, and it was found that the musculature took on the function of contracting rhythmically, and as often as two hundred times a minute. At the same time, the muscular wall of the bladder becomes very considerably thickened, and its cells differentiate into striated muscle-cells, similar to those of heart-muscle. These remarkable results are due to the effect of the function of expelling large quantities of fluid at high pressure. Other cases of functional differentiation are to be found when tadpoles are fed on herbivorous and carnivorous diets. To obtain the same amount of energy from animal and from vegetable food, it is necessary to eat much more of the latter, and consequently the alimentary canals and absorbtive digestive surfaces of herbivorous animals are as a rule larger than those of carnivores. Of the tadpoles treated with the two kinds of diets, it is actually found that the absorbtive area of the vegetarian tadpoles is twice that of their carnivorous brethren.

These cases of functional differentiation grade insensibly into those of the functionally adaptive effects of use and disuse. This can be particularly well illustrated by contrasting the muscular development of athletes and of persons who lead a more sedentary life. The nervous system itself, after a rough outlining of its rudiments by non-functional differentiation, becomes perfected with the help of function.

The Nervous System.—The functional differentiation of the nervous system is peculiar because of the particular nature of its function. Nerves are composed of fibres which are formed as outgrowths from the nerve-cells or neurons. Their development can be studied in tissue-cultures, and their formation is a self-differentiation. Other experiments have shown that the direction of the outgrowth of the fibres can be controlled at will by passing an electric current through the tissue culture. Now, one of the manifestations of the axial gradient is a difference in electric potential passing down the axis of the body. (The head-end is electro-negative in the external circuit relatively to other regions.) It must therefore be due to this electric gradient that the fibres in the brain and spinal cord grow down the cord and give rise to the fibre-tracts. Further, the tissue-culture experiments have shown that if a conductor carrying an electric current is led through the culture, the fibres grow out at right angles to the conductor. Returning to the nervous system, when a nervous impulse passes down a fibre, it may be compared with a conductor carrying an electric current. If, therefore, impulses pass down the fibres which run down the spinal cord, the neurons which are then differentiating will tend to grow their fibres out at right angles from the spinal cord. This is precisely what the motor nerve-roots of the spinal cord do.

The question now arises as to why the nerves connect up with their proper terminations. If a limb-bud of a newt is cut out and replaced a certain distance behind its normal site, the nerves which normally supply it grow out, and find the limb-bud in its abnormal position. There must therefore be some kind of chemical attraction which guides the nerves to their appropriate destinations.

The next problem to consider is why the brain and spinal cord develop special accumulations of nerve-cells exactly where they do, in relation to particular organs, such as the eyes or the limbs. The fibres running into the brain from the eyes end in the roof of the region known as the midbrain, where normally there is an accumulation of other nerve-cells which carry on the impulses elsewhere. If the eye be removed at an early stage, however, this accumulation of nerve-cells in the roof of the midbrain does not arise. Similarly, a frog deprived of its hind legs does not develop the hinder region of its brain properly. If an extra limb-bud is grafted on to the side of a newt, it is the sensory nerve-cells, but not the motor cells which are increased in number. Conversely, the motor nerve-cells in the limb-region of the spinal cord become

increased in number if an extra brain is grafted into the spinal cord in front of the limb-region. The sensory cells receive their impulses from the limbs, and the motor cells receive their impulses from the brain. The increase in number of nerve-cells in any special region of the nervous system is therefore governed by the number of nervous impulses which these cells receive. Here, again, function controls differentiation, and it becomes easy to see why animals which have certain senses particularly well developed also have enlargements of the corresponding regions of the nervous system. Lastly, there is the principle of neurobiotaxis, according to which a nerve-cell tends to move in the direction whence its habitual stimulation by nervous impulses comes. This principle accounts for the intricate internal disposition of the various centres of the nervous system.

Chemical Correlation.—The period of functional differentiation is essentially one of correlation of the various regions of the organism into one whole, and of an internal struggle between them. Some organs are on a footing of equality with others, others again are related by a system of dominance and subordination. The effects of such correlation can be well shown in the case of the sea-squirt *Perophora.* This animal is colonial, and the members of a colony are interconnected by a tube-like structure, the stolon, which is common to them all. If an individual with a portion of stolon is isolated in a glass vessel, the normal dominance of the individual over the stolon in the "struggle of the parts" asserts itself, and the latter may be absorbed by the former. In unfavourable circumstances, however, the balance may be upset against the individual and in favour of the stolon, which will then grow at the expense of the individual.

The correlation of the various parts of the organism is carried out by the nervous system and by the circulation of the internal body-fluid, the blood, which comes to be called the "internal environment." The importance of the blood as a correlating agent is based on the presence in it from time to time of chemical substances with specific effects (hormones) produced by special (endocrine) glands (or glands of internal secretion). During development, some of these hormones have very important effects. The pituitary produces a secretion which accelerates growth, while the reproductive organ's secretions in birds and mammals play an important part in the differentiation of the sexual characters. In frogs and newts, the thyroid gland is of particular interest and importance, because it is largely concerned in the conversion of the fish-like water-living tadpole into the land-living adult frog or newt. For the details of this phenomenon *see* METAMORPHOSIS.

External Factors.—In all the cases hitherto considered, the external environment of the developing embryo has been taken as normal and constant. It is, however, of the utmost importance to realize that external factors exert a control over development. Temperature is an important factor which affects the speed at which the chemical reactions which go on during development take place. The various reactions are not all affected by temperature to the same extent, so that a rise or fall of temperature may throw the developmental processes out of gear with one another. Sea-urchin embryos grown in a raised temperature, show the anomaly of everting the alimentary canal (forming so-called exogastrulae) instead of pushing it in.

Electric currents have been shown to affect the direction of outgrowth of nerve-fibres, and they also control the direction of development of the sea-weed *Fucus,* and the regeneration of the hydroid polyp *Obelia,* by inducing polarity in them. The chemical concentration of the surrounding medium has a very important effect on development. This can be shown in the case of marine forms, and either by adding certain chemical substances to the water, or by making up artificial sea-water identical with the normal except that it lacks some constituent. So, with regard to sea-urchins, it is found that chlorine is necessary, or no cleavage of the egg will take place. Calcium is also essential, for without it the blastomeres into which the egg cleaves do not remain together but become separated. Use of this fact is made in the experiments to determine the potencies of isolated blastomeres, which, after separation, continue their development. Addition of lithium to the water has the remarkable effect of suppressing the ectoderm of the gastrula at the expense of the endoderm. Potassium prevents the larva from developing the skeleton and arms of which they are typical. Perhaps the most remarkable effect of all is obtained after treating very young embryos of the fish *Fundulus* with solutions of magnesium chloride, chloroform, alcohol or ether. In these cases, instead of the fish developing the normal two eyes, there are varying degrees of fusion between them corresponding to the strengths of the solutions, until in the extreme cases, like the Cyclops of old, the fish have only one median eye.

The Relation Between Internal and External Factors During Development.—The case of eye-fusion or Cyclopia is of the greatest interest. It shows that fertilization, a proper store of food, and an organizer, are not the sole conditions necessary for the normal development and differentiation of the paired eyes so characteristic of vertebrates. These internal factors, and here must also be included the hereditary factors or Mendelian genes, are powerless to produce anything out of the fertilized egg if the external factors of the environment are not normal. This matter leads on to the consideration of the relative importance of internal and external factors in development, a question often put as the relative value of heredity and environment on the production of the individual.

In the first place, it must be noticed that although the fertilized egg contains a number of hereditary factors, yet, as development proceeds, these are not the only internal factors which the organism contains. The possession of the organizer in the newt's egg is an internal factor, but it cannot be said to be inherited, since its appearance is evoked by an external factor, the entrance of the sperm. (The presence of an organizer in eggs which have been stimulated to development by artificial parthenogenesis, and therefore without a sperm, must be due to the establishment of an axial gradient by other means.) New internal factors which were, as such, not inherited, are constantly arising during development, as a result of the interplay between the existing internal factors and the external factors.

There is another point to consider, and that is that while the hereditary factors (*see* GENE) govern the kinds of structures to which the embryo can by differentiation give rise, yet these hereditary factors cannot of themselves be held to account for the origin of such differentiations. This conclusion follows from the proof that nuclear division during cleavage is not qualitatively unequal, but that on the contrary, all the cells receive an equivalent outfit of hereditary factors. Further, there is the positive fact that the quality of the organs differentiated and their positions in the organism depend on their relations to the axial gradients of rate of protoplasmic activities, and these can be shown to be due to external factors acting on the embryo. Without an axial gradient a sea-urchin will not develop although it contains the complete set of hereditary factors.

The conclusions of the preceding paragraphs enable an answer to be given to the old question as to whether development takes place by Preformation or Epigenesis. Of the old crude notion of preformation in the sense of spatial invisible rearrangement, it is no longer necessary to speak. But it is not so easy to dismiss the hereditary material as a non-spatial predetermination. However, it has just been shown that the differentiations which the hereditary factors may be held to determine, do not arise if external factors have not previously evoked axial gradients. Further, the factors which are operative in the later stages of differentiation (especially the functional period) do not yet exist at the earlier stages. It follows, therefore, that development is a true creation of differentiation in each individual that develops; it is a response to the external factors made by the successive internal factors as and when they arise. As such, development partakes of the nature of an Epigenesis; the embryo is not preformed in the fertilized egg. The only proviso which it is necessary to make is that if the embryo is formed at all, the hereditary factors ensure that it belongs to the same species as its parents. In other words, the hereditary factors limit the possibilities of the response which the embryo can make to the external factors.

The connection between parents and embryo by means of the hereditary factors has been compared with a narrow bridge, across

which it is very difficult to see how the beautifully delicate adjustments of the fully-developed body can be conveyed. Such efforts of understanding can however be spared, because it has been shown that the adaptive perfection of the tendons, of the bones, of the blood-vessels, muscles and nervous system, are the result of functional differentiation. They are developments made independently and afresh by each individual of each generation, and the same applies to the relation between the lens and the eye. The correlations take place during ontogeny; they are not transmitted through phylogeny. The result of these considerations is to throw much of the burden of genetics (in the wide sense) off heredity and on to experimental embryology.

Regulation.—The reader of the foregoing account will already have noticed a number of cases of regulation. Isolated blastomeres of the sea-urchin and other forms, blastulae with part of the animal hemisphere cut off, will develop as reduced wholes instead of as incomplete parts. For this to be possible it is necessary that the embryo when operated upon should still be in a stage when the tissues are plastic, and before the cells have been irrevocably determined by chemo-differentiation. But the chief problem is: how can that which was a part acquire the properties of a whole, especially since it is immaterial what relation the part in question bore to the original whole? To Driesch, this question appeared to be unanswerable in terms of the physical categories of the universe, for which reason he abandoned the attempt to explain development in physico-chemical terms. He substituted a vitalistic system of "entelechies," which admittedly placed living processes in a category apart. Unfortunately, this procedure also has the effect of withdrawing the study of development from the possibility of attack and analysis by scientific, and therefore by mechanistic, method. The programme which modern experimental embryology follows, as laid down by its founder Wilhelm Roux, is the splitting up of the processes of development into simpler component processes, of which it may be said that such a result always follows from the action of such and such factors under given conditions. So it may be said that the organizer induces the differentiation of the axial structures in newts and frogs; that the eye-cup induces the differentiation of the lens in *Rana fusca;* that nerve-fibres react in a definite way to electric currents; that the multiplication of nerve-cells is a function of the number of nervous impulses which they receive; that axial gradients determine the place of and nature of differentiation of various organs, and so on. These components of development may not yet be simple enough to be analyzed by terms of physics and chemistry, but that does not matter. It is already a great step in advance to have a body of fact relating to the biological properties of certain tissues, as ascertained by their biological effects. In this way, experimental embryology or *"Entwicklungsmechanik"* (developmental mechanics) is becoming an exact science. Now, on turning to regulation, it becomes important to inquire whether a formal mechanistic explanation is possible, before relegating the problem to a position where it cannot be attacked. For this purpose, a few more cases of regulation will be considered.

The case of the blastula of the sea-urchin can be paralleled very closely in the development of the newt. If the ventral half of the blastula of a newt be removed, the dorsal half which contains the organizer will go on developing. When the neural folds arise in such an embryo, they are of the correct size relatively to the reduced size of the embryo; in other words, regulation has taken place. If the ventral half of the embryo is removed at a later stage however (during gastrulation), the neural folds when they appear are of the original normal size, and therefore quite disproportionate to the reduced size of the embryo.

Stylaria is a small worm, the head of which occupies the first five segments of the body. Behind the head are the crop and the oesophagus which occupy segments six to eight. If the body is cut across anywhere behind the head, five segments are regenerated from the anterior cut surface, and these undergo differentiation into a new regenerated head. But the alimentary canal of the next three segments, which were part of the ordinary trunk, becomes transformed into crop and oesophagus. This case forcibly suggests the action of axial gradients, which, passing back from the head, have certain relative levels (degrees of intensity of protoplasmic activities) at which tissues become qualitatively determined into crop and oesophagus.

The hydroid polyp *Tubularia* shows a comparable state of affairs. If the polyp is cut off, a new one forms beneath the cut surface without regeneration, by transformation *in situ* of the stem. The polyp contains four distinct zones, and these zones bear fixed proportions to one another as regards their width. But the whole reformed polyp bears a relation to the length of the whole piece of stem, and what is more, the size of the polyp can be controlled by external factors which are known to affect protoplasmic rates of activities, and therefore the axial gradients. These cases of regulation therefore suggest that axial gradients are somehow involved in the problem. Now reverting to the proposition to the effect that the fate of a cell is governed by its position with regard to the whole organism and to its axial gradients, it is only necessary to assume that the levels on the gradient at which particular differentiations are evoked, have a relative and not an absolute value, in order to arrive at a mechanistic formal explanation of regulation. Actually, this is no assumption, but a statement of fact, for there is considerable experimental evidence from the quality of regenerates of pieces of the worms *Planaria* and *Lumbriculus,* to show that it is relative rates of protoplasmic activities, or in other words the steepness of the axial gradient, which are responsible for the quality of the differentiation.

Lastly, it is necessary to guard against the danger of exaggerating the effects of regulation. Thus, the vegetative half of a gastrula of a sea-urchin is by itself capable of forming a little gastrula, but such a gastrula is deficient in that it possesses no mouth. This follows from the fact that the organ-forming substance for a mouth is already determined and restricted to the upper or animal portion of embryo from a very early stage. There is therefore a simple mechanistic explanation for the absence of a mouth in these operated embryos. But on the vitalistic theory of entelechies, it is inconceivable why the regulating principle, which is supposedly responsible for the perfection of the embryo, should fail in this respect.

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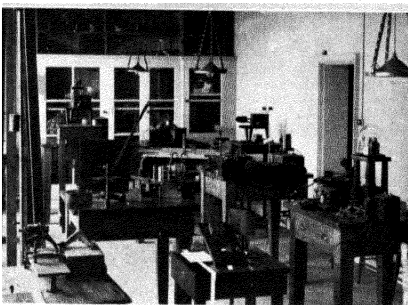
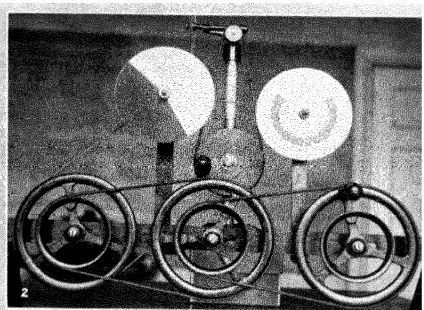
EXPERIMENTAL PSYCHOLOGY is a method of studying psychological problems and is not to be regarded as itself constituting separate subject-matter. It is a systematic attempt to determine the conditions of animal and human conduct by the arrangement and variation of typical situations in response to which such conduct normally occurs. Like every other science it is thus primarily concerned with the discovery of causal laws operating within the field of its study. Experimental psychology does not, so long as it keeps within its proper limits, speculate as to the exact nature of the materials with the relation of which to their stimuli it is directly concerned—that is, with sensations, images, ideas, judgments, trains of reasoning, feelings, emotions, sentiments, impulses, volitions—but it does set out to find the conditions for the occurrence of all of these, and to explain how, when they have occurred, they may themselves operate as conditions of subsequent conduct. Moreover, the experimental psychologist professes to deal with conduct as it occurs in the intact organism, and the implications of this are now coming to be much more completely realized than was the case a few years ago. Many of his problems appear to be similar to those of the physiologist. Both alike, for example, study the conditions of visual and auditory reactions. But the physiologist is largely concerned directly with the reactions of the special sensory apparatus involved. Whenever possible he can legitimately isolate this and consider what occurs within it when various stimuli are being brought to bear upon it as giving an answer to his questions. The experimental psychologist is concerned with the reaction to similar

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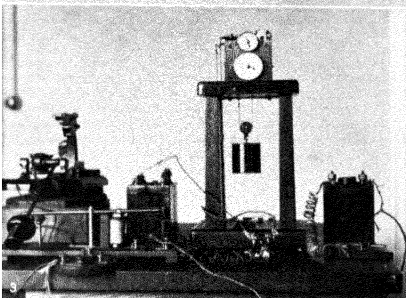
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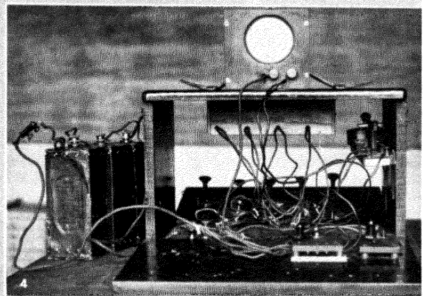
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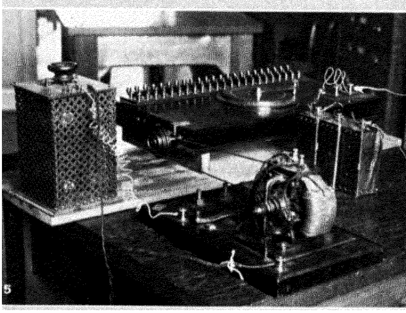
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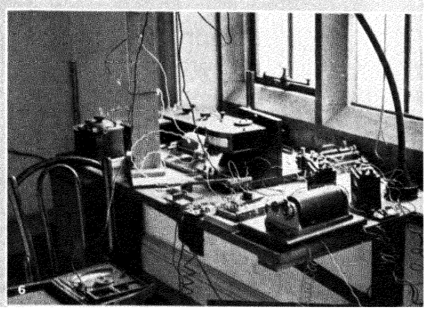
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INSTRUMENTS IN THE PSYCHOLOGICAL LABORATORY OF THE UNIVERSITY OF CAMBRIDGE

1. Corner of a modern psychological laboratory. On small table, middle foreground, McDougall dotting apparatus, for experiments on attention and mental fatigue; right forground, Hipp's Chronoscope (*see* figure 3); left centre, Krapelin's Ergograph for measuring muscular fatigue; right centre, "Psychogalvanometer" for experiments on emotion; left background, on high stand, Müller memory apparatus
2. Colour wheels which rotate rapidly, to show the effects of mixing colours of varied hues, and to demonstrate the effect of one colour upon another simultaneously exposed in a neighbouring field
3. The Hipp Chronoscope, developed from an instrument first made by Wheatstone in 1840, and used to measure human reaction to given signals. The dial hands operated by an electro-magnetic mechanism may be started when a prearranged signal is given and stopped when the reaction is observed. The time of the response is measured in thousandths of a second
4. A Choice reaction apparatus, which measures speed of reaction when any one of a number of signals occurs and the observer does not know beforehand which one is coming. The timing instrument is an electrically controlled hundredth-second stop-watch over the box; the stimuli may be lights of different colours or a sound. There are five Morse keys, one for each signal produced on the opposite side of the box
5. An instrument used by experimental psychologists for any purpose involving the production of series or groups of momentary stimuli. The appropriate grouping is secured by putting in circuit with the instrument telephones, electric lamps or other apparatus to produce whatever electrically controlled stimuli are being employed
6. Corner of a research room in a modern experimental psychological laboratory. The apparatus illustrated is part of an instrumental setting for investigating phenomena in the localisation of sounds

stimuli, not, for instance, of the eye alone, but of the visual mechanism in its intimate relations to the conduct of the rest of the organism. Naturally this renders his problems very much more complex and his solutions at present have to be expressed more tentatively, more contingently.

Sources.—Experimental psychology as a systematic study grew out of the work of physicists and physiologists who were compelled to recognize the important part played by the human observer in the results which they obtained from their experiments. Thus it was at first almost entirely concerned with the measurement of "reaction-times"—*i.e.*, the time elapsing between the giving of a stimulus and the making of a prescribed response by the observer—and with a study of the special senses. In a brief survey, it is impossible even to mention the names of many pioneers whose work gradually developed modern methods of experiment in psychology. A very great amount was due to Gustav Theodor Fechner, however, who, appointed professor of physics at Leipzig in 1834, elaborately endeavoured to obtain exact quantitative statements of the relation between the intensity of a stimulus and of the sensation which it evokes. His reasoning has never commanded wide assent, but the actual methods of observation which he initiated have been developed in many ways and are the foundation of a large part of modern experimental procedure. In 1885 Hermann Ebbinghaus published the results of a long series of experiments which he had made upon himself in the memorizing of nonsense syllables. He claimed that the use of this kind of material made it possible for the first time to experiment successfully on the "higher mental processes." Although, as in the case of Fechner, there is reason for doubting the validity of many of his claims, his work undoubtedly inspired a large quantity of further research. Near the beginning of the present century Oswald Külpe took a further step by encouraging a number of researches upon judgment and volition, while throughout the whole period, from Fechner onwards, experimental work on feelings and on certain specific psychophysical problems, such as that of fatigue, have been continued. In England the approach to experimental work in psychology has been, from the time of Francis Galton, in general by a biological route. The importance of statistics as a method of dealing with experimental results has received special attention and in many ways experimental psychology has been closely in touch with neurology and medicine.

It is curious that the genuine experimental study of animal behaviour is a very recent growth. With a few exceptions, and those for the most part due to the interest of comparative anatomists in the localization of various bodily functions, the anecdotal method of Aristotle remained predominant in the study of animals till the present day. That there is now a flourishing school for the experimental study of animal behaviour is due in the main to America and in particular to Edward L. Thorndike, Robert Yerkes and John B. Watson.

The Present Status of Experimental Psychology.—There is now no important university anywhere in the modern world but in some way recognizes the right of experimental method in psychology to a position in the scheme of higher education and of scientific research. Most of the leading universities, at least in America, Great Britain, Holland, Germany, France, in most of the British colonies and, to a rapidly increasing extent in Russia, China and Japan, provide actual experimental laboratories, though there is still room for much improvement in this respect. A considerable number of well-established journals exist for the publication of the results of experimental research in psychology. Apart from university teaching there are, in almost every vigorous modern nation, flourishing organizations for the practical application of psychology in various directions, particularly those of education and industry. There is a rapidly growing recognition of the importance of psychological teaching and research in relation to the practice of medicine and law and to the organization of a country's defensive and offensive services. It would be easy to show that the development of this practical aspect of psychology has been made possible directly and almost entirely by the use of experimental methods.

The Psychological Laboratory.—It is still true to say, however, that the majority of people who are interested in psychology in a general way have never seen the inside of a psychological laboratory and are somewhat puzzled to think what problems the experimental psychologist investigates and how he proceeds. In the accompanying plate are reproduced photographs of some of the apparatus which experimental psychologists frequently use. Only a very small selection can be reproduced in this way, however, and it will therefore be of interest to describe certain typical equipment and methods as they are to be found, or as they are employed in any modern laboratory devoted to psychological work.

As has been stated already the earliest experimental psychologists were physicists and physiologists and consequently a great amount of work in the psychological laboratory is concerned with the special senses of touch, temperature, taste, smell, vision, hearing and movement. Let us select two groups of these, for a somewhat more careful description: those dealing with visual and those dealing with auditory reactions. Here, then, are colour wheels on which discs of different colours may be rotated so rapidly that the resulting sensations combine and the effects of mixing colours in varying proportion can be accurately determined. Special apparatus demonstrates the after effects of continued light and colour stimulation, and the occurrence of colour blind or colour weak zones in the normal eye. A dark room is provided designed to show clearly the differences between vision in daylight and in twilight and to bring out some of the theoretically and practically important facts connected with abnormalities of colour vision and with night blindness. All of these may be seen in the physics laboratory or in the physiological laboratory. But the psychologist now realizes that his main problems and his methods of approach are his own. The physicist is chiefly concerned with an analysis of the stimulus, the physiologist with the mode of reaction of the eye itself, for instance, and with its connections with the central nervous system. The psychologist must be concerned with these also but has all the time to keep clearly in view how the accuracy of the observations themselves is determined. Thus he has to be particularly careful to study the effects of the method and order of presentation of the stimuli. He knows that these and numerous other factors, some of which may be extraneous to the particular experiment involved, determine the observer's *attitude* towards what is set before him, and that this general *attitude* for which there is no obvious or immediately available physical or physiological expression, in turn may powerfully influence his observations.

With the same aim the psychologist carries out experiments on sound. He notices a man's normal reactions to sounds of different pitch, intensity and complexity, studies the results of combining tones in various ways, measures the acuteness of an observer's reaction to sounds of given character, and demonstrates how the ears make it possible to judge where a sound has its source. He shows how all these apparently simple responses are in reality exceedingly complex and how an important part of their conditions often has to be stated in terms of what are called the "higher mental processes."

But obviously the world in which men live is not mainly a world of shifting patches of light and shade, of colour, of isolated sounds, tastes, smells and similar sensory characters. It is a world of *things* identified, named, referred to some position in space, or apprehended as moving in some direction. So the experimental psychologist must try to show the conditions, not only of the relatively abstract sensory response, but of the more concrete perceptual processes that men are constantly carrying out. He has apparatus for the controlled exposure of objects: stereoscopes and devices for the study of the perception of solidity or of distance, and of the various optical illusions; means by which he can demonstrate how sensations of differing kinds may all come together into a single complex perception.

A very little study of these perceptual processes is enough to demonstrate that in many instances what is actually perceived at the moment is only a little of what a person reports that he has observed. We fill up the gaps of perceptual data by using images, or relying upon recollection, in some form, of past events,

as when a person, travelling at high speed in an express train sees only parts of things through the carriage window and then reports his observations with much more detail than could possibly have been discriminated at the time. Considering this the experimental psychologist is led to arrange special situations with a view to the production of mental imagery and to study the types and functions of the imagery produced. Once more employing his exposure apparatus, so that the conditions of reaction can be at least partially controlled, he presents common objects incomplete in some respects, or material arranged in a series which gradually approaches a climax, or material directly designed to produce ambiguous or alternating reactions, or material conflicting with some other simultaneously presented perceptual data, and in these and other ways seeks to arouse mental imagery and so to discover what functions it fulfils.

It is now but a little step to the study of memory proper. Here a vast field of research, with its own peculiar technique in the construction and presentation of material to be memorized, is opened up. The experimenter has to investigate economical methods of learning, rates of forgetting, the influence of specific factors such as position in a series upon immediate and remote recall, and to try to measure association strengths between items presented simultaneously or in succession. For all this he has his specially devised material, his specially arranged methods and his specially constructed apparatus.

Throughout the whole range of psychological experiment an observer frequently has to judge, to choose, to decide, and often reports that his reaction processes are accompanied by feelings and emotions. How can these functions of judging, choosing, deciding and feeling be themselves experimented upon? As regards the first three of them the essential method is to place an observer in some situation which sets him an interesting problem. The solution has to be effected by judgment, choice or decision. Thereupon the experimentalist brings into play apparatus by which he can record some of the physiological changes which accompany these mental processes, such as variations in respiration, in pulse rate, or in glandular secretion. At the same time the observer, acting throughout under relatively controlled conditions, gives a verbal report of the processes which seem to him to have led up to the judgment, or the choice, or the volition. The problem situations may be indefinitely varied in complexity, from the simple judgment as to which of two weights is the heavier to decisions upon controversial questions of great difficulty. In regard to feeling also some exciting stimulus or situation is presented, and the observer reports verbally the factors which appear to induce his feeling, while changes of respiration, of pulse beat, of glandular secretion, of resistance to the passing through the observer's body of an electric current and so on, are recorded.

As a part of practically all of the general fields of investigation already mentioned it is often of interest to measure the speed at which the combination of physical, physiological and psychological processes involved takes place. For this purpose the psychologist has developed elaborate and delicate "reaction-time" apparatus by which he can determine, up to a thousandth of a second, the time elapsing between the occurrence of a stimulus and the response to that stimulus in some pre-arranged manner.

Especially interesting questions arise in the investigation of abnormal conditions. What, for instance, are the effects of glare, or of flicker in the visual field; of excessive and continued noise or vibration in the auditory and tactual fields; of drugs and fatigue upon psychical processes generally? The study of muscular and mental fatigue in particular has developed a mass of special apparatus and methods of research and has an immediate practical application.

In nearly all cases of psychological experiment very little reliance can be placed upon single and isolated observations. The conditions involved are always complex, always only partially controlled. Repeated observations are necessary. If these are to be successfully interpreted the experimentalist must be well acquainted with the technique of the "psychophysical methods," and he must have some knowledge of statistical theory and practice.

The experimental psychologist has no lack of problems with which to concern himself. In all the directions mentioned and in many others the application of experimental method is as yet in its infancy. The greatest success has so far been won in the realm of the study of the special senses and of perception. But his methods and results are now extending rapidly. More and more the higher mental processes are coming within the experimentalist's purview, so far as knowledge and control of their conditions are concerned.

In one direction in particular it is highly probable that the near future may see important advances. A great many of the conditions of our conduct are directly social in character and source. There has been little attempt to observe these under experimental conditions, but the task is by no means hopeless. We can so arrange experiments as to be able to observe at least some of the effects of socially derived motives: competition, pugnacity, assertiveness, submissiveness, friendliness, liability to suggestion and the like. The results obtained in this way must inevitably react upon the experimentalist's study of the individual, forcing him to investigate not only the operations of the intellectual, cognitive mechanism, but also the extremely important play of temperament and character. In some ways the most striking achievement of the experimental psychologist in recent years has been the development of exact methods of studying and ranking "intelligence." These may well be supplemented in the near future by more exact methods for the study of the social determination of conduct and the influence of individual temperament.

The Contemporary Situation.—A considerable change has come over experimental psychology since its early days. Then the chief aim was to render a description of certain experiences as they were experimentally produced and controlled. On the one hand the interpretation of the results obtained was dominated by theories taken over from general psychology according to which all complex experiences were regarded as made up of unitary elements of a sensory order which had been built together in the course of individual life by the "principles of association." On the other hand the actual methods employed were, as nearly as possible, copied from other experimental fields. Particular forms or varieties of experience, whether of a sensory, or of a "higher" order were, as far as possible, cut off from other kinds and correlated with their immediate physical stimulus. The result was often artificial in the extreme and experimental psychologists were constantly doing or initiating work which could be done much better by physiologists, with their specific training in the technique of the study of relatively isolated bodily activities. The view that complex experiences and reactions are genuinely aggregations of simpler forms has now practically disappeared. In consequence the problems of the experimental psychological laboratory have been brought very much nearer those of real life and, as has been indicated already, the experimental psychologist has developed a technique and a point of view which are as distinctive as they are effective.

A very powerful influence in bringing about this change has been the movement known as "Behaviourism" (*q.v.*). Men have always been interested in the study of the behaviour of animals. But until very recently their interest led them either to the descriptive type of study attempted by the field naturalist, or to the collection of remarkable animal stories interpreted in the light of human conscious experience. The development of an experimental approach to biology made "behaviourism" possible. At first, as in the field of general human psychology, experiments were mainly concerned with the special senses, and in particular with an anatomical study of the parts of the central nervous system in which various special sensory reactions, of sound, vision, taste, balance and the like may appear to be localized. Then experimenters began to try to observe exactly how various species of animals learn to discriminate one object from another, or to run successfully more or less complicated pathways in a maze. They decided to avoid explaining animal conduct in terms of human experience, and to limit themselves strictly to relating the conditions of their experiments, as any competent observer would describe them, to the conduct of the animals, as that, again, could

be described by any instructed on-looker. It seemed possible to do a great amount, and perhaps the whole of this without once using the notion of consciousness as a causal factor, for these experimenters rightly held that to attribute consciousness to an animal is to go beyond directly observable fact. Their success led them to put forward an exactly similar programme for experimental work in general human psychology.

Most experimentalists in psychology, however, still maintain their right to include in the conditions of the reactions which they study many that are, certainly for the present and it may be forever, incapable of being expressed in physiological terms. Many attempt to hold themselves free from any systematic theory about the nature of human experience and, taking up certain specific problems of reaction in human beings, insist that such reactions must be regarded as part determined by "attitudes," both conscious and unconscious, by "tendencies" whether instinctive or of a higher level, and by the accumulation of the results of past experience which appear or which function in the form of images, ideas, sentiments and so on. For example, much work is still being done on the minimal intensity of stimuli of varying quality which will produce a reaction. The experimental psychologist shows that these "threshold values" of stimuli of all kinds can be shown to depend in part upon "attitudes," images and like factors occurring during the course of the experimental investigation. He holds that, independently of any discussion as to their ultimate character, it is impossible at present to reduce these to physiological and much less to physico-chemical terms. Such a view being admitted experimental laboratories are to-day investigating problems over the whole field of human response. There is a revived interest, due largely to certain important practical difficulties which arose during the World War, in the psychology of the special senses, particularly those of vision and hearing. The image processes and their relation to perceptual reactions are the subject of constant experimental study. Memory is being investigated, less as an isolated type of response, and more as falling into place in a whole complex learning-process which may continually involve also the higher mental activities of judging, choosing, reasoning and the like. On the side of feeling and emotion increased interest in experiment has grown out of recent work on the effects of the secretions of endocrine glands. Methods of registering emotional expression through metabolic change are being further developed, and both in this field and in that of volition some psychologists expect much from the use of the galvanometer which appears to be capable of being used to indicate when certain changes commonly called mental take place.

In general the evidence seems to be going against strict behaviourism as a tenable theory. Towards this conclusion the experimental researches of the *Gestalt* school, as it is often called, have greatly contributed. Professor Max Wertheimer, followed by Professors Wolfgang Köhler and Kurt Koffka and many others, starting from some striking experiments on the way in which the perception of movement may be produced, have urged that it is impossible to consider the phenomena of perception as in any way made up of a number of isolable elements whether of sensory or of any other origin. We perceive "forms," "shapes," "configurations," which are doubtless complex, but whose character considered *as a whole* gives them their properties and their functions. The theory has been worked out most fully in the realms of visual and auditory perception, but as applied to problems of conduct it is clearly diametrically opposed to an interpretation which treats complex behaviour as the expression of numerous simple and relatively self-contained reflexes. The view that all high-level forms of activity possess characteristics of their own, in no way theoretically deducible from a study of the simpler conduct out of which they have undoubtedly developed is also in line with a mass of research of a more physiological and neurological order.

In whatever realm and with whatever general background of theory he works, however, the modern experimental psychologist is definitely committed to a biological method of approach. He regards mental processes as falling into their place in a biological adaptation of the organism to its environment, and his problems are thus becoming more and more an enquiry into the *functions* which such processes carry out, and less and less a mere description or a mere analysis of the processes themselves.

Modern Practical Applications.—A very few remarks may be added concerning current practical applications of experimental method. The application of experimental psychology to the solution of practical problems was strongly stimulated by the World War. During that period of time every important belligerent country called upon its psychologists for advice in the development, organization and training of its offensive and defensive forces. Much of the work then done continued and has been developed in many different ways. In industry psychologists have their special tests for vocational aptitudes and their methods of vocational guidance and training. The regulation of bodily movements, organization against "fatigue," and the study of accident liability have direct application both to the fighting services and to many departments of industrial work. In education the "intelligence test" movement has grown to enormous dimensions. In medicine the study of abnormal conduct and its explanation both by organic lesion and by functional disability for which no satisfactory organic lesion can readily be found have been rendered easier and more definite by the union of experimental method with clinical observation. In legal practice psychological experiments have been tentatively proposed and used in connection with the detection of crime.

The whole of this practical development has reacted powerfully upon those methods of academic research without which it could itself never have grown to importance. In this way also the laboratory has been brought nearer to the problems of real life, and the very great possibilities of experiment as contributing to a more complete understanding of man's multifarious activities is being explored with greater eagerness than ever before.

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EXPERT, strictly, skilled, or one who has special knowledge; as used in law, an expert is a person, selected by a court, or adduced by a party to a cause, to give his opinion on some point in issue with which he is peculiarly conversant. These are to be distinguished from the many experts, popularly so called who do not pass any recognized standard. In ordinary practice, the expert commonly met with gives evidence on technical matters not within common knowledge, *e.g.*, handwriting, medical and other sciences, engineering, valuation, etc.

There is some evidence that in England the courts were in early times in the habit of summoning to their assistance, apparently as assessors, persons specially qualified to advise upon any scientific or technical question that required to be determined. (*Year Book*, 21 Hen. VII., pl. 30, p. 33.) The practice of calling in expert assistance in judicial inquiries was not confined to medico-legal cases (*Buckley* v. *Rice Thomas*, 1554, Plowden, 124 a).

Foreign law can only be proved in English courts,—and the same rule applies in Scotland,—(*a*) by obtaining an opinion on the subject from a superior court of the country whose laws are in dispute under the Foreign Law Ascertainment Act 1861 or the British Law Ascertainment Act 1859, or (*b*) by the evidence of a lawyer of the country whose law is in question, or who has studied it *in that country*, or of an official whose position requires, and therefore presumes, a sufficient knowledge of that law (*Perlak, etc.*, v. *Deen*, 1924, 1 K.B. 111).

Statutory provision has been made in England for the summoning of expert assistance by the legal tribunals in various cases.

In France, whenever the court considers that a report by experts is necessary, it is ordered by a judgment clearly setting forth the objects of the *expertise* (Code Proc. Civ. tit. xiv.).

Experts in the United States stand in substantially the same position in the Federal and state courts as in England.

In addition to the authorities cited in the text, *see* J. D. Lawson, *Law of Expert and Opinion Evidence* (1900); J. P. Taylor, *Treatise on the Law of Evidence* (11th ed., 1920).

EXPLANATION. What is meant by explaining a phenomenon? There is no need to insist on the importance of this question. It is obvious that the entire structure of science will necessarily depend upon the reply given. The usual answer is that explanation consists in showing that a phenomenon obeys a law. This is the formula apparently first enunciated by Berkeley: *Nam inventis semel naturae legibus, deinceps monstrandum est philosopho, ex constanti harum legum observatione, hoc est, ex iis principiis, phaenomenon quodvis necessario consequi: id quod est phaenomena explicare et solvere, causamque, id est rationem cur fiant, assignare.* As is well known, Comte based his "Positivism" on this principle: Science seeks nothing but laws and, once these are discovered, science remains simply a collection of them. Whatever is not law is vain or, at most, provisional scaffolding,—for what science really aims at is simply preparation for action:—"Science, whence prevision; prevision, whence action." This is almost a translation of Hobbes's statement: *Scientia propter potentiam . . . omnis denique speculatio actionis vel operis alicuius gratia instituta est.*

Berkeley, as we have just seen, identified cause and law. Comte, on the contrary, saw that it is possible to investigate the cause of a phenomenon *after* having determined its law. But he severely forbade research of this kind. In his view, "only men absolutely devoid of the scientific spirit" are inclined to adopt such a procedure.

This way of conceiving scientific explanation is quite in accordance with the etymological meaning of the term if we remember that this implies merely that what was not entirely "level" has now been made so. From the same order of ideas is derived the German expression, *erklären*, "to make clear," so that what was hidden may become visible. All this seems in harmony with the positivist view that to explain a phenomenon is to describe it.

The term "explanation" however has, for its synonym, *explication* (in French this latter alone has been retained), while, in Latin, *explicare* originally meant "to unroll," and is almost synonymous with *evolvere* (whence the modern concept "evolution"). Thinkers of the Middle Ages often gave this interpretation to it, and among moderns, Hegel, Wallace and Ward have followed them. So understood explanation appears to be something quite different from description; it implies the preformation of the consequent in the antecedent. A phenomenon will be explained only when it is shown that what is new, what is surprising in it, should not have surprised us, since it was already present in a disguised form. And it is precisely in this element of wonder and certainly not in the desire to prepare for action, that Plato and Aristotle saw the true motive force of science.

Might this, however, not be a vicious, chimerical form of the search for knowledge? Might not the orientation of present day science in fact run counter to that of the past (tainted according to Comte with the "metaphysical spirit"), in conformity with the positivist scheme? This is a question which cannot be settled without an investigation of science itself.

Positivism.—It is to be noted, in the first place, that the search for causes, as distinct from that of laws, has been quite general in modern science; it is enough to think of gravitation to be convinced of it. Newton had determined its *law* (the accuracy of which had hardly been questioned before Einstein); but physicists declared themselves far from satisfied with the result, and continued to seek the *cause* of the phenomenon. Hundreds of theories, each more hazardous than the other, were suggested; and Maxwell (certainly one of the most genuine representatives of the purest scientific spirit in our age), far from condemning these efforts, has, on the contrary, expressly declared that a scientific theory which could lead to an explanation of gravitation would be sufficient inducement for scientists to devote the rest of their lives to it. But it would be difficult to define what they would be seeking if the law suffices to explain the phenomenon.

One must remember besides, that, as against Comte's formula, the dominant rôle in science is played not by law, but by causal hypotheses. Now, at bottom, the very existence of such theories is embarrassing for strict Positivism. Comte himself felt it and vacillated a little on their account, sometimes ruling them out entirely, at other times admitting them as a kind of provisional make-shift. Impelled by a strong scientific instinct, he even went so far as to declare the atomic theory "a good hypothesis."

But Mach, who built his theory of science upon a basis completely analogous to that of Comte, was more logical, for he violently opposed the revival of atomistic conceptions since the end of the 19th century, declaring (during a well-known controversy with Planck) that if physicists affirmed the reality of atoms to constitute an essential point of their scientific *credo*, he (Mach) would cease to think as a physicist and would forego their approval of his work. The majority of positivists, however, maintain a less uncompromising attitude. They admit causal hypotheses, hoping that subsequent progress in knowledge will eliminate them and reduce science to a system of laws entirely freed from hypotheses. Now, it is sufficient to consider the actual evolution of knowledge to convince oneself how little its progress corresponds to these views. Never has a mechanistic hypothesis disappeared before a simple law; like the priest of Nemi, it always had to be annihilated by some other theory that succeeded it. This fact seems sufficient to overthrow the positivist scheme.

Finally, there is observable in science the existence of a series of propositions (the most important, or, at any rate, the most general throughout the whole domain of our knowledge) the nature of which is ill determined, namely, the principles of conservation. Some thinkers have taken them to be simple empirical statements, while others have declared them to be *a priori*. But on a rather closer examination of these two opinions, it will be easily seen that neither has any solid foundation, and one wonders therefore how these principles met with such ready acceptance at the time they were proposed, and how they came to occupy such a high place in the hierarchy of dominant scientific truths.

So the positivist scheme is incapable of embracing the whole of science; it is quite vain to try to adjust the whole of science to this bed of Procrustes. What the positivist formula defines is only a part of science, the knowledge of laws; and if this part be subtracted from the total (an operation which Comte's formula enables us to do—and in this lies his great merit), there remains, so to speak, a residue. To use another image, the positivist key does indeed open many of the doors of science but not all of them;—there still remains a whole series of locks which it does not fit.

Preformation.—Now, it is possible to show that one new key, and only one, fits all these locks, namely, that of Preformation, referred to already. Statements about conservation, taken in the most general sense, affirm that despite apparent changes observed in the "real," something—velocity, mass, energy—remains invariable; atomism, or universal mechanism, proves on careful examination rather to be an explanation of change by displacement; and lastly, the search for the cause of gravitation (after its law had been determined) appears to be prompted in the main by mechanistic theories, and so is simply a case of the same procedure.

Is the solution which we have just reached quite complete? On examination, the concept of cause is found to involve motions to which the solution does not seem directly applicable. First, there is the fact that we demand the cause not only of that which changes, but also of that which persists. Aristotle himself sometimes spoke of "cause" in such cases, and Leibniz declared that if it were proved that the ultimate particles of matter were spherical, we still should ask why they were not cubical. Would this tendency be entirely alien to the nature of physics? It is easy to realize, on the contrary, that it exerts the most powerful influence

upon it. On this tendency depends an essential idea of mechanism, namely, the unity of matter, which it has not ceased to proclaim from the time of Leucippus and Democritus up to our own day; also another equally characteristic idea, viz., that this matter, of which all "reality" is made, has no quality except that of occupying space, and is therefore identical with *empty* space. Descartes, who may be called the codifier of modern science, boldly proclaims this identification, although he expresses it in a rather different way. He declares that there is no space where there is no matter; but one realizes through his very deduction that this "matter," having only geometrical qualities, is, at bottom, nothing but space.

In modern physics (or more precisely, before the appearance of Einstein's "general relativity") this reduction was carried out by a more round-about route; a semi-material medium, the ether, was postulated, and it was sought to explain material particles by such peculiar properties of this medium as rings, vortices, etc. It was understood, however, that this ether must possess no "occult quality," and this requirement obviously ended by making it identical with empty space, as Maxwell recognized, or else a simple hypostasis of space, according to Helmholtz. The relativists, in this respect, resumed the Cartesian tradition by abandoning to a greater or less degree the hypothesis of an ether.

Paradoxes.—A very thorough scrutiny is hardly necessary in order to see that this train of thought leads to an exceedingly paradoxical conclusion. For space (at least, the three-dimensional space of the pre-relativists) is evidently not susceptible of any change, and even if we suppose it filled with some quasi-material substance everywhere identical with itself (such as the hypothetical ether), movement becomes impossible, for its successive states cannot be distinguished one from another, "even by an angel," as Leibniz declared. Therefore, the outcome of all this labour of reduction, if by some miracle it might be brought to a successful conclusion, would be tantamount to reducing the real to nothing, to absolute annihilation. And we are driven to the conclusion that such aims, so paradoxical, so contrary to that which the physicist firmly believes to constitute his nearest and surest aim, namely, the understanding of the real, can only derive from a tendency rooted in the deepest part of the human mind—the *intellectus ipse*, whose existence is affirmed by Leibniz when to the scholastic formula, *Nihil est in intellectu quod non fuerit prius in sensu*, he adds the words *nisi intellectus ipse*. It will also be seen how far this tendency to discover the cause of the diversity among the co-existent is connected with that which attacks the diversity of the changing. The solutions, further, resemble each other. A moment ago we explained change, by showing it to be merely apparent, and so concealing a basic identity. Now we endeavour to establish that the "real," whatever be the matter which seems to fill it, is everywhere identical with itself. Explanation is accomplished, then, in both cases, by the help of what has been called the *principle of identity*, but which might have been better named the *schema of identification*. Hegel, indeed, has justly pointed out that the formula of strict identity A=A, constitutes a tautology pure and simple and, therefore, cannot serve as an instrument for any progress in thought. In reality, the second A is always regarded as differing from the first in some respect, and the work of the mind consists in establishing, or at least affirming, identity in spite of this difference.

Free Will.—Again, it is maintained, on the other hand, that the term "cause" is sometimes employed in cases where this concept of the identity of the antecedent and the consequent seems to be precluded from the outset, since their diversity is expressly affirmed, *e.g.*, when the reference is to an act of human or divine free-will. We are not here concerned to affirm or deny the existence of a free will; it is certain that we have the immediate sensation that our volition is the cause of our movements and that, for believers, acts of Divine volition cause phenomena. This causality may be called *theological*, in distinction from the "identifying causality" which is properly *scientific*. For while it would be an error to assert that science denies miracles, it is nevertheless true that it excludes them from its realm, just as it excludes human free will. Science does not limit itself to prevision but begins with it: whatever eludes prevision therefore cannot belong to scientific research.

The Irrational.—Since reason seeks identity, whatever opposes its efforts in this procedure appears to it as fundamentally incompatible with itself, as *irrational*. The clearest type of concept of this order is that which results from Carnot's principle. This affirms, in effect, that the antecedent and the consequent can not be identical for the cosmic process proceeds constantly and irresistibly always in the same direction and without any possibility of reversal. Carnot's principle thus stipulates a "becoming," which is contrary to the principles of conservation. It is noteworthy that while the latter have been accepted both by science and commonsense, on grounds far from conclusive, the former has encountered a lively resistance. Clausius, nearly a whole generation after Carnot, had to discover the principle a second time, and even then, it only gradually secured its legitimate place in physics. Now, this principle is based upon an observation which is perhaps the commonest mankind is capable of making; namely, that heat passes steadily from a warmer body to one less warm, and never conversely. But this observation, however certain and commonplace, is contrary to that causal tendency of mind which imposes the *schema of identification*, and leads the mind to set aside, to declare negligible, whatever opposes it. So it comes about that what persists in phenomena appears to us as essential, as their "substance," and that which changes, as accidental. Now, on the contrary, it is sufficient to consider reality without preconception to become convinced that what remains unchanged is indeed little compared with what undergoes modification. Thus, inertia is, without any doubt, a purely ideal concept; no one has ever seen a uniform movement in a straight line, so, *a fortiori*, no one could see that it would continue indefinitely. And besides, is velocity really more essential than position, and direction than velocity, along a curved line? When I see a red powder (such as oxide of mercury) give rise to a liquid metal and a colourless gas, can I affirm, because I see that the weight remains the same, that the change was without significance? The situation is still worse when we come to the conservation of energy. For, following Carnot's principle, which tells us that energy is incessantly being degraded, we see that its conservation does not at all guarantee the indestructibility of movement. In the state of final equilibrium towards which the universe is steadily tending (the famous *Waermetod* of Clausius), there will no longer be a fall anywhere; and consequently no movement of more than microscopic scale will be possible in it, while energy will none the less be completely preserved.

An "irrational" of a different order from that which Carnot's principle has brought to light, becomes apparent if we consider *sensation*. This, without doubt, is the ultimate source of all our knowledge of the real, but it is easy to see that our modern science excludes that which is its characteristic element. This science does by a somewhat indirect route, banishing it first of all into one of its most complex and least advanced branches, namely, physiology. Once there, it is enveloped in mystery, shut up in the nerve and in the *specific energy* of the nerve. Leucippus and Democritus had already allowed this exclusion, and Descartes (and all modern science with him) maintained it. Aristotle certainly attempted to create a different system of physics, a *qualitative* physics, and the middle ages docilely followed his lead. But we know that this attempt has been absolutely ineffectual. However magnificent it may have appeared at the time, at the present day the edifice is an irremediable ruin: absolutely nothing can be saved from it. And even those who have occasionally tried to incorporate a few fragments of it into modern physics have had to recognize the vanity of their efforts. (The loyal attempts of Duhem were the most brilliant and persevering of this kind ever made.) Vain too have proved to be the objections of philosophers against what they considered unjustifiable prejudice on the part of physicists, as well as the efforts during the first part of the 19th century (especially in Germany) which were directed to elaborating—alongside the physics of physicists, nay, in opposition to it—a different science incorporating and explaining the *quid proprium* of sensation. And, what is more remarkable, is that even in Ger-

many, scientists did not take the trouble to refute these attempts, but simply disdained them, passing them by unnoticed, despite the great authority which their authors—we need only mention the names of Hegel and Goethe—enjoyed at the time.

Another "irrational" arises if we consider the explanation of the *persistent,* of which we have just spoken. This explanation amounts in the last resort to dissolving the whole of reality into the undifferentiated whole of space. It is clear therefore that whatever opposes such a dissolution must play the rôle of an obstacle. In this way, all diversity inevitably appears as an irrational. Perhaps it will not be pointless to make the significance of this assertion more precise by the aid of an example. We know that chemistry has for a long time been constituted as a science distinct from the other physical sciences, and that what differentiates it is its affirmation of the qualitative diversity of substances. Under the name of Mendeléeff's theory, this diversity has been questioned, for it seemed to be demonstrated that the various elementary substances themselves should not be considered completely isolated from each other, but, on the contrary, as derivative from a more general system. As a consequence, on the one hand, of the discovery of radio-active bodies and other discoveries connected therewith, and, on the other, of a series of researches which better enable us to understand the nature of the chemical atom, this current has acquired great strength, and, it may be said to dominate chemical theory at the moment. Clearly, were these efforts to prove completely successful,—in other words, were it possible to reach an explanation of the *entire* behaviour of chemical substances through the spatial configuration of elementary particles (electrons and protons, according to the dominant conception), the specific nature of chemistry would vanish. But, on the other hand, to encounter phenomena fundamentally inexplicable by such configuration, would be to discover the presence of an "irrational." We can realize, then, that such a situation is particularly liable to arise wherever we admit the existence of *separate* sciences. Thus, it is most probable that when our knowledge of biological phenomena is more advanced, and when we are in a position actually to reduce a great number of them to physical chemistry, there will remain, nevertheless, something which we shall not be able fully to account for, and then science will be compelled to admit one or more "irrationals" as being related to the manifestations of organic matter.

However, it should be realized that not all irrationals could be foreseen in this way, by even the boldest speculation. Indeed, from those very phenomena which we believe to be the most fully understood, something inexplicable may arise. This is just what happened during the first decades of this century. We refer to the observations concerning radiation which led to Planck's theory of *quanta,*—a theory so strange and disturbing, because it is so difficult to reconcile it with the remaining hypotheses of physics. And who can say that this surprise will be the last, and that science will not encounter in the future other anomalies just as disagreeable?

The Real and the Necessary.—If now we take a comprehensive survey of this great effort of science to explain and to identify, we see that it aims at a rationalization of the real, that is to say, at its reduction to purely rational elements. The real appears to us as a fact,—a datum. Now reason would like to conceive it as *necessary.* Hence the extravagant attempt to reduce it to space, namely, to nothingness,—or (what amounts to the same thing), to reconstitute it with the aid of space alone. Newton, who had before him the attempts of Descartes, admirably discerned that such an effort could only end in failure. *"A coeca necessitate metaphysica,"* he says at the end of the third edition of his *Principia, "quae utique eadem est semper et ubique, nulla oritur rerum variatio."* One sees, none the less, that the effort has been renewed in our own day by the physics of relativity. But by the very fact that space is there supposed capable of modifying its curvature, of disclosing "wrinkles," it ceases to be always and everywhere homogeneous, and this construction thus escapes Newton's objection to some extent.

This notion of the irrational, as an obstacle which mind constantly encounters in its advance towards an explanation of nature, shows that we should be wrong in charging science with the tendency to dissolve the real into nothingness. For this tendency is quite obviously something which precedes science, something by the aid of which science itself has been created. We begin the penetration of the real with the profound conviction that it should prove itself everywhere penetrable. It might be objected, it is true, that a science confined to the discovery of laws, according to the formula of Comte, seems practically to rule out any intelligibility strictly so-called, by contenting itself with the supposition that nature obeys laws. But apart from the fact that there never has been such a type of science, and in all probability never will be, it is easy to see that even if, in an exposition of science *already made,* it could in strictness, be made to appear as simply a tissue of laws, this would become absolutely impossible so soon as it became a question of science *in the making,* of science in process of development. Francis Bacon believed it possible to establish laws by means of experiments undertaken at random, and summed up later by a sort of mechanical book-keeping. But Liebig has declared that between this variety of science and real science the same relation holds as between the noise made by a child beating a drum and music, and in this the unanimous opinion of scientists would agree with him. In reality, when trying to discover a law the scientist is compelled to select among the conditions of phenomena which are infinite in number, in order to observe those which seem to be more closely connected with each other. What he is intent upon determining is what Lord Balfour calls the *fibre,* that is to say, one of the fibres of which the real is constituted. And simply this fact, that the whole body of the real is not chaotic, but actually consists of a tissue of such fibres, allows us not only to penetrate into it but even to live in it. Now it is only by means of hypotheses concerning the nature and essence of the real that we can seek out this fibre and make a supposition as to its existence and precise place in the scheme of things. Thus, a science directed to the discovery of laws is itself ultimately based upon the conception that nature is intelligible.

The schema of identity constitutes the eternal framework of the mind, and science as a product of the mind, cannot be other than pervaded by it. But, far from submitting to it passively, it reacts, because the real itself reacts, in showing that it is *not completely* penetrable. The idea of the irrational is the manifestation of reality's resistance to intellect. Hence in science, the two tendencies which might be thought opposed to each other,—the idealist tendency toward a negation of the real by rationalization of the diverse, and the realist tendency toward an affirmation of the fundamental irreducibility of the diverse,—co-exist peacefully. It should be noticed that if idealist negation is at the end of its course, physics does not cease for a moment to be fundamentally realistic. The "vortices" of Kelvin, like the "wrinkles" of the relativity theory, show themselves the very moment we try to bring them nearer to ether or space, just as real, just as independent of our own selves, as any common-sense objects. Even more independent, indeed, for, as Planck has shown, science tends in its progress to draw further and further away from the *anthropomorphism* that common-sense imposes on us.

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EXPLOSIVES are substances capable of developing a sudden pressure on their surroundings, this development of pressure being caused by the rapid conversion of the explosive substance into gases having a much greater volume than the original explosive, and to the further expansion of these gases by the simultaneous generation of heat. Explosives may consist of gases, liquids, or solids; for example, the explosive mixtures of gas or petrol vapour with air in the internal-combustion engine, and nitroglycerin, and gunpowder are familiar cases of these three classes respectively.

The starting-point in the story of explosives is the discovery by Friar Roger Bacon of the process of purifying a salt by crystallization from aqueous solution. By applying this process to the purification of naturally occurring saline deposits, Bacon obtained, for the first time, pure nitre or potassium nitrate, and one may

imagine that with this pure nitre he attempted to imitate one of the "fiery" or "incendiary" compositions which had long been known and used. Instead of a smouldering and fuming action, the result was the first artificial explosion. As Col. Hime states (*Gunpowder and Ammunition,* 1924), there is no evidence of the knowledge or existence of a real explosive before Bacon's experiments. Fuming, fiery or flaming compositions, such as sulphur and various kinds of natural pitches or bitumens, were not difficult to obtain, and these along with charcoal were easily made into incendiaries. The addition of the natural nitre, natron, etc., can easily be accounted for by a happy accident. Col. Hime, after a thorough examination of all the available evidence, concludes that Roger Bacon was the first maker of the "fundamental" mixture leading to gunpowder. For a surprisingly long time gunpowder (of sorts) was practically the only known explosive.

In the last three-quarters of a century many explosives have been invented or discovered. These modern explosives vary widely in composition, chemical constitution and the kind of explosion they produce. It was not until the 19th century was well advanced that gunpowder had a serious rival either for military or civil employment. Slight modifications in its composition were made, more by accident than by calculation, in order to render it more effective and local in action as a blasting agent for mining. This result was attained mainly by increasing the proportion of sulphur at the expense of the charcoal. Still later, military modifications, known as "brown" powders, were introduced for special uses, in which most of the charcoal was substituted by a "caked cellulose," whilst the proportion of sulphur was reduced to one-fifth and the nitre increased. Speaking generally, the era of new explosive substances started soon after the discovery of the compounds collectively termed gun-cotton or nitrocellulose and nitroglycerine, although fulminating silver and a few similar substances may have been known at a prior date. Gun-cotton and nitroglycerine may be considered as commencing the series of explosives derived from nitric acid in a more or less direct manner. Later, other substances, such as picric acid (or lyddite), were discovered, more or less accidentally, to be explosive under certain special conditions, and following on this discovery it was found that analogous substances (nitro-compounds) of a slightly simpler type of constitution than picric acid could also be induced to explode, especially when submitted to violent or sharp percussion, a mode of explosion distinguished as *detonation.* With more complex nitrogen compounds such as the hydrazines, and, later still, the azides, there have been valuable additions to the list of compounds showing in various degrees the detonating form of explosion.

Careful study of the heat production or absorption in chemical actions of combination or decomposition places practically all chemical compounds in one of two classes: (1) *exothermic* compounds, which give out heat energy during the process of formation, and (2) *endothermic* compounds, which can be formed only by having energy, as heat or in some other form, expended on them during the process of formation. Chalk, water and sand are good examples of exothermic compounds, since much energy—mostly as heat—was dissipated during the formation of these substances, and therefore they are not very active in taking part in chemical actions. Consequently they cannot, with advantage, be employed in explosive compounds or mixtures. On the other hand many explosive compounds are endothermic and, on explosion, liberate a part of their stored-up energy. The essential properties of any explosive are that it should be capable of (*a*) complete or nearly complete conversion into gaseous products, (*b*) generation of heat; (*c*) rapid and simultaneous production of gas and heat. The formation of gases in the products of explosion is usually due to a process akin to combustion or burning, in which the combustible parts of the explosive are oxidized or burned to gaseous oxides such as carbon monoxide, carbon dioxide and steam. This process is called "internal burning" and differs from ordinary burning in that the oxygen required is not derived from external sources, but is already contained in the explosive in some readily available form. The production of heat is due either to the exothermic nature of the products of internal burning, or, in some cases, to the breakdown of an unstable endothermic compound into its elements.

The speed at which explosive action takes place may vary considerably with different substances, and with the conditions under which explosion is initiated, the variation extending from a few metres per second to several thousand metres per second. Explosions at lower speeds may be utilized as sources of power in the internal-combustion engine, where the pressure of explosion is developed sufficiently slowly to move a piston against an external load. Similarly, in small arms or ordnance, the pressure of explosion of the "propellent" charge or cartridge is utilized to drive the bullet or heave the shell along the bore of the weapon. Explosions having speeds of several thousand metres per second have a disruptive or shattering effect (Fr. *brisance*) on their surroundings, the duration of the pressure being so short that it cannot be used to produce a propulsive or heaving effect. Explosive effects of this order are called detonations and are made use of in high explosives for military purposes, also for many blasting explosives used in mines and quarries.

Classification of Explosives.—The Explosives Act of 1875 in Great Britain contains regulations drawn up by the Home Office for the control of the processes of manufacture of explosives and of the conditions of storage and handling of the manufactured products. This act classifies explosives in seven classes, according to liability to ignition by fire, friction, chemical decomposition, etc. Regulations based on similar considerations with particular reference to the needs of military and naval explosives are contained in the service "Magazine Regulations." Explosives may also be classified according to their uses, as: (*a*) *Propellents.* Explosives with low speed of explosion, used in the manufacture of cartridges for small arms (pistols, shot guns, rifles) and ordnance (guns, howitzers, mortars), *e.g.*, gunpowder, ballistite, cordite. (*b*) *High explosives.* Explosives with high speed of explosion, used for filling shell, bombs, mines and for demolitions; *e.g.*, amatol, gun-cotton, etc. Blasting explosives of the dynamite and blasting gelatine types, *e.g.*, gelignite. (*c*) *Initiators.* Explosives of a sensitive nature used in caps, primers, and detonators to initiate the explosion or detonation of less sensitive materials, *e.g.*, mercury fulminate, lead azide, in caps and detonators. (*d*) *Pyrotechnic mixtures.* These materials, although not strictly speaking explosives, require care in handling and storage; they are used for the production of: (1) Smokes, both white and coloured, for purposes of concealment and signalling. (2) Coloured flares and stars, for warlike purposes and for fireworks. (3) Incendiary compositions.

Classification may also be based on chemical considerations, *i.e.*, according as the explosives are simple chemical compounds or mixtures. Within the first class are carbon compounds containing combined oxygen which, on explosion, oxidizes the combustible elements, carbon and hydrogen, to form the gases of explosion. These explosive compounds are formed by the action of nitric acid on various organic materials, and are usually nitric esters or nitro-compounds. The combined nitrogen present in these forms is on explosion mainly liberated as elemental gaseous nitrogen. Included in the second class of explosives are those which, being sensitive, endothermic substances, readily break up into their elements with generation of heat, and do not depend on combined oxygen for their explosive effect. Mercury fulminate and lead azide are examples of this class. Explosive mixtures may contain substances in the above-mentioned group together with non-explosive substances containing oxygen, or consisting of combustible matter. Such mixtures are of two kinds—those containing explosive compounds, *e.g.*, cordite, amatol, and those made up of non-explosive materials, *e.g.*, gunpowder.

Blasting explosives are used in engineering and mining operations for breaking up rock or minerals. For many years gunpowder was the only explosive available, until Nobel introduced dynamite in 1867, followed by blasting gelatine and gelignite in 1887. These blasting explosives may be classified in two groups: (1) High explosives. (*a*) Containing nitroglycerine, *e.g.*, dynamite, gelignite, etc. (*b*) Not containing nitroglycerine, *e.g.*, ammonal, etc. These are fired by a detonator containing mercury fulminate (*q.v.*) or other suitable initiator. (2) Gunpowders. These are of the black powder type, *e.g.*, bobbinite, a typical black powder explosive con-

sisting of potassium nitrate 63·5%, charcoal 19·5%, starch 3%, sulphur 2%, paraffin wax 8% and moisture 3%. Typical compositions of blasting explosives are given in the following tables:

	Blasting gelatine	Gelatine dynamite	Gelignite	Dynamite
Nitroglycerine	90·6	74·1	61·1	75
Nitrocellulose	8·8	5·9	3·8	..
Potassium nitrate	..	15·7	27·6	..
Woodmeal	..	4·0	7·2	..
Chalk	0·6	0·6	0·3	..
Kieselguhr	..	..	..	25

Permitted Explosives

	Super-rippite	Rex powder	Denaby powder	Roburite	Dynobel
Nitroglycerine	52	12	..	..	32·5
Nitrocellulose	3	..	..	..	0·75
Potassium nitrate	14·5	..	13·5	..	..
Ammonium nitrate	..	59·5	34	60·5	..
Potassium perchlorate	..	..	..	..	27
Trinitrotoluene	..	..	13	16·5	..
Charcoal	..	..	..	..	..
Woodmeal	..	7·7	..	..	9·5
Starch	..	..	..	..	..
Sulphur	..	..	..	..	..
Paraffin wax	..	..	..	..	..
Ammonium chloride	..	..	19·5	22·5	..
Sodium chloride	..	19·5	..	..	..
Potassium chloride	8	..	..	..	..
Ammonium oxalate	..	..	..	..	29·5
Borax	16·5	..	..	..	..
Moisture	6	1·2	0·75	0·75	0·75

Of these foregoing groups certain explosives may safely be used for getting coal in fiery mines, and are accordingly on the British list of permitted explosives. All are explosives of the mixture class, containing explosive and non-explosive compounds. Among the latter are inert substances such as chlorides and oxalates which act as coolers in reducing the flame temperature. The individual types of explosive will now be described, but gunpowder and picric acid (lyddite) are dealt with in separate articles under their own headings.

Nitroglycerine and Nitrocellulose.—Nitroglycerine, glyceryl trinitrate or trinitrin was first made by Sobrero in 1846. It is manufactured by spraying glycerol (glycerine) into a mixture of nitric and sulphuric acids; the nitroglycerine separates as an oily liquid and is purified by washing and filtration. Its use as an explosive was suggested by Nobel in 1863, but owing to its sensitive nature, the danger in its transport and use prevented its employment unless mixed with solid materials to form a plastic mass which could be handled with safety. Such mixtures are cordite, dynamites and blasting gelatines. Nitroglycerine, a liquid of density 1·6, exists in two solid forms melting at 2° C and 13° C. When soaked in absorbent paper it burns quietly with a green-edged flame, but when heated it decomposes just before boiling, and finally detonates. It is used medicinally for the treatment of asthma and angina pectoris in the form of a 1% solution in alcohol.

Nitrocellulose is the name given to the nitric esters formed by the action of nitric acid on cellulosic materials, *e.g.*, purified cotton or wood pulp. Pelouze in 1838 discovered that cotton could be converted into a violently inflammable substance by nitration with nitric acid, and in 1845 Schönbein discovered its value as a high explosive, also improving the method of preparation by the addition of sulphuric acid to the nitric acid used in nitration. Many attempts were made to utilize this substance as an explosive for civil and military purposes, but owing to a series of serious accidents in manufacture, storage and use, it was abandoned temporarily. Sir Frederick Abel of the Royal Gunpowder Factory, Waltham Abbey, England, discovered subsequently that these dangers were due to the presence in the nitrocellulose of minute traces of acid-forming substances which were not removed by the processes of washing then in use and caused a cumulative decomposition of the nitrocellulose, finally resulting in explosion. On the basis of these discoveries improved methods of washing the nitrocellulose were introduced and resulted in the manufacture of a safe, stable product.

The chemical action between cellulose and nitric acid may be represented by the equation

$$C_6H_{10}O_5 + x\,HNO_3 = C_6H_{(10-x)}O_{(5-x)}(NO_3)_x + x\,H_2O.$$

The proportion of nitrogen in the form of nitrate groups is represented by the variable quantity, x, the value of x depending on the time and temperature of nitration and on the composition of the mixture of nitrating acids. The function of the sulphuric acid is to remove water formed in the action and thereby to prevent dilution of the nitric acid. The properties of the nitrocelluloses vary with the percentage of nitrogen they contain (*i.e.*, according to the value of x), particularly in their behaviour towards organic solvents. Nitrocellulose containing 13·0% or more nitrogen content can be detonated by percussion or by the use of a detonator. Their chief properties and uses are summarized in the following table:

% Nitrogen	Name	Properties	Chief uses
10·7–11·2	..	Soluble in alcohol	Celluloid plastics
11·2–11·7	..	Soluble in ether +alcohol	Photographic films. Artificial silk
11·8–12·3	Pyroxylin or collodion cotton	Soluble in ether +alcohol. Insoluble in alcohol	Cellulose lacquers. Smokeless powders
12·6–13·5	Gun-cotton	Insoluble in ether+alcohol. Soluble in acetone	Gun-cotton slabs. Smokeless powders.

The manufacture of a smokeless propellent consists in the mechanical incorporation of the nitrocellulose with the other constituents in such a manner as to give a product which is gelatinous or colloid in its nature and free from the porosity characteristic of untreated nitrocellulose. In the case of nitrocellulose propellents, gelatinization is effected by kneading the nitrocellulose with a volatile liquid such as acetone, the product being a dough-like mass which can then be rolled into sheets or pressed through dies to form strips or cords. The volatile solvent is then removed by heating, leaving the nitrocellulose in a horny non-porous condition. With nitroglycerine propellents, gelatinization can be effected in various ways: (1) Heat treatment. In this method the mixture of wet nitrocellulose with nitroglycerine and any other constituents of the powder is passed between hot rollers which first expel moisture and finally cause absorption of the nitroglycerine by the nitrocellulose to form a translucent mass, *e.g.*, ballistite. In some cases non-volatile substances are added to the mixture which facilitate gelatinization and act as stabilizers in lessening subsequent deterioration of the finished propellent, *e.g.*, Ardeer cordite. The gelatinized mass can then be rolled or pressed into the required shape and is ready for use. (2) Kneading with a volatile solvent, as in the case of nitrocellulose powders, followed by pressing and drying, *e.g.*, cordites.

The chief drawbacks of smokeless propellents are the erosion of the bore of the gun caused by their use, and the brilliance of the flash of discharge, the latter being specially undesirable in the case of propellents used for warlike purposes. Erosion is caused by the high temperature of the gases of explosion and is less with powders of the nitrocellulose type than with those containing nitroglycerine. This effect is due to the deficiency of oxygen in nitrocellulose and to the excess of oxygen in nitroglycerine. An illustration of this is found in the cordites: Cordite Mark I. is highly erosive owing to its high percentage of nitroglycerine, but cordite M.D. is much less so. Reduction of the temperature of explosion can be effected by the admixture

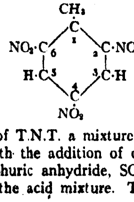
of substances which absorb heat or produce gaseous nitrogen in place of the exothermic oxides of carbon in the gases of explosion. This not only has the effect of reducing erosion but also reduces the brightness of the flash of discharge.

Propellents.—Propellent explosives are required for: (1) The propulsion of shell or other projectiles in rifled arms: (*a*) ordnance, *e.g.*, guns, howitzers, mortars; (*b*) small arms, *e.g.*, pistols, rifles. (2) The propulsion of shot in smooth-bore guns for sporting purposes. For many years the only explosive available as a propellent was gunpowder which is far from being an ideal material for the purpose. Its uncontrolled rate of burning and smoke-producing properties are the chief obstacles to its use. The discovery of nitrocellulose and nitroglycerine led to the development of an entirely new type of propellent, usually called smokeless powder. These propellents differ not only in being smokeless, but also in that the rate of burning is uniform owing to the non-porous texture of the powder preventing the hot gases of explosion penetrating below the surface layer.

Modern smokeless propellents may be either nitrocellulose propellents, consisting mainly of nitrocellulose, or nitroglycerine propellents, consisting mainly of nitrocellulose plus nitroglycerine. In addition to these principal constituents, small quantities of other substances are in some cases added (*a*) to act as "stabilizers" in preventing the deteriorating action of acid substances formed by the slow decomposition of the nitrocellulose or nitroglycerine, or (*b*) to act as "moderants" in regulating the rate of burning of the propellent. Typical compositions of some modern smokeless propellents are given in the following table:

	E.C.	Kynoch	Ballistite	Cordites Mark I.	Cordites M.D.	Cordites R.D.B.
Nitrocellulose	79	52·1	62·3	37	65	52
Nitroglycerine	..	..	37·6	58	30	42
Stabilizer:						
Camphor	4	..	..	..	..	..
Vaseline	..	..	..	5	5	6
Moderant:						
Dinitrotoluene	..	10·5	..	..	..	..
Potassium nitrate	4·5	1·4	..	..	..	..
Barium nitrate	7·5	22·2	..	..	..	..
Woodmeal	3·8	2·7	..	..	..	..

Trinitrotoluene (T.N.T.).—This is a derivative of toluene and in some respects similar to picric acid (*q.v.*). Toluene, $C_6H_5{\cdot}CH_3$, is a liquid boiling at 110° C, obtained from the lower-boiling portions of coal tar (*q.v.*) or from Borneo petroleum. Generally speaking, it is more easily brought into chemical reaction than benzene, C_6H_6, but not so easily as phenol, $C_6H_5{\cdot}OH$. Nitric acid acts on it in several stages, the highest stage being the trinitro-compound or T.N.T., $CH_3{\cdot}C_6H_2(NO_2)_3$. The lower stages of nitration are represented by mono- and di-nitrotoluene. They and T.N.T. itself were employed, either alone or mixed, in the dye industry for quite a long time before any explosive property was associated with them. There are six possible modifications of trinitrotoluene, these isomerides differing in form, colour, melting point, chemical reactivity, etc. (*see* ISOMERISM). The ordinary variety of T.N.T. used as an explosive is represented in the following graphic formula as the most symmetrical isomeride, *i.e.*, as 2:4:6-trinitrotoluene:



In the manufacture of T.N.T. a mixture of nitric and sulphuric acids is employed with the addition of oleum or sulphuric acid containing some sulphuric anhydride, SO_3, thus minimizing the amount of water in the acid mixture. To this mixture the toluene is gradually added with constant agitation, jacketed iron vessels being employed so that cooling or heating may be arranged as required. Nitrous fumes are conducted away and reconverted into nitric acid. The oily product is separated from the dilute mixed acids, which are run off and concentrated for further use. The oil is poured into water, where it solidifies, and is then washed free from adhering acids and purified by treatment with a solution of sodium sulphite, which dissolves all the unsymmetrical trinitrotoluenes (present as by-products) but has no action on the symmetrical variety.

The pure substance melts at 82° C, and when heated to about 150° C it gives off a little gas which is much increased at about 180° C; the melt darkens as the temperature rises, and intumescence may take place at or below 300°. By rapidly heating a few grams of the melted substance in a test tube over a large flame, it is possible to get quite a marked explosive effect. When large quantities catch fire, the burning may become explosive, although this substance, when pure and alone, is one of the safest of high explosives. Some unexplained explosions have taken place, which may possibly have been due to the presence of a trinitrobenzoic acid, produced by too drastic nitration, such an acid being more sensitive than T.N.T. itself. Minute quantities of substances containing available oxygen, *e.g.*, chlorates, nitrates, etc., in contact with nitro-compounds, such as trinitrotoluene, greatly increase the sensitiveness of these compounds to heat or percussion. Nitrate of ammonia, however, is almost the only substance of this class capable of being safely employed in admixture with trinitrotoluene or like substances on a large scale (*see* below).

Trinitrobenzene, $C_6H_3(NO_2)_3$, is difficult to make, otherwise it would doubtless be largely employed for both civil and military purposes. The lower nitration stages—mono- and di-nitrobenzenes—are constituents of various blasting compositions.

Amatol.—Ammonium nitrate has been in use for a considerable time for blasting purposes in mine work, especially coal mining, and was first employed with trinitrotoluene in 1914. After the safety of this mixture had been proved through a wide range of proportions and conditions, it was largely employed under the name of amatol, a composition of 80 parts of ammonium salt to 20 of trinitrotoluene being favoured. The advantage of such a mixture is that practically no carbon is left unburnt on its explosion. The ammonium nitrate is a self-combustible and may, in favourable circumstances, respond to a detonator. The necessity for using special explosives in coal mines instead of ordinary gunpowder drew attention to ammonium nitrate as not being so hot, producing much steam and nitrogen and no red-hot solid particles, and therefore less liable to ignite coal dust or inflammable gases. Ammonium nitrate is hardly to be regarded as a possible substitute for the nitre of gunpowder owing to its deliquescent properties. Compositions of nitro-naphthalene, paraffin, rosin, etc., were formerly used for blasting, being mixed as dry powders, pressed into form, and waterproofed by treatment with paraffin wax. Since then many changes have been made on this type of explosive, particularly in regard to the aromatic nitro-compounds introduced, generally with a view to greater safety or power.

Ammonal.—The enormous amount of heat evolved by the oxidation of some powdered metals, such as that of aluminium in thermite compositions, led to its being introduced into ammonium nitrate mixtures. For ordinary blasting work (out-of-doors) one uses a composition such as: ammonium nitrate, 72%; aluminium, 25%; charcoal, 3%; or ammonium nitrate, 47%; aluminium 22%; T.N.T., 30%; charcoal 1%. The velocity of explosion of these mixtures may be in the vicinity of 4,000 to 4,500 metres per second. For coal mines the aluminium must be reduced to a few units per cent, the larger proportion of ammonium nitrate keeping down the temperature; thus: ammonium nitrate, 93–95%; aluminium, 2·5–3·5%; charcoal, 2–3%.

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LIQUEFIED GASES

Liquid Oxygen Explosives consist of mixtures of liquid oxygen with combustible substances. The combustible substances (lamp-black, wood pulp, cork dust, hydrocarbons absorbed in inert materials, or even pulverized metals) are packed in absorbent paper or cloth cartridges, and immediately before use the cartridges are soaked in liquid oxygen until saturated. The cartridges are removed from the liquid and fired with a detonator in a manner similar to that employed with ordinary dynamites. In the process of explosion an extremely rapid reaction takes place between the liquid oxygen and the combustible material, with the production of a large quantity of gas at high temperature and pressure. The mechanism of the explosion is similar to that taking place in other explosive mixtures, except that the oxygen supply is obtained from liquid oxygen instead of from chemically combined oxygen. The advantages of these explosives are that neither the cartridge nor the liquid oxygen are explosive until brought together and, due to the low temperature (−183° C) of liquid oxygen, the oxygen completely evaporates in a relatively short time after the cartridges have been removed from the liquid, and they are then once more non-explosive. This latter fact gives rise to the disadvantage, however, that the explosive strength diminishes as the oxygen evaporates, and if too long a time elapses before the cartridge is fired, insufficient oxygen is available for complete combustion to CO_2 (carbon dioxide), and large quantities of toxic CO (carbon monoxide) may be formed. This constitutes a hazard in the use of this explosive in underground mining. Under favourable conditions liquid oxygen explosives are considerably cheaper than dynamite.

Practical Applications.—In practice, liquid oxygen is manufactured at the mine or quarry by liquefaction of air and subsequent separation of the nitrogen by fractional distillation. Liquid oxygen is a bluish liquid and boils at −183° C. It cannot be stored under pressure but is kept in double-walled vacuum-insulated metal containers and allowed to evaporate slowly to compensate for the heat conduction from the surroundings. These containers have been built with capacities as high as 1,000 gal., but the ordinary sizes hold 4 to 25 gallons. The cartridges are soaked in insulated dipping containers just before use, and are then loaded in the bore-holes and fired as soon as possible.

An investigation of liquid oxygen explosives by the U.S. Bureau of Mines has shown that the packing density, or weight of combustible in unit volume of the cartridge, is one of the most important factors in determining its explosive characteristics. Lamp-black or gas-black was shown to be the optimum material for most purposes. The available life of a cartridge, or time after removal from the liquid during which it could be exploded effectively, was found to augment with increasing cartridge diameter; *e.g.*, a cartridge 1½ in. in diameter had a life of about 30 min., whereas one 6 in. in diameter had a life of several hours. The explosive strength of the cartridge was found to bear a direct relation to the amount of oxygen present per unit weight of combustible, and greater explosive effect was obtained by increasing the packing density.

The explosive strength of the cartridge was found to be a variable quantity which depended upon the composition of the cartridge material, density of packing, size of cartridge and time of evaporation after cartridges are removed from the liquid and before firing. Cartridges begin to lose strength almost from the moment they are removed from the liquid. It has been shown by tests with the ballistic pendulum (*see* BALLISTICS) at the explosives experiment station of the U.S. Bureau of Mines that 1½ in. cartridges packed with gas-black, fired 5 min. after removal from the dipping container, may have a strength 10% greater than 40% gelatin dynamite, volume for volume; but no cartridge material has been found which will develop a greater relative strength than this. If fired after 10 min. evaporation, the strength is about 95% that of dynamite. On the other hand, if longer life is desired, a cartridge packed to a lower density will retain enough oxygen for complete combustion for 10 min., but will have an explosive strength less than the more dense cartridge. After 5 min. evaporation the strength of such a cartridge will be about 99% that of 40% gelatin dynamite, and after 10 min. evaporation about 80% the strength of dynamite. The rate of detonation of liquid oxygen explosives ranges from 3,000 to 6,000 metres per second, depending on the composition of the combustible material.

History.—The possibility of using liquid oxygen as one of the components of an explosive was perhaps first suggested by Sprengel, in 1873, who stated that the *beau ideal* of a detonating explosive was a mixture of eight parts of liquid oxygen and one part of liquid hydrogen. The possibilities were foreseen at this early date, but obviously they could not be given serious consideration until liquid oxygen could be produced in commercial quantities. In 1895, Linde evolved a method of producing liquid air commercially, and in 1897 he introduced a liquid air explosive "oxyliquit." This was first tried out in 1895 in a cross-cut of the Penzberg coal mine in upper Bavaria; but the first large-scale blasting was not done until 1899, when liquid oxygen explosives were used in driving the 12 m. Simplon tunnel between Italy and Switzerland. Little further work was done until the beginning of the World War, when the need for conserving glycerine and nitrates forced Germany to look for substitutes for use in industrial explosives. Under this stimulus, the use of liquid oxygen explosives grew until in 1917 there was a total of 160 coal, metal, salt and potash mines using liquid oxygen explosives where the plants had an hourly production of 4,860 litres. The use has dropped off to some extent since 1918, but in 1926 there was still more than 1,000,000 litres of liquid oxygen produced in Germany for blasting purposes. The explosive was used with some success after the war in the iron mines of Lorraine, and is now used to a limited but increasing extent in open-cut blasting in the United States (mainly coal) and in Chile (copper ore).

Liquid Carbon Dioxide is a new agent employed to blast coal in the United States. The liquid is compressed in a steel shell 4 in. in diameter and 3 ft. in length to a pressure of about 1,500 lb. per square inch. At this pressure the shell contains 4 lb. of the liquid. In the centre of this shell is a heating element consisting of a mixture of sodium chlorate, aluminium and charcoal, with means for igniting it electrically. One end of the shell is closed by a metal disc which is sheared when the shell is fired. The heating element provides sufficient heat to gasify the carbon dioxide and increase its pressure to about 20,000 lb. per sq.in., at which pressure the disc is sheared and the gases are released. In blasting, the shell is placed in a bore-hole 4 in. in diameter and tamped with stemming. The shell is so placed that the gases are discharged at the bottom of the bore-hole and thus break down the coal. It may be added that, whereas liquid carbon dioxide may be safely used in underground coal mines, liquid oxygen can not, because its long and hot flame may ignite a possible accumulation of fire-damp or a cloud of coal dust and start an explosion. (G. St. J. P.)

UNITED STATES

Any substance that changes chemically and with great rapidity from its natural state to that of a large volume of gases, accompanied with heat, is classed as an explosive in America. The transportation of explosives in the United States is regulated by the Interstate Commerce Commission with the co-operation of the Bureau for the Safe Transportation of Explosives and the Institute of Makers of Explosives. In the United States explosives may be classified as follows: blasting powders, dynamites, other high explosives, initiating explosives (detonators), military explosives, shotgun, rifle and common powders.

Blasting Powders.—Black powder for blasting purposes contains sodium nitrate instead of the more expensive potassium nitrate, together with charcoal and sulphur. This is known as "B" blasting powder. About 80% of the blasting powder manufactured in the United States is used in the mining of coal. The granulations of black blasting powder vary widely. Its strength is comparatively low and is the same for all granulations, but as the finer granulations burn faster than the coarser ones their effect is a

trifle more shattering. Black powder containing potassium nitrate, instead of sodium nitrate, and known as "A" blasting powder, is used for black sporting powders, for the manufacture of safety fuse, for pyrotechnics and, to a very limited extent, in quarrying dimension stone. In recent years a mixture of various grains of black blasting powder has been used successfully, under certain conditions, for column-loading in deep-hole blasting in quarries, in conjunction with Cordeau-Bickford detonating fuse extending the entire length of the bore-hole. Granulated black powder is also compressed into cylindrical pellets having a central perforation, which are wrapped in cartridge paper and fired by a fuse.

Dynamites.—The majority of dynamites in the United States consist of an explosive compound, usually nitroglycerine, mixed with an absorbent composed of sodium nitrate and wood meal or other carbonaceous material. The proportions are so chosen that the mixture will have an excess of available oxygen on explosion and therefore will produce a minimum of carbon monoxide and other poisonous gases. The use of Kieselguhr as an absorbent was abandoned many years ago in the United States. A dynamite containing no nitroglycerine, but nitrostarch and a mixture of oxidizing and carbonaceous ingredients, finds considerable use in the United States.

It has the advantage of not freezing at any temperature and of not producing headaches, which are often caused by nitroglycerine dynamites. Dynamites are divided into the following types: straight nitroglycerine, ammonia, gelatine, ammonia gelatine, blasting gelatine and permissible dynamites. All dynamite, with the exception of the larger diameters, is packed in cartridge form by large, semi-automatic machines. Straight nitroglycerine dynamites are made in strengths from 15% to 60%. Their percentage strength represents the equivalent of the same proportion of liquid nitroglycerine. The nitroglycerine is mixed with a combustible absorbent which contributes to the force of the explosion.

Straight nitroglycerine dynamites have a relatively high rate of detonation, and therefore are used wherever a quick action or a shattering effect is required. They resist water fairly well. Practically all dynamites made in the United States, shown in the above classification, with the exception of blasting gelatine, contain low-freezing ingredients which prevent freezing at prevailing winter temperatures. These low-freezing ingredients are either tetranitrodiglycerine, nitro-compounds, or both.

Ammonia dynamites, the most widely used, contain in place of part of the nitroglycerine ammonium nitrate. This salt slows down the velocity of detonation somewhat, and makes the action less shattering. They are safer to handle than straight nitroglycerine dynamites, and their gases are less objectionable.

Gelatine dynamites contain, instead of nitroglycerine, a colloidal solution of nitrocotton in nitroglycerine, absorbed in a mixture of sodium nitrate and wood meal. Their plastic consistency allows them to be extruded through a nipple of the required diameter into paraffin-paper shells to form cartridges. Gelatine dynamite is water-proof, and is used for wet work and under-water blasting. The strength of these dynamites ranges from 20% to 90%. They produce the least amount of noxious gases of any type of explosive.

Ammonia gelatine dynamites resemble the above except that a portion of the nitrocotton-nitroglycerine colloid is replaced by ammonium nitrate. Their explosive characteristics resemble gelatine dynamite.

Blasting gelatine consists of nitroglycerine in which has been dissolved nitrocotton to form a jelly, together with a small proportion of an antacid, such as chalk. It is a tough, rubbery material upon which water has no effect, and is only used where the greatest possible concentration of energy is required. Because nitroglycerine has a better colloiding action on nitrocotton than the low-freezing tetranitrodiglycerine, the latter is not used in blasting gelatine. Blasting gelatine is the strongest and one of the quickest explosives manufactured for commercial use.

Permissible Explosives.—This is one which has passed certain tests of the U.S. Bureau of Mines to determine its safety for use in coal mines, and is permissible when used in accordance with conditions prescribed by the bureau.

The principal characteristics of permissible dynamites are that the flame of explosion is relatively cool, small and of short duration. There are three types of permissible explosives, viz., nitroglycerine, ammonium nitrate and gelatine. Very little of the nitroglycerine type of permissible explosive is made. The principal type permissible contains about 10% nitroglycerine and a large proportion of ammonium nitrate, together with a small amount of wood meal or other carbonaceous ingredient. The relatively cool flame from the explosion of ammonium nitrate does not ignite gas or dust in a coal mine when used under conditions prescribed by the Bureau of Mines. Gelatine permissible dynamites contain flame-quenching salts.

A recent advancement in the explosives industry is the production of bulky dynamites. One hundred pounds of straight nitroglycerine dynamite contains approximately 200 cartridges of the 1¼ in. by 8 in. size. Between 60% and 70% of all dynamite used in the United States is of this standard size. Because of the desirability in many operations of spreading the explosive force along the bore-hole instead of concentrating it at the back, ammonium nitrate dynamites have been increased in bulk until certain of them are now manufactured to contain 500 of the above size cartridges to the hundred pounds. The advantages attained are a less shattering action and a resulting economy. In recent years considerable improvement has been made in the reduction of the amount of poisonous gases evolved on explosion of dynamites. This has been accomplished mainly by improving the oxygen balance of the ingredients and reducing the weight of the paper wrapper.

Other High Explosives.—Practically all nitroglycerine made in the United States consists of a mixture of nitroglycerine and tetranitrodiglycerine, or a mixture of nitroglycerine and nitrated sugar. These are made by nitrating a mixture of glycerine and diglycerine, or a solution of sugar in glycerine. Liquid nitroglycerine transportation over common carriers in the United States is forbidden. Other than its use in the manufacture of explosives, its only application is in oil-well shooting. Very small quantities of nitroglycerine are used for medicinal purposes in glonoin, a dilute solution of nitroglycerine in ethyl alcohol.

Cordeau-Bickford (detonating fuse) consists of a small-bore lead tube made in lengths of several hundred feet and containing compressed trinitrotoluene (T.N.T.). When a blasting cap is detonated at one end of Cordeau-Bickford, it initiates a detonation of the trinitrotoluene, which detonation travels along the explosive at a high uniform velocity. This detonating fuse finds a wide use in simultaneously firing a series of loaded bore-holes, for which purpose it is put into the bore-hole with the dynamite and extended to a main line above ground. When the main line of fuse is detonated, the explosive wave travelling along detonates each branch leading to the several bore-holes, and thus detonates all of the charges in rapid, almost simultaneous succession. (Liquid oxygen [L.O.X.] and liquid carbon dioxide as explosives are described below.)

Initiating Explosives.—Initiating explosives comprise many organic compounds and inorganic salts, only a few of which have obtained commercial importance as constituents of detonator compositions. The most important and the most widely used at present is mercury fulminate (*q.v.*). This is very sensitive to heat, shock and friction and detonates with great violence. When used in detonators it is usually mixed in the proportion of 80 parts of fulminate to 20 parts of fine, dry potassium chlorate. The ordinary No. 6 detonator contains one gram of this mixture. Lead azide (lead trinitride), although not used in the United States, is another important initiating explosive.

It is used in blasting caps, but only as a priming or top charge over organic explosives which do not by themselves ignite by the flame from a fuse. It is frequently mixed with lead trinitroresorcinate to improve the ease of ignition by a fuse. Organic explosives not detonated directly by the spark from a fuse, such as tetryl (tetranitromethylaniline), T.N.T. (trinitrotoluene), picric acid (trinitrophenol) and nitromannite are frequently used in detonators as base charges beneath an initiating charge of fulminate of mercury.

Military Explosives.—Military explosives comprise those used for such purposes as filling shell, submarine mines, grenades, bombs, torpedoes, and for boosting charges. The most important explosives of this class are T.N.T. and amatol, a mixture of T.N.T. and ammonium nitrate. In amatol the proportion of ammonium nitrate varies from 80% for large shell to 50% for small shell. It is comparatively difficult to detonate, and therefore relatively safe to handle. An amatol bursting charge in a shell requires a booster charge, because small amounts of fulminate of mercury are not sufficient to detonate it. Booster charges consist of tetryl, detonated by a small amount of fulminate of mercury. Amatol is used for shell larger than those using T.N.T.

Picric acid, or trinitrophenol (*q.v.*), for use as a shell filler, has been largely displaced by T.N.T. and amatol, principally on account of inconvenience in the manufacture of picric acid and the fact that it is likely to form, with the metal of the shell, highly sensitive salts which might cause premature detonation. Like amatol, picric acid requires a booster charge for proper detonation. Ammonium picrate was used during the World War as a shell filler for very large shell. Gun cotton (*q.v.*) was once used in torpedoes and submarine mines, but has been rendered obsolete, in the United States, by T.N.T. and amatol. Nitrostarch explosives were used extensively during the World War for filling hand and rifle grenades.

Shotgun, Rifle and Cannon Powders.—These powders consist of two types, viz., black sporting powder and smokeless powder. Black sporting powder is a potassium nitrate powder, and, although formerly used extensively as a load for shotgun shells and rifle cartridges, it has been replaced largely by smokeless nitrocellulose and nitrocellulose-nitroglycerine powders. Nitrocellulose (single base) powders do not give as much heat in combustion as nitrocellulose-nitroglycerine (double base) powders, and are therefore not as severe on the rifling of the barrel.

Single base powders are made by colloiding nitrocotton of a suitable degree of nitration with a solvent, forming into grains of various sizes and shapes and dried. Double base powders are made by colloiding nitrocotton with nitroglycerine and a solvent and forming into grains. As a rule smokeless powders for large guns are made in the form of cylindrical pellets containing several longitudinal perforations. The object of these perforations is the attainment of lower breech pressure and higher average pressure during the travel of the projectile along the barrel. This is effected by a uniformly accelerated burning speed, due to the increasing area of the internal perforations as combustion proceeds.

(N. D. R.)

EXPONENT, a modern term used in algebra to indicate the number of times the expression to which it refers is to be taken as a factor. For example, in the monomial $3x^2$, the exponent of x is 2 and it states how many times x is taken as a factor; that is, $3x^2$ means $3xx$. Although the idea of power of a number is very old, and the use of the exponent (but in a form unlike the present one) is found as early as the 14th century, the actual form a^3 first appears in Descartes's *La Géométrie* (1637). The early concept of exponent was broadened as algebra developed, and gradually meanings were found for such forms as a^{-n}, a^0, $a^{\frac{1}{2}}$, $a^{\sqrt{2}}$, and so on, the exponent being any kind of number whatsoever. As new types of exponent were suggested, the question arose as to what meanings were to be assigned to them so that the fundamental laws of positive integral exponents should be retained. This desideratum led to defining a^0 in such a way that the law $a^m a^n = a^{m+n}$ should remain valid; that is, $a^0 a^n$ must continue to be a^{0+n}, or a^n. Evidently this required that a^0 should be equal to 1, excepting when $a=0$. Similarly, $a^{\frac{1}{2}}$ came to mean $\sqrt{a}$, $a^{\frac{3}{2}}$ to mean $\sqrt{a^3}$, and a^{-n} to mean $1/a^n$. These facts had long been known, but without our modern exponential symbols. In like manner meanings came to be assigned to $a^{\sqrt{2}}$ and even to $a^{\sqrt{-1}}$. Indeed, one of the most interesting relations, and most fruitful, is that which asserts that $e^{\pi i} = -1$, where e is the base of the natural system of logarithms, π is the incommensurable ratio of the circumference of a circle to the diameter, $i = \sqrt{-1}$, and -1 is the negative unit. It is by means of this relation, to which the name of Euler is attached, but which is easily derived from the relation $\phi i = \log(\cos\phi + i\sin\phi)$, due to Cotes (1722), that it can be shown that every number has an infinite number of logarithms, only one being real. Even before the time of Cotes it appears that De Moivre (1707) knew a similar relation. The first algebraist to explain fully the significance of negative and fractional exponents was John Wallis (1655), his work being supplemented soon after (1669) by Newton. (D. E. S.)

EXPORT CREDITS, a post-war scheme adopted by the British Government to assist British export trade. The export credits scheme was initiated by Mr. Lloyd George's coalition government in the autumn of 1919 as a means of facilitating the finance of export business and of promoting the restoration of British trade. Importers in many markets found it difficult at the time to pay cash or do business on short-term bills; and it was felt that trade could be secured if facilities were provided for financing transactions which, owing to the length of credit required, or for other reasons, would not be acceptable to the banks.

Power was also taken to insure goods against risks of an abnormal or exceptional nature, but this part of the scheme has remained inoperative. At first the application of the scheme was limited to business with certain European States, viz., Finland, the Baltic States, Czechoslovakia, Yugoslavia, Rumania and others. This restriction was due in part to a concomitant policy of assisting in the economic reconstruction of countries which had been specially disorganized by the World War. In 1921 the sphere of operations was enlarged to include the whole world, subject to exceptions adopted in the administration of the scheme.

The legislation governing the scheme is contained in the Overseas Trade (Credit and Insurance) Act 1920; in an amending Act of 1921; and in the Trade Facilities Act 1921–26. It is administered on behalf of the Board of Trade by the export credits guarantee department of the department of overseas trade, with the assistance of an advisory committee of business men. The aggregate amount outstanding in respect of credits at any given time may not exceed £26,000,000. Credits and guarantee may only be given for British goods. The period within which new credits may be given expires in Sept. 1929.

System of Guaranteed Drafts.—Under the original scheme the export credits department made advances to the exporter in cash up to 80% of the cost of the goods, but early in 1921 an important modification was introduced, the object of which was to bring the method of operation into closer correspondence with the normal machinery of trade. Instead of making advances, the department was authorized to guarantee drafts drawn against the shipment of export goods. The advances system was in consequence discontinued, and the bulk of the business done under the scheme was effected under the guarantee plan. The scheme was further re-modelled in July 1926 as the result of recommendations made by a committee appointed in the preceding year to examine the whole question of credit insurance. The facilities now offered may be classified as follows: (1) Facilities of an insurance character, by which the department's guarantee is given without recourse to the exporter. In these cases the guarantee may not exceed 75% of the amount of credit granted to the importer. (2) Facilities of a financial character, by which the guarantee is given with full recourse to the exporter. In these cases the guarantee may be for the full amount of the credit granted to the importer. (3) Facilities of an intermediate character, by which the guarantee is given for the whole or part of the credit either without recourse to the exporter or with such recourse as may be agreed. In these cases the exporter will not be relieved of more than 75% of the risk on the bill unless approved security is provided.

A floating contract has also been introduced which provides assistance to exporters without each specific transaction having to be submitted to the department. An exporter can now obtain a contract from the department covering each of the countries with which he is doing business on the basis of bills of exchange. Cover to an agreed amount is given for a forward period of six months. Appropriate premia are charged in all cases.

The total business up to Dec. 1927 was about £1,750,000 under the advances scheme; £6,260,000 under the first guarantee scheme (1921–26), and £834,000 under the new guarantee scheme (1926). Losses were made under the advances scheme but the credit insurance committee found that under the guarantee scheme no material profit or loss had been made up to 1926.

As the limit fixed by the original act was £26,000,000 it is clear that the scheme has not been taken advantage of to the extent expected. This may be due to various causes. It has taken time for the scheme to become widely known; business men have been perhaps sceptical about the handling of such matters by a government department; there may have been complications and rigidities of practice such as would discourage applicants. Published figures, however, show that very much larger amounts of credits have been sanctioned than have actually been taken up—presumably because the applicant eventually failed to secure the business for which the credit was required, or perhaps was ultimately able to finance it without assistance from the department. They also show that the scheme in its latest form is making much more rapid progress. On the whole, the figures indicate that the scheme has been helpful to British trade at a difficult juncture.

Bibliography.—*Overseas Trade (Credits and Insurance) Act 1920* (10 and 11 Geo. 5 Ch. 29); *Do. Do. Amendment Act 1921* (11 and 12 Geo. 5 Ch. 26); *Trade Facilities Act 1921* (11 and 12 Geo. 5 Ch. 65); *Trades Facilities and Loans Guarantee Act 1922*, Session 2 (13 Geo. 5 Ch. 4); *Expiring Laws Continuance Act 1923* (13 and 14 Geo. 5 Ch. 37); *Trade Facilities Act 1924* (14 and 15 Geo. 5 Ch. 8); Do. 1926 (16 Geo. 5 Ch. 3); Report of the Credit Insurance Committee 1925–26, cmd. 2619; quarterly statements of applications sanctioned and credits and guarantees taken, published in *The Board of Trade Journal*, London. (W. H. Cl.)

EXPORT DUTIES. Customs duties on the exportation of commodities are rarely levied, it being usually held by Governments that exportation is to be encouraged in the interests not only of the exporter but of the general community. Indeed, in the history of taxation instances of the payment of bounties upon exports to encourage trade are commoner than export duties. Generally, taxes upon the exportation of commodities are incident upon the producers of the taxed commodities. In ordinary cases, the foreign importer cannot and will not pay the extra cost of production caused by the tax, which has, therefore, to be paid by the exporter. If, however, a country possesses a monopoly product essential to the foreign importer, then, within certain limits, an export tax upon that commodity will be paid by the foreign importer because he is willing to buy it at a price enhanced by the tax.

Cases have occurred in which the manufacturers of a nation have appealed to their Government to tax the exportation of a valuable raw material with the purpose of monopolizing for themselves the use of that material or to prevent its use abroad. Thus it is on record that when the first crucible cast steel was made in England by Huntsman, the Sheffield manufacturers unsuccessfully appealed to the Government to tax the exportation of that steel to France to prevent the French cutlery manufacturers from using it.

EXPORT OF CAPITAL: *see* Capital, Export of.

EXPORTS, a term used to describe goods sent out of a country by its traders. To the individual trader who sells it abroad, an export represents individual profit which he receives by the process of exchange. The individual act of exportation made for personal gain is, however, of the greatest national and public importance. Few countries produce all the commodities they require for their convenient existence, and to obtain from abroad articles which are not produced at home it is necessary to pay for them in an acceptable way. Hence the function of exportation, which from the national point of view represents payment for importation. For a full discussion of the subject and for the statistical records of exportation reference should be made to the articles Commerce and Export Statistics, and to the economic details appended to the articles on each of the different nations.

The exportation from a nation may take the form of goods, services or securities. The Custom Houses of all nations take records of the goods sent out, and these are compiled as national statistics showing values and sometimes quantities also. These statistics form a valuable record of national progress. The exportation of services and securities is not precisely recorded, but estimates have been formed for some nations from time to time. Because the exports of services do not appear in the trade accounts published by the nations, they are sometimes called "invisible exports," a term invented by the late Sir Robert Giffen. For further particulars of invisible exports, reference should be made to the article Balance of Trade. (L. C. M.)

EXPORTS IN PRACTICE

The very extensively organized machinery and methods employed in export trade have been evolved in the course of centuries to enable a trader in one country to sell to, or buy from, a trader in another country. The enabling process has consisted mainly in overcoming difficulties created by space and time in regard to selling, buying, distribution and methods of payment and credit. There are two principals to an export transaction, though neither need have definite knowledge of the other. One is the manufacturer, producer or factor with goods to export; the other is the wholesale distributor in the importing country. Between them exists the export machine consisting of various intermediaries and services, by means of which buyers can maintain effective touch with all sources of supply, while manufacturers are enabled to supply in many scattered markets the needs of customers whom they would never otherwise reach, whose requirements they could never discover, and whose credentials they could not test. The machine performs this comprehensive task by co-ordinating three distinct lines of effort, the first of which is selling, buying and distribution, the second transport by rail and steamship, and the third finance and insurance.

Two Basic Export Systems.—For selling, buying and distributing two different, yet parallel, systems are employed. One is more closely identified with British practice, and the other with American, though neither is a national monopoly. The broad difference between the two is that under the British system the manufacturer's immediate customers are merchant-shippers or commission buying agents established at his door, who accept all financial responsibility for the orders they place in fulfilment of indents received from their importing clients overseas; while under the American system the intermediaries are commission selling houses acting on behalf of groups of manufacturers, and combining the functions of merchant-shippers and sales representatives. Even these two systems leave some gaps, particularly in regard to certain markets which lack wholesale distributing firms of sufficient importance or which present credit difficulties of an exceptional nature. Such territories often fail to attract the enterprise of selling organizations, whose energies are absorbed by safer and larger markets; while the same drawbacks render commission buying agents in London, Paris or New York unwilling to assume responsibility for traders in countries which lack sound or comprehensive importing systems. In these relatively few cases, the manufacturer or shipper desiring to do business with the countries concerned has to devise special and more or less direct methods, safeguarding himself as well as he can by such devices as the *del credere* agency system, which has for years been used considerably in Egypt, and under which a local agent undertakes financial responsibility for the orders he forwards, and is remunerated by a correspondingly higher rate of commission.

The Merchant-Shipper.—The merchant-shipper and the commission buying agent exist side by side, and in modern times their duties have become so closely related as to be in part identical. The former is an independent trader, definitely a middleman, taking such profit as he can make, initiating his own selling efforts abroad, and acting as a principal toward his customers. He is the heir of a system as old as civilization itself, but changing conditions have compelled him to change with them. Whereas he once had the entire world to serve, in the 19th century he was confronted by the growth of a new order of things. Among his customers in such markets as the principal British dominions, the South American republics, and similar progressive countries, were many importing houses whose turnover became so extensive that

they were in a position to go direct to manufacturers, and to perform for themselves the duties previously undertaken for them by merchant-shippers. In many cases, too, these importers were urged to this change by the competition of great trading companies with headquarters in Europe, and widely distributed branches or stations. They therefore established their own buying and shipping houses in supplying centres, or appointed agents to act for them. The merchant-shipper thus found his scope becoming more and more limited, with—apart from certain special lines of business—only undeveloped markets, and the smaller importing accounts in the larger markets, offering him business on the old lines. Consequently, he has to an increasing extent been compelled to combine the work of commission buying with his more independent shipping operations.

The Commission Buying Agent.—Under the commission buying system an agent may act for a number of overseas importing firms, usually confined to only one or two markets. The procedure is for them to indent on him, an indent being an instruction to buy certain goods, and is not in itself an order. The agent acts on this instruction, buying the goods on quotations obtained from various manufacturers, arranging for their packing and shipment, and paying the accounts of manufacturers and ship-owners, for which he makes himself directly responsible. For these services he receives a commission on the amount of his purchases, the average rate being $2\frac{1}{2}\%$, though it may vary according to the nature of the goods bought. He usually undertakes to pass all discounts and rebates to the importers for whom he buys.

The Commission Selling Agent.—With the commission buying system so strongly entrenched, the export selling agency has not found much room for development in Great Britain, nor in certain European countries, but in the United States of America and in Canada it largely prevails. Its advantage lies in its active efficiency as a selling force on behalf of manufacturers; its principal defect lies in the virtual impossibility for a single concern to have a sufficiently expert and intimate acquaintance with buyers in all markets, to be able to arrange credits safely, or to cover the ground with adequate selling effort. In practice a certain amount of specialization occurs from necessity rather than intention. An export selling house may be formed as the result of a number of manufacturers of allied goods combining for the purpose, or an independent agency firm may obtain the sole right to sell on commission abroad the goods of a similar series of manufacturers. Such a concern despatches salesmen to obtain orders from wholesale buyers in selected markets, often establishing branches and showrooms in suitable centres, and attends to details of shipment, payments and credits, etc., on behalf of its principals.

The Manufacturer's Export Department.—Under the merchant-shipping and commission buying systems it is clear that no selling force operates on behalf of the manufacturer, and he is therefore compelled to provide his own. He begins, probably, by employing a special representative to solicit orders from the buying houses who are in receipt of indents for his class of goods. Some members of his counting-house staff will also specialize in knowledge of shippers' requirements in connection with shipping and customs documents. Then the need will become apparent for getting particular brands and designs specified in the indents sent home by overseas importers, or it will prove advisable to find further methods of stimulating business, so commission agents travelling in the markets served will be employed. Such agents usually represent a number of manufacturers, confine themselves to one market or group of markets, and call only on wholesale importers. Their mission is not to accept orders direct, but to persuade importers to specify certain goods and quantities when indenting on the commission buyers. The manufacturer is informed by his agent concerning each promised order, and then seeks confirmation of it from the buying house concerned. The agent is paid commission on all the orders received for shipment to the territory covered by him, and frequently obtains in addition a contribution toward his expenses from each of the manufacturers he represents. An alternative method is to employ an export agent who has headquarters in the supplying country, and who performs the entire work of sending representatives abroad and obtaining confirmation of the indents they influence.

In a few special trades, of course, and in a few specially conditioned markets, it is possible for the manufacturer to solicit orders directly, and to ship the goods without the intervention of any intermediaries. On the whole, however, direct export trading of this kind is regarded as inexpedient, and even dangerous, for it carries none of the safeguards which form an essential feature of the recognized systems described. In general trade, too, it is obvious that the direct shipper is almost certain to be barred from participating in the overwhelmingly preponderant proportion of shipments controlled by merchant-shippers and agents, and must, on adopting such a policy, recognize that the range of his possible clientèle will be severely limited.

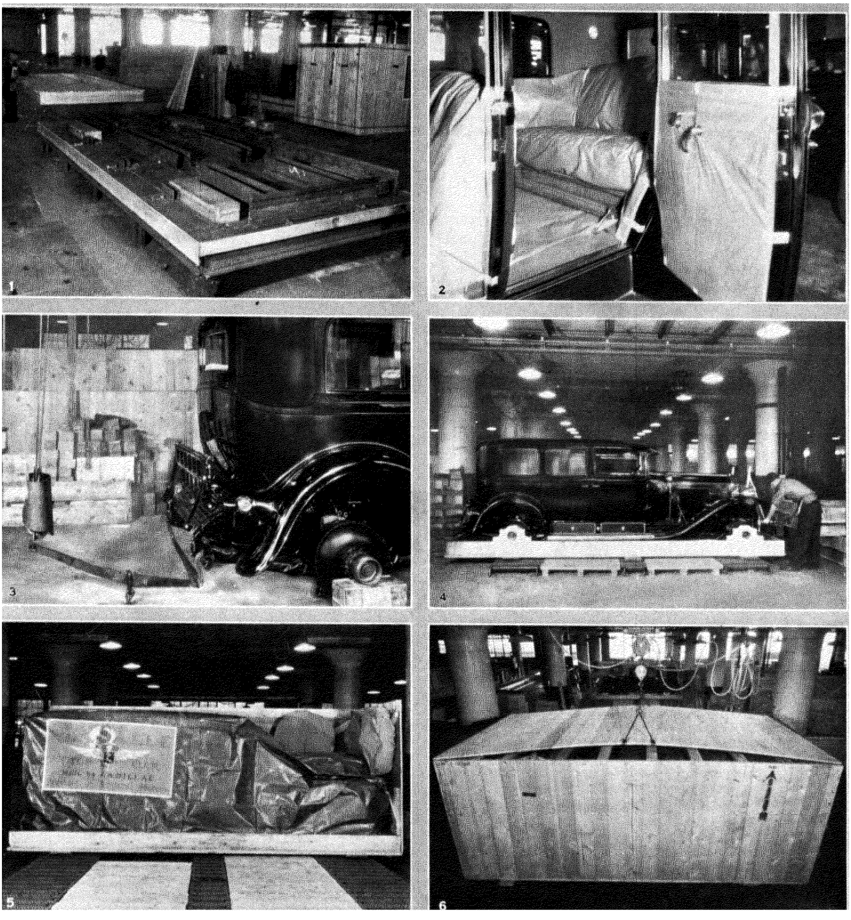
Shipping Methods, Finance and Insurance.—The actual work of shipping is the same if performed either by manufacturer, merchant-shipper or commission agent. It involves the arrangement of freight with shipowners, packing, carriage to the docks, and perhaps forwarding from an inland centre, the preparation of consular invoices and customs declarations, the receipt and mailing of shipping documents, possibly the hypothecation of the latter, and the insurance of the consignment.

Packing for Shipment.—This is a matter beset with special requirements for different markets, and even for different consignees. So far as these are concerned, the instructions of the indentor can be the only guide apart from knowledge of a prevailing custom. Goods are baled or cased according to their nature, baling being the cheaper, and the first step in either method is "making-up" or "knocking-down," the former term covering the folding, marking and ticketing of textiles, and the latter the separation into convenient parts of certain types of furniture, or the dismounting of machinery. The goods are then arranged in compact lots for measurement, and the case or baling material prepared to suit. If this work is done by a specialist packing firm, full instructions must accompany the goods, which should be inspected by the shipper when ready to close down. Marking is done in large stencilled letters, the consignee's "mark" and port of destination being placed on at least two sides of each package. The bales or cases are then handed over to a carrier for transport to the docks, where they are weighed or measured, and a "weight note" is handed to the carrier, this constituting in some circumstances a certificate of delivery, and even going forward with the shipping documents.

Shipping.—Before this stage is reached the shipper arranges freight with a shipowner or shipping company. For a special cargo it may be necessary to charter a vessel, and for this a charter-party is prepared. This document provides on the one side that the ship shall be seaworthy, properly equipped and waiting at the specified port by a certain date; while the charterer agrees to load promptly, pay the charges due, and use the vessel for a definite voyage, or as he desires during a definite period.

The general shipper, however, simply arranges for freight-space on a ship sailing with other cargo on a convenient date. He does this at a fixed or agreed rate per ton, the shipowner retaining the right to charge on ton-weight or ton-measurement, the latter being 40cu.ft. per ton, and used for light or bulky goods. To the carrying rate is added "primage," a charge for the use of the ship's cargo-handling machinery. "Primage and average accustomed" indicates a *pro rata* charge on each consignor. On embarkation a "mate's receipt" is obtained, and this is exchanged later for a bill of lading, which details the goods shipped and constitutes proof of ownership. The bill of lading is made out in several "parts" or copies, one of which is sent to the consignee by an earlier or faster vessel, so that he may obtain prompt delivery of the goods on arrival. The first "part" of a bill of lading to be presented is the only effective one, the others automatically becoming of no effect. It should be understood that if a bill of lading is made "to order," and not in a particular consignee's name, it must be endorsed by the shipper before it becomes valid.

Freight Terms.—Closely connected with the question of freight rates is that of quoting prices for export, as manufacturing costs and shipping charges obviously have to be joined at some point before the consumer of the goods is reached. There is a



BY COURTESY OF THE GENERAL MOTORS EXPORT CO.

PACKING FINE MOTOR CARS FOR FOREIGN MARKETS

1. A modern jig or pattern frame in the boxing factory of an automobile plant. Bottom of case is built around sections of frame shown
2. Interior view of closed car packed for export shipment. Upholstery is protected from dust and moisture by waterproof oiled-paper cover
3. Equipment used for compressing rear springs of cars to prevent up-and-down movement of car in the case. When springs are sufficiently compressed, they are clamped to fix them firmly in the case
4. Base of shipping case, showing car resting on axle blocks. Wheels are removed and holes are drilled for lag screws to hold the axles in place. The car is carried to location by overhead monorail conveyor; from location by roller conveyor seen below the case
5. Car unit completely wrapped in specially prepared oiled paper, ready for boxing in export case. Besides the paper envelope on car, the case is lined with heavy paper, water and vermin proof. Wheels are packed separately and bolted inside case. Roller conveyor is seen beneath case
6. Packing case complete, with lid lifted to show 4x4 timbers placed under the top to prevent injury to the car from the cases piled above it in transit

multitude of terms, each with some interesting variation of meaning, but the two basic methods of quoting are "Free on Board" and "Customs, Insurance and Freight," usually indicated as "F.O.B." and "C.I.F." The former covers all charges from the factory to loading and stowing in the ship's hold; the latter covers all costs to the port of delivery, but not such items as import dues and carriage after unloading. A "C.I.F." quotation is obviously more convenient to the importer, but it should be understood that it does not alter the fact that the shipper's ownership ends, and the consignee's begins, when goods are placed on shipboard. In arranging or paying any charges beyond that point the shipper is merely acting as agent for the consignee. Incidentally, freight becomes payable on arrival of the vessel at the port of destination, the shipper being legally liable for it to the shipowner, but having power of recovery from the consignee.

Marine Insurance.—The fact that ownership in a consignment rests in the consignee from the moment of shipment makes it necessary for any insurance policy to be taken out in his name, the shipper again doing this as his agent. On this subject it is sufficient to say that there are two principal classes of risks. One is "With Particular Average," which covers all risks, including damage and loss by disaster to the vessel, by exposure to heat or water, and by rough handling or accident. The second is "Free of Particular Average," and is limited to total loss, being usually adopted to cover rough goods, such as timber. "General Average" is another term referring to loss or charges incurred in preserving the vessel or cargo and involves a *pro rata* payment by all consignees.

Export Finance.—This is a wide subject, but in severe summary it may be explained that a shipper can reasonably well ensure payment from a customer overseas after shipping goods, and can also avoid having large sums lying idle, by a suitable use of bills of exchange in conjunction with shipping documents. He draws a bill of exchange on the customer, and forwards it to him for acceptance. He may draw "on demand" or "at sight," or he may draw at any given period "after sight" or "after date." On receiving it back "accepted" he can give it to a bank to collect, accompanied by the bill of lading and other documents necessary for obtaining delivery of the goods. The acceptor, if the bill is "at sight," is given the shipping documents on meeting the bill, this being done by the bank's local branch or agent. Like the bill of lading, the bill of exchange is also drawn in several parts, the first to reach the drawee being the one on which he writes his acceptance, and it becomes the "first of exchange." According to the state of the bill market, a shipper can usually take unmatured bills to a bank or discounting house, and obtain an advance against them. He may also do this when giving the bills to a bank to collect as described above, the shipping documents being the security. (*See* also EXCHANGE, FOREIGN; IMPORTING; INTERNATIONAL PAYMENTS; INSURANCE: *Marine.*)

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EXPORTS, INVISIBLE. While, broadly speaking, it is true that imports must always be paid for by exports and vice versa, this payment is not always made in actual physical goods or bullion and specie. Other factors play their part in the balance sheet of a country's financial and commercial condition, and those which fill an economic rôle similar to exports are known as "invisible exports."

Among the more important of such factors which can thus be offset against imports are the following: (1) earnings of national ships in the trade of foreign countries; (2) disbursements of foreign shipping in national ports for harbour dues, bunker coal and other stores, repairs, etc.; (3) expenditure of foreign tourists in the country; (4) emigrants' remittances to friends and relations in the country; (5) loans raised abroad; (6) receipts on account of interest on or amortisation of national capital invested abroad; (7) commissions, royalties, brokerage, etc., earned by nationals for services rendered to foreigners (insurance, etc.); (8) government receipts from overseas (including repayment of and interest on loans by the national government to foreign governments).

In some cases separation is made between items which may be termed "revenue" (as interest, earnings, etc.) and those which are of a "capital" nature (as repayment of loans, loans raised abroad), while in some cases "revenue" items only are taken into account.

While it is impossible to make exact calculations as to the value of many of these items, governments are usually in a position to make estimates as to the approximate magnitude of some or all of the various factors which operate in balancing the economic situation of their countries; in some cases, however, the task of making—or at least of publishing—such an estimate is left to a financial institution or economic journal. In some cases, only the balance after deducting the corresponding "invisible imports" items is published.

Great Britain.—The economic balance sheet for the United Kingdom is prepared and published by the Board of Trade early in the ensuing year in the *Board of Trade Journal* under the caption "The Balance of Trade." This estimate is of a provisional nature, and is accompanied by a revision of the figures for the previous year or years, in the view of more complete information which has since become available, and brief notes as to the basis of the estimates used. The published figures relate only to balances after deducting the corresponding "import" items, and (except as regards Government expenditure and receipts) to "revenue" transactions only.

The following table from the *Journal* for Feb. 2, 1928, gives the figures (together with the revised figures for 1925 and 1926) so far as "export" items are concerned.

	1925.	1926.	1927.
	(In million £.)		
Estimated excess of Government receipts from overseas*	..	3	..
Estimated net national shipping income†	124	120	140
Estimated net income from overseas investments	250	270	270
Estimated net receipts from short interest and commissions	60	60	63
Estimated net receipts from other services	15	15	15
Total	449	468	488

*Including some items on loan account.
†Including disbursements by foreign ships in British ports.

United States.—A statement entitled "The Balance of International Payments of the United States" is published annually by the Department of Commerce in its *Trade Information Bulletin* series which gives considerable detail and discussion under the

	1924.	1925.	1926.
Credits.	(In million $.)		
Current items, visible:—			
Exports of merchandise (net)	970	666	426
Exports of silver (net)	36	34	22
Exports of gold (net)	..	134	..
Current items, invisible:—			
Interest on foreign investments (net)	464*	515*	688*
Ocean freight payments (net)	8	..	..
Motion picture royalties	†	75	71
Miscellaneous	†	†	96
Total	1,478	1,424	1,303
Capital items:			
Foreign loans paid off	45	140	470
Sales of securities to foreigners	319	411	298
Principal of debts to U.S. Government	23	27	35
Miscellaneous	†	†	32
	387	578	835
Total	1,865	2,002	2,138

*Including interest received by U.S. Government from foreign countries.
†Estimate not made.

various sections. The American estimates deal with both "revenue" and "capital" items, but they are distinguished throughout. In addition to the usual items referred to above, an investigation is also made in the change in foreigners' bank deposits and book accounts, and the figure thus arrived at should, of course, represent the balance of the statistical calculation. The small discrepancy which appears (less than ½% of the total sums involved) represents the margin of error in the estimates.

The table on p. 995 from the *Bulletin* No. 503 gives the summary so far as "export" items are concerned.

Other Countries.—Statements or estimates of a similar nature in respect of a number of other countries are published by the League of Nations in its *Memorandum on International Trade and Balances of Payments.* (H. Cr.)

EXPORTS: STATISTICS. The following tables give an account of the recorded official export statistics of the chief exporting nations. In comparing them, it should be remembered that different nations make their records in very different ways and this has been made clear as far as possible in the notes attached to the tables, which should be carefully read.

UNITED KINGDOM

The following statistics relate to Exports of United Kingdom produce and manufacture only.

The grouping into categories in the published returns was entirely re-cast in 1920, but figures for 1913 were republished on the revised grouping.

(A) *Old Classification*

	1891†	1900	1913
	Thousand £	Thousand £	Thousand £
I. Food, drink and tobacco*	9,996	14,049	32,588
II. Raw materials and articles mainly unmanufactured	24,512	44,987	69,905
III. Articles wholly or mainly manufactured‡	211,071	228,302	411,368
IV. Miscellaneous and unclassified (including parcel post)	1,656	3,854	11,384
Total	247,235	291,192	525,245

(B) *New Classification*

	1913	1927
	Thousand £	Thousand £
I. Food, drink and tobacco*	33,876	52,280
II. Raw materials and articles mainly unmanufactured	66,173	76,356
III. Articles wholly or mainly manufactured‡	413,821	563,964
IV. Animals, not for food	2,230	1,897
V. Parcel post	9,154	14,608
Total	525,254**	709,105

Total exports for 1928 were valued at £723,000,000.

*Including animals for food: in 1900, these animals were not separated from those not for food and all animals were grouped in Class IV. in that year. The two classifications differ in that oil seed cake and other feeding stuffs for animals are now grouped in I. instead of III. as formerly, and Bladders and Sausage Skins in I. instead of II.

†1891 was the earliest year for which this summary was published, although somewhat similar summaries—without details—were published back to 1883.

‡Including Crude Metals. The old classification excludes Coke, Patent Fuel and refined mineral oils (included in II.) but includes Coal Tar Pitch (now in II.). There are also minor adjustments between II. and III.

**In the new classification British and Foreign Spirits mixed in bond and Lime Juice fortified in Bond, previously classed as re-exports, are included in British Exports.

DOMINION OF CANADA

The following particulars relate to the Exports of the Produce and Manufactures of the Dominion, including Gold and Silver, the direct product of the Mining Industry. The values are those at the point in Canada at which shipped, as declared by exporters.

	Year ended June 30		Year ended March 31	
	1891†	1900	1914	1927
	Thousand $	Thousand $	Thousand $	Thousand $
I. Agricultural and vegetable products:*				
(a) Mainly food	13,743	28,230	169,717	505,502
(b) Other than food)			31,473	69,492
II. Animals and animal products	36,399	68,774	76,591	167,292
III. Fibres and textiles	873	1,622	1,933	7,666
IV. Wood, wood products and paper	25,351	32,901	63,202	284,120
V. Iron and its products	556	3,347	15,483	74,285
VI. Non-ferrous metals	1,619	18,863	53,304	80,639
VII. Non-metallic minerals	3,989	5,956	9,364	28,510
VIII. Chemicals	851	455	4,890	16,575
IX. Miscellaneous	5,291	8,824	5,731	18,077
Total	88,672	168,972	431,588	1,252,158

*Excluding fibres and wood. Beverages are included under I. (b).
†The earliest year for which this grouping is available.

UNION OF SOUTH AFRICA

The following particulars relate to Exports of South African Produce from the Union to countries overseas, and exclude exports to Northern and Southern Rhodesia (and in 1926 to S.W. Africa Protectorate). Gold Bullion is included, and also Bunker Coal. The values shown represent f.o.b. values, as declared by exporters.

	1910*	1913	1926
	Thousand £	Thousand £	Thousand £
Living animals	42	38	24
Agricultural and pastoral produce	9,485	12,240	21,314
Products of the mines	41,996	51,857	47,668
Other articles	240	430	1,393
Total	51,763	64,565	70,399

*Prior to 1910, particulars were only available for the separate provinces of the Union, including inter-trade.

AUSTRALIAN COMMONWEALTH

Particulars relate to exports of Australian produce only. The values shown represent values in the principal markets of the Commonwealth. Ships' stores are included in 1903 but not in subsequent years. Bullion and Specie are shown separately; they are included in total value of exports, since they are part of the produce of the soil of the Country.

	Year ended December 31		Year ended June 30,
	1903*	1913	1926
	1,000 £	1,000 £	1,000 £
Animals, living	199	298	222
Food, drink and tobacco	4,027	22,301	50,759
Raw materials	22,634	48,296	79,246
Manufactures	1,069	1,942	9,832
Total merchandise	27,929	72,837	140,059
Bullion and specie	17,729	2,301	5,436
Total	45,658	75,138	145,495

*The earliest year for which particulars are available.

DOMINION OF NEW ZEALAND

The following particulars relate to the Exports of the Produce and Manufactures of the Dominion, including Bullion. The values are f.o.b. values as declared by exporters.

	1890	1900	1913	1926
	1,000 £	1,000 £	1,000 £	1,000 £
Products of the mines	840	1,590	1,792	855
Products of the fisheries	17	22	73	72
Products of the forest	582	863	874	821
Animals and products	6,135	8,787	18,519	40,763
Agricultural produce	1,290	1,231	280	902
Manufactures	548	549	987	926
Miscellaneous	17	13	53	
Total	9,429	13,055	22,578	44,339

BRITISH INDIA

The Particulars relate to the Sea-Borne trade of British India, and to Indian produce only. The values are f.o.b. values as declared by exporters. Treasure is excluded, and Government stores shown separately.

	Year ended March 31			
	1890	1900	1913	1927
	1,000 Rupees	1,000 Rupees	1,000 Rupees	1,000 Rupees
Food, drink and tobacco	25 46 11	30 55 96	78 07 72	74 56 47
Raw materials and produce mainly unmanufactured	44 90 30	42 87 91	104 65 97	138 68 15
Articles wholly or mainly manufactured	28 51 18	31 79 28	57 33 16	85 30 95
Animals, living	9 81	20 07	33 33	38 32
Parcel post	12 70	25 15	94 71	2 49 69
Total private	99 10 10	105 68 37	241 34 89	301 43 58
Government stores	3 57	6 06	7 88	1 31 39
Total	99 13 67	105 74 43	241 42 77	302 74 97

UNITED STATES

The particulars given relate to exports of Domestic produce and manufacture only; the values are declared and represent the value at port of shipment. Bullion and Specie are excluded.

	Year ended June 30			
	1890	1900	1913	1928
	1,000 $	1,000 $	1,000 $	1,000 $
Crude foodstuffs*	132,073	225,906	181,907	366,730
Manufactured foodstuffs	224,757	319,696	321,204	457,050
Crude materials	309,482	340,139	740,290	1,174,251
Semi-manufactures	46,455	153,276	408,807	713,623
Finished manufactures	132,527	331,747	776,297	2,061,210
Total	845,294	1,370,764	2,428,506	4,772,865

*Including animals for food.

Note:—The above particulars include the trade of Hawaii, Porto Rico and Alaska with abroad, but exclude the trade between Continental U.S.A. and the non-contiguous territories and also Guam and Tutuila.

FRANCE

The following particulars relate to "Commerce Special," *i.e.*, exports of French Produce. The values for 1890, 1900 and 1913 are based on official unit values, fixed annually by the Permanent Valuation Commission, those for 1927 are as declared by exporters, in both cases, frontier (f.o.b.) values are intended. Bullion and Specie are excluded.

	1890	1900	1913	1927*
	1,000 Francs	1,000 Francs	1,000 Francs	1,000 Francs
Food and drink	855,378	769,159	838,898	5,384,383
Raw materials	899,036	1,084,784	1,858,091	16,780,531
Manufactures†	1,999,044	2,254,756	4,183,228	33,059,803
Total	3,753,458	4,108,699	6,880,217	55,224,717

*Provisional figures, expressed in paper Francs.

†Including parcel post.

Note:—For 1927, the particulars relate to Post-war France (including Alsace Lorraine), and the Saar Basin.

GERMANY

The particulars relate to the German Customs Union (which included Luxemburg until 1919). The values for 1890 and 1900 are official values; those for 1913 and 1927 declared values; in both cases frontier (f.o.b.) values are intended. Bullion and Specie are excluded. Owing to a change in the form of the published figures, the particulars for 1913 have been shown according to both groupings.

	A. Old classification			B. New classification	
	1890	1900	1913	1913	1927*
	1,000,000 Marks	1,000,000 Marks	1,000,000 Marks	1,000,000 Marks	1,000,000 Marks
Living animals	471	518	1,019	7	29
Food and drink				1,070	441
Raw materials and semi-manufactures	708	1,111	2,406	2,274	2,608
Manufactures	2,148	2,982	6,672	6,746	7,719
Total	3,327	4,611	10,097	10,097	10,797

*Including reparation deliveries.

ITALY

The following particulars relate to Special Trade, *i.e.*, exports of Italian produce only. The values are official values, fixed annually by the Valuation Commission up to 1913, and declared values in 1927, frontier (f.o.b.) values are intended throughout. Silver Bullion is included but not Specie or "Gold Bullion."

	1892*	1900	1913	1927†
	1,000 Lire	1,000 Lire	1,000 Lire	1,000 Lire
Food and living animals	284,545	349,479	762,432	3,953,319
Raw materials	181,073	235,663	360,672	1,866,882
Semi-manufactures	361,437	449,728	590,444	3,544,034
Manufactures	131,132	303,376	798,091	6,250,545
Total	958,187	1,338,246	2,511,639	15,614,780

*The earliest year for which comparable figures are available.

†Values in paper currency.

RUSSIA

The following particulars relate to exports of Russian produce. In comparing 1913 and earlier figures with the later 1925–26, etc., figures it is important to remember that the former relate to Russia which then included the Baltic States and Poland and the latter to the Union of Soviet Socialist Republics as instituted after the 1917 Revolution.

	1890	1900	1913	1926–27*
	1,000 Roubles	1,000 Roubles	1,000 Roubles	1,000 Roubles
Foodstuffs, spirits and tobacco	391,100	393,333	839,853	357,983
Raw materials and semi-manufactured goods	271,147	272,319	564,027	370,652
Livestock	11,160	18,204	34,359	3,193
Manufactures	19,093	32,562	84,806	38,715
Total exports	693,400	716,418	1,520,135	770,543
Of which:				
(a) Across European frontiers	615,468	609,486	1,288,038	678,241
(b) Across Asiatic frontiers	77,932	106,932	232,100	92,302

*Year Ended Sept. 30.

JAPAN

The following particulars relate to Total exports from Japan (including re-exports), in trade with Foreign Countries. Trade with Japanese Colonies, etc., is excluded from the time the areas in question became part of the Japanese Empire, *i.e.*, Formosa throughout, and Korea (chosen) in 1927.

	1907*	1913	1927
	1,000 Yen	1,000 Yen	1,000 Yen
Food, drink and tobacco:			
(a) In a natural state	17,111	24,655	54,165
(b) Partly or wholly prepared	27,584	37,488	91,397
Raw materials	43,690	51,340	137,324
Manufacture for further use in manufacturing	198,929	328,084	852,183
Articles wholly manufactured	142,254	184,914	831,221
Miscellaneous articles	2,845	5,079	26,012
Total	432,413	632,460	1,992,302

*1907 is the earliest year for which this table was published.

(H. Cr.)

EXPOSITION, a word of numerous applications. One of the most common is the theological, *i.e.*, the action of expounding, the explaining of a text. In *logic*, the word is used to indicate a "showing forth" of principles, a "statement" of the nature of things and their disposition. In its modern industrial application it is a synonym for exhibition (*q.v.*).

EX POST FACTO (lit. "from what is done afterwards"), a phrase used especially of laws operating retrospectively.

EXPRESS, a word signifying that which is clearly and definitely set forth or represented, explicit, and thus used of a meaning, a law, a contract, and the like, being specially contrasted with "implied." Thus in law, malice, for which there is actual evidence, as apart from that which may be inferred from the acts of the person charged, is known as "express." The word is most frequently used with the idea of something done with a definite purpose. The term "express train," which has become associated with the idea of speed, originally meant a train running for some specific purpose or engaged by a private person.

In the United States, express companies for the rapid transmission of parcels and luggage and light goods generally perform the function of the post office or the railways in Great Britain and the Continent of Europe. Not only do they deliver goods, but by the cash on delivery system (*see* Cash) they act as agents both for the purchaser and seller of goods. They also serve as a most efficient agency for the transmission of money, the express money order being much more easily convertible than the postal money order, as the latter can only be redeemed at offices in large towns. The system dates back to 1839, when one William Frederick Harnden (1813–45), a conductor on the Boston and Worcester railway, undertook on his own account the carrying of small parcels and the performance of small commissions. Obliged to leave the company's service or abandon his enterprise, he started an "express" service between Boston and New York, carrying parcels, executing commissions and collecting drafts and bills. Alvin Adams followed in 1840, also between Boston and New York. From 1840 to 1845 the system was adopted by many others between the more important towns throughout the States. The attempt to carry letters also was stopped by the Government as interfering with the post office. In 1854 began the amalgamation of many of the companies. Thus under the name of the Adams Express Company the services started by Harnden and Adams were consolidated. The lines connecting the west and east by Albany, Buffalo and the lakes were consolidated in the American Express Company, under the direction of William G. Fargo (*q.v.*), Henry Wells and Johnston Livingston, while another company, Wells, Fargo and Company, operated on the Pacific coast. The celebrated "Pony Express" was started in 1860 between San Francisco and St. Joseph, Mo., the time scheduled being eight days. The service was carried on by relays of horses, with stations 25m. apart. The charge made for the service was $2.50 per ½ ounce. The completion of the Pacific Telegraph Company line in 1861 was followed by the discontinuance of the regular service. In 1918 the several Express companies were brought under the control of a single company, the American Railway Express Company, which acted as agent for the U.S. Director of Railroads, in handling express matter on railroads placed under Government control. The Transportation Act of 1920 specifically permitted the American Railway Express Company to continue as a private organization after the Government returned the railroads to private owners, during that year. Thus, one company has since practically handled the entire express business of the country with 27,500 offices and 125,000 employes, and operating over 260,000 miles of railroad. In Sept. 1927 the Air Express was inaugurated. This is being expanded so that ultimately there will be a network of Air Express routes.

EXPRESSION OF THE EMOTIONS, the facial and other bodily changes which are the characteristic accompaniments of Emotion (*q.v.*). According to Darwin (in *Expression of the Emotions*) these expressions are survivals of actions which were once useful under conditions which induce the emotions. They are "serviceable associated habits." As this theory does not appear to account for all cases, it has been supplemented by various auxiliary hypotheses, of which the following are the most important. Experiences which induce like emotions express themselves in the same way, namely, in the once useful way of one of them. On the other hand, experiences which excite opposite emotions express themselves in opposite ways, assuming that one of them has an expression that was once useful. Some psychologists explain the expression of the emotions as a "direct nervous discharge" resulting in muscular activity; pleasurable emotions causing an increase in muscular activity, while painful ones inhibit it.

See Feeling, Psychology of; James-Lange Theory of Emotions.

EXPROPRIATION, the taking away or depriving of property. The term is particularly applied to the compulsory acquisition of private property by the State or other public authority. (*See* Compensation.)

EXPULSION, the act of removing a person from the membership of a body or the holding of an office, or of depriving him of the right of attending a meeting, etc. In Great Britain the House of Commons can by resolution expel a member. Such resolution cannot be questioned by any court of law. But expulsion is only resorted to in cases where members are guilty of offences which render them unfit for a seat in the House. It is customary first to order the member, if absent, to attend in his place, before an order is made for his expulsion. (*See* May, *Parliamentary Practice*, 1917, p. 61 *seq.*) Municipal corporations or other local government bodies have no express power to expel a member, except in such cases where the law declares the member to have vacated his seat, or where power is given by statute to declare the member's seat vacant. In the case of officers and servants of the Crown, tenure varies with the nature of the office. Some officials hold their offices *ad vitam aut culpam* or *dum bene se gesserunt*, others can be dismissed at any time and without reason assigned and without compensation. In the case of membership of a voluntary association (club, etc.) the right of expulsion depends upon the rules, and must be exercised in good faith. Courts of justice have jurisdiction to prevent the improper expulsion of the member of a voluntary association where that member has a right of property in the association. In the case of meetings, where the meeting is one of a public body, any person not a member of the body is entitled to be present only on sufferance, and may be expelled on a resolution of the body. In the case of ordinary public meetings those who convene the meeting stand in the position of licensors to those attending and may revoke the licence and expel any person who creates disorder, and by the Public Meeting Act 1908 any person acting in a disorderly way for the purpose of preventing the proceedings is liable to a penalty of £5 or to one month's imprisonment. (*See* Aliens; Nationality and Naturalization.)

EX-RIGHTS, without rights. Stock which is entitled to privileged subscription rights may be sold alone and the rights to subscribe to new stock retained by the seller. Such a sale is known as a sale "ex-rights." (*See* Rights.)

EXTEMPORIZATION, in music, is the art of inventing the music performed and performing it simultaneously, in the same way as an orator speaks *ex tempore* when he has no notes to aid him and frames his remarks spontaneously as he proceeds. The humblest amateur who strings a few chords

together is in the strict sense extemporizing, no less than the trained musician whose "profuse strains of unpremeditated art" take shape in complete and perfectly worked-out compositions. Truly marvellous were the performances in this way of some of the great masters of the past.

Thus of Bach we are told that his powers in this respect were absolutely unlimited—the inexhaustible flow of his invention being at the same time invariably combined with the most rigorous regard for form. Schweitzer tells us further concerning him that if he improvised for as long as two hours together on the organ the theme remained the same from beginning to end.

Handel's wonderful powers in this respect drew attention to him at a very early period of his career. And these powers he retained to the end of his days, so that in the case of his organ concertos it was his habit more often than not merely to sketch in the solo part, leaving it with serene confidence to the inspiration of the moment to supply all else that was required.

As for Mozart he excited amazement even as a child by his astonishing achievements under this head. Those were the days of the musical duello, in the shape of formal contests of skill between acknowledged masters, and many were the combats of this kind in which Mozart engaged.

And not less memorable were some of the contests of the same order in which Beethoven took part. In one which caused great stir his opponent was Steibelt, an arrogant virtuoso of the day, who professed nothing but contempt for his youthful and uncouth-looking opponent, but whose mortification was such as he listened to Beethoven's marvellous and inspired playing that he could finally stand it no longer and rushed out of the room.

As to Beethoven's improvisation in general, many eloquent accounts have been left by those who heard him. "His extemporization," said Czerny, "was most brilliant and striking. In whatever company he happened to be he knew how to produce such an effect upon his hearers that frequently not an eye remained dry while many would break out into loud sobs." Ries, in turn, recorded, "No artist that I ever heard came anywhere near the height which Beethoven attained in this branch of performance. The wealth of ideas which forced themselves on him, the caprices to which he surrendered, the variety of treatment, the difficulties, were inexhaustible."

Among more recent composers no one excelled more in this line, perhaps, than Mendelssohn, of whose extraordinary facility many astonishing stories are told—as, for instance, that of the famous three cadenzas which he introduced when playing Beethoven's G major piano concerto with the London Philharmonic Society—the first two at rehearsal and the third, totally different from either of its predecessors, at the concert itself. Yet, his great facility notwithstanding, Mendelssohn extemporized in public with reluctance and in one of his letters even went the length of registering the determination never to perform in that way again. Did he feel, perhaps, acutely sensitive as he was, that the public listened to such performances more as feats of wonder than for the music which they heard, and so came to resent this showman-like exhibition of his powers?

Four-handed improvisation, that is, by two players together, was also sometimes practised in earlier days—as by Clementi and Mozart, by Beethoven and Wölfl and by Mendelssohn and Moscheles. Needless to say this called for the highest skill.

Extemporization of another kind was that required in supplying the embellishments and other details of a composition which were formerly left to the taste of the performer. Of such details the cadenza, or special passage for the display of the soloist's powers, in instrumental concertos is nowadays the sole surviving example, and even this in only a nominal sense. For in modern concertos the cadenzas are almost invariably provided by the composer, or if still entrusted to the soloist are assuredly never left in these days to the hazard of improvisation but are carefully prepared and rehearsed beforehand. (H. A. Sc.)

EXTENDED ORDER, a formation in which the men composing a body of troops, and the various smaller component units, are opened out with intervals between them, so as to afford a more difficult target and minimize the effects of enemy rifle or shell fire. The power of modern weapons is such that all movements on the battlefield within sight or range of an enemy must of necessity be carried out in extended order, if heavy casualties are not to be incurred and further progress to become impossible. (*See* further INFANTRY.)

EXTENSION, the action of straining or stretching out (Lat. *ex*, out; *tendere*, to stretch) (*see* ELASTICITY). It is usually employed metaphorically (*cf.* the phrase an "extension of time," a period allowed in excess of what has been agreed upon). It is used as a technical term in logic to describe the objects or kinds of objects to which a given term may be applied; thus the meaning of the term "King" in "extension" means the kings of England, Italy, Spain, etc. (*cf.* DENOTATION), while its "intension" consists of the qualities or attributes which are suggested by the term king (*see* CONNOTATION). In psychology the literal sense of extension is retained, *i.e.*, "spread-outness." The perception of space by the senses of sight and touch, as opposed to semi-spatial perceptions by smell and hearing, is that of "continuous expanse composed of positions separated and connected by distances" (Stout); to this the term "extension" is applied. The perception of separate objects involves position and distance, but these taken together are not extension, which necessarily implies continuity. To move one's finger along the keys of a piano gives both the position and the distance of the keys; to move it along the frame gives the idea of extension. By expanding this idea we obtain the conception of all space as an extended whole. To this perception are necessary both form and matter. It should be observed that the actual quality of a stimulus (rough, smooth, dry, etc.) has nothing to do with the spatial perception as such, which is concerned purely with what is known as "local signature." The elementary undifferentiated sensation excited by the stimuli exerted by a continuous whole is known as its "extensive quantity" or "extensity." The term has to do not with the kind of object which excites the sensation, but simply with the vague massiveness of the latter. As such it is distinguishable in thought from extension, though it is not easy to say whether and if so how far the quantitative aspect of space can exist apart from spatial order. Extensity as an element in the complex of extension must be carefully distinguished from intensity. Mere increase of pressure implies increase of intensity of sensation; to increase the extensity, the *area*, so to speak, of the exciting stimulus must be increased. Thus the extensity (also called "voluminousness," or "massiveness") of the sensation produced by a roll of thunder is greater than that produced by a whistle or the bark of a dog. It should be observed that this application of the idea of extensity to sensation in general, rather than to the matter which is the exciting stimulus, is only an analogy, an attempt to explain a common psychic phenomenon by terminology which is intrinsically suitable to the physical. As a natural consequence the term represents different shades of meaning in different treatises, leaning sometimes towards the physical, sometimes towards the psychic, meaning.

In connection with extension elaborate psycho-physical experiments have been devised, *e.g.*, with the object of comparing the accuracy of tactual and visual perception and discovering what are the least differences which each can observe. At a distance two lights appear as one, just as two stars distinguishable through a telescope are one to the naked eye (*see* VISION): again, if the points of a compass are brought close together and pressed lightly on the skin the sensation, though vague and diffused, is a single one.

See PSYCHOLOGY and works there quoted; also SPACE AND TIME.

EXTENUATING CIRCUMSTANCES. This expression is used in law with reference to crimes, to describe cases in which, though an offence has been committed, its gravity is mitigated or reduced by reason of facts attending the commission of the offence. It is common practice for juries to add to their verdict a rider recommending the accused to mercy on the ground of circumstances which in their view should mitigate the penalty. In case of a wilful murder, a crime as to which the judge has no discretion as to punishment, the recommendation is sent to the Home Office for consideration in advising as to exercise of the prerogative of mercy.

Under the French law it is the sole right and the duty of a jury in a criminal case to pronounce whether or not the commission of the offence was attended by extenuating circumstances. When the whole or the majority qualify the verdict by finding extenuation the powers of the court to impose the maximum punishment are taken away and the sentence to be pronounced is reduced in accordance with the scale laid down in art. 463 of the *Code pénal*. The most important result of this rule is to enable a jury to prevent the infliction of capital punishment for murder.

EXTERRITORIALITY, a convenient term or metaphor for the immunities enjoyed by certain persons, property or places from the jurisdiction of the State in which they are situate.

Persons and Property.—In most systems of law, including that of England, foreign sovereigns and titular heads of States are exempt from the local jurisdiction (even if travelling incognito) not merely for acts done in their sovereign, but also for acts done in their private, capacity. The same immunity extends to their property and would appear to extend to members of their family and suite. The English courts, however, assume jurisdiction over the person or property of a sovereign where (a) he has instituted proceedings or has voluntarily submitted to the jurisdiction; (b) property in which he is interested and which is subject to some equitable claim is found in the hands of a private person or corporation over whom the court has jurisdiction; (c) he is a subject of the Crown; (d) he is owner of immovable property. It is commonly stated that foreign sovereigns are exempt not only from civil but also from criminal jurisdiction. There does not appear to be any support for this proposition in English law. On the contrary, when Mary of Scotland claimed her immunity as a sovereign, Sir Christopher Hatton L.C. replied "You say you are a queen; be it so. But in such a crime the royal dignity is not exempted from answering, neither by the civil nor canon law, nor by the law of nations." And Sir Robert Phillimore stated that if a sovereign abused the hospitality, or committed an offence against the welfare, of the country in which he is a guest, the authorities would by international law be justified in placing him under arrest, and that if he perished in resisting such restraint, no maxim of international law is violated. Further it is at any rate clear that there is no rule or custom of international law exempting from criminal jurisdiction a foreign sovereign who has invaded the territory of another sovereign and committed an offence therein. Diplomatic agents representing heads of States enjoy similar immunities, which are also extended, so far as they are applicable, to members of their families and persons in their fixed service. They are also exempt from taxation and from custom duties on articles imported for their personal use. They retain the domicile of their own country and their children born within the embassy or legation acquire their domicile and nationality. Whilst it is said that they cannot be tried for a criminal offence and cannot as a rule be arrested, many jurists agree that they are not wholly free from the local jurisdiction in respect of crime committed by them whether against individuals or the State. If the offence is serious and urgent there is no doubt they may be arrested and retained in custody pending redress by their State, or for other reasons. In spite of the statute of Anne 1708, which provides that all writs and processes which may be sued or prosecuted whereby an ambassador or minister or their domestic servants are arrested or imprisoned or their goods detained, shall be null and void, Count Gyllenborge, the Swedish ambassador, was arrested and kept in custody in 1717 for treason. It would appear, therefore, that the statute only refers to civil jurisdiction. And in 1718 Prince Collemare, the Spanish ambassador in Paris, was arrested for a similar offence, and detained until the return of the French ambassador from Madrid. Such measures, says W. E. Hall, may be justified on the ground that the ambassador of a friendly power must *prima facie* be supposed to be exceeding his instructions in doing acts inimical to the Government to which he is accredited. Nor is he wholly exempt from civil jurisdiction. Such jurisdiction extends to property real or personal held by him as an owner, trustee or trader. He is free from all forms of taxation, but not from local rates unless by mutual arrangement. The position of the military forces of one State within the territory of another State with which it is in amity is similar to that of public vessels in territorial waters.

Places.—The residence of a diplomatic agent and its precincts are exempt from the local jurisdiction so far only as to secure the free exercise of his functions. Thus, where the safety of the State or public order is involved, entry may be made by the local authorities, papers may be searched and persons arrested, whether they are the minister himself, or members of his staff or retinue, or political refugees or criminals. But where the local sovereignty is in abeyance or unable to act owing to local disturbances or civil war, legations, like any other body, may grant asylum. In some non-Christian countries, *e.g.*, Turkey, Egypt, Japan, Morocco, Muscat, Persia, China, Korea and Siam, communities have been established consisting of persons who, whilst resident in certain areas, are deemed for the purposes of civil and criminal jurisdiction to be extra-territorial and subject only to their respective national laws administered by their respective consuls or other authorities appointed by their respective Governments. Such communities have been established by capitulations or treaties. In such communities the consulates are regarded as exterritorial and the consuls themselves enjoy diplomatic immunities. Public vessels in the ports or territorial waters of a friendly Power, the crew and persons on board, and all property thereon are also exempt from the local jurisdiction. Private vessels, however, are not exempt, and legal processes may be served and arrests effected on board. Persons born on board a British vessel wherever situated or in an exterritorial community are natural-born British subjects (*see* NATIONALITY). An instance of immunity is that granted to the pope by the Italian Law of Papal Guarantees, 1871.

(H. H. L. B.)

EXTORTION, in English law the term applied to the exaction by public officers of money or money's worth not due at all, or in excess of what is due, or before it is due. Such exaction, unless made in good faith (*i.e.*, in honest mistake as to the sum properly payable), is a misdemeanour by the common law and is punishable by fine and (or) imprisonment. Besides the punishment above stated, an action for twice the value of the thing extorted lies against officers of the king (1275, 3 Edw. I. c. 26). There are numerous provisions for the punishment of particular officers who make illegal exactions or take illegal fees; *e.g.*, sheriffs and their officers (Sheriffs Act, 1887), county court bailiffs (County Courts Act, 1888), clerks of courts of justice, and gaolers who exact fees from prisoners. A gaoler is also punishable for detaining the corpse of a prisoner as security for debt. The term "public officer" is not limited to offices under the Crown; and there are old precedents of criminal proceedings for extortion against churchwardens, and against millers and ferrymen who demand excessive tolls.

The term extortion is also applied to the exaction of money or money's worth by menaces of personal violence or by threats to accuse of crime or to publish defamatory matter about another person. These offences fall partly under the head of robbery and partly under blackmail (*q.v.*).

EXTRACT, in pharmacy, the name given to preparations formed by evaporating or concentrating solutions of active principles; *tinctures* are solutions which have not been subjected to any evaporation. "Liquid extracts" are those of a syrupy consistency, and are generally prepared by treating the drug with the solvent and causing the solution to be concentrated until it attains the desired consistency. "Ordinary extracts" are thick, tenacious and sometimes even dry preparations.

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